

Section 9.3 References

1. CRCG (Cultural Resource Conservation Group) 2005, Meeting Notes, Saluda Hydro Relicensing – Cultural Resource Conservation Group, October 14. Available at [http:// www.saludahydrorelicense.com/cultural.htm](http://www.saludahydrorelicense.com/cultural.htm).
2. CRCG 2006, Meeting Notes, Saluda Hydro Relicensing – Cultural Resource Conservation Group, September 8. Available at [http:// www. saludahydrore license.com/cultural.htm](http://www.saludahydrorelicense.com/cultural.htm).
3. Dames & Moore 1974, *Draft Final Report Site Selection Study Proposed Nuclear Power Plant for South Carolina Electric & Gas Company*, October 4, 1974.
4. Dominion (Dominion Energy, Inc. and Bechtel Power Corporation) 2002, *Study of Potential Sites for the Development of New Nuclear Plants in the United States*, 2002.
5. GoogleEarth 2007, Google Earth (Release 4). January 8. Available at [http:// earth.google.com](http://earth.google.com).
6. Hockensmith, Brenda L. 2001, *Potentiometric Surface of the Black Creek Aquifer in South Carolina*. November. Available at http://www.dnr.sc.gov/water/hydro/HydroPubs/Report_29_Black_Creek.pdf.
7. Housing Economics 2007, *Permits Using New OMB Definitions for Metropolitan Statistical Areas (MSAs)*; Available at http://www.nahb.org/fileUpload_details.aspx?contentID=55104.
8. Kleinschmidt (Kleinschmidt Energy and Water Resource Consultants) 2005, *Saluda Hydro Initial Consultation Document, Prepared for South Carolina Electric and Gas Company, April*. Available at [http://www.saludahydrore license.com/documents/FinalSaludaCD_2005-4-29.pdf](http://www.saludahydrorelicense.com/documents/FinalSaludaCD_2005-4-29.pdf).
9. Miller, James A. 1990, *U.S. Geological Survey Groundwater Atlas of the United States –Alabama, Florida, Georgia, South Carolina*. HA 730-G. Available at http://capp.water.usgs.gov/gwa/ch_g/index.html.
10. NANFA (North American Native Fishes Association) 2002, *Regional Outreach Program South Carolina*, May 24. Available at www.nanfa.org/regional.shtml.
11. NatureServe 2006, *Flatwoods Salamander (Ambystoma cingulatum)*. Available at [http:// www. natureserve.org/explorer/servlet/ NatureServe?searchName=Ambystoma+cingulatum](http://www.natureserve.org/explorer/servlet/NatureServe?searchName=Ambystoma+cingulatum).
12. NCES (National Center for Education Statistics) 2006a, *Common Core of Data South Carolina Table by County for the 2004-2005 School Year*. Available at <http://nces.ed.gov/ccd/bat>.

13. NCES 2006b, *Common Core of Data Georgia Table by County for the 2004-2005 School Year*. Available at <http://nces.ed.gov/ccd/bat>.
14. NMFS (National Marine Fisheries Service) 1998, "Final Recovery Plan for the Shortnose Sturgeon (*Acipenser brevirostrum*). Silver Spring, Maryland." Available at www.nmfs.noaa.gov/pr/pdfs/recovery/sturgeon_shortnose.pdf.
15. NMFS (National Marine Fisheries Service) 2000, *A Protocol for Use of Shortnose and Atlantic Sturgeons*, NMFS-OPR-18. Silver Spring, Maryland. Available at http://www.nmfs.noaa.gov/pr/pdfs/species/sturgeon_protocols.pdf.
16. NPS (National Park Service) 2006a, *National Register Information System – "Aiken, Allendale and Barnwell Counties, South Carolina and Burke and Richmond Counties, Georgia*. Available at <http://www.nr.nps.gov>.
17. NPS 2006b, *National Register Information System – Orangeburg and Bamberg Counties, South Carolina*. Available at <http://www.nr.nps.gov>.
18. NPS 2006c, *National Register Information System – Greenwood, Newberry, and Saluda Counties, South Carolina*. Available at <http://www.nr.nps.gov>.
19. SCDHEC (South Carolina Department of Health and Environmental Control) 1995, *Policies and Procedures of the South Carolina Coastal Management Program, An Excerpt of the South Carolina Coastal Management Program Document*. Available at http://www.scdhec.net/environment/ocrm/regs/docs/OCRM_Policies_Procedures.pdf.
20. SCDHEC 2001, *A Preliminary Assessment of the Groundwater Conditions in Charleston, Berkeley and Dorchester Counties, South Carolina*. July. Available at <http://www.scdhec.gov/eqc/water/pubs/tridentrpt.pdf>.
21. SCDHEC 2002, *South Carolina Ambient Ground Water Quality Monitoring Network 2001 Annual Report*. April. Available at <http://www.scdhec.net/environment/water/docs/amb2001.pdf>.
22. SCDHEC 2004a, *Watershed Water Quality Assessment, Edisto River Basin, October 2004*. Available at www.scdhec.net/eqc/water/pubs/edisto.pdf.
23. SCDHEC 2004b, *Watershed Water Quality Assessment, Saluda River Basin*. Bureau of Water Columbia, South Carolina. Available at <http://www.scdhec.net/water/pubs/saluda.pdf>.
24. SCDHEC 2005, *South Carolina Water Use Report 2004 Summary*. Bureau of Water. Columbia, South Carolina July. Available at <http://www.scdhec.gov/eqc/water/pubs/wtruse2004.pdf>.

25. SCDHEC 2006a, *Air Quality Permitting for Industrial Facilities*. Bureau of Air Quality. Columbia, South Carolina, October. Available at <http://www.scdhec.gov/administration/library/CR-004162.pdf>.
26. SCDHEC 2006b, *South Carolina Water Use Report 2005 Summary*. Bureau of Water. Columbia, South Carolina, April. Available at <http://www.scdhec.gov/eqc/water/pubs/wtruse2005.pdf>.
27. SCDNR (South Carolina Department of Natural Resources) 2000, *Species Gallery: Shortnose Sturgeon*, Executive Summary Biological Resources, Characterization of the Ashepoo-Combahee-Edisto (ACE) Basin, South Carolina. January. Available at <http://www.dnr.sc.gov/marine/mrri/acechar/specgal/sturgeon.htm>.
28. SCDNR 2004, *Water Resources Data for South Carolina 2000-2001*. Report 31. Available at www.dnr.sc.gov/water/hydro/HydroPubs/Abs_dnr_R31.
29. SCDNR 2005, *Species Account: Red-cockaded Woodpecker (Picoides borealis)*. 2005 Comprehensive Wildlife Conservation Strategy. Available at <http://www.dnr.sc.gov/cwcs/pdf/Redcockadedwoodpecker.pdf>.
30. SCDNR 2006, *South Carolina Rare, Threatened, and Endangered Species Inventory*. January 17. Available at https://www.dnr.sc.gov:4443/pls/heritage/county_species.select_county_map.
31. SCDOT (South Carolina Department of Transportation) 2006a, *2005 Average Annual Daily Traffic for Bamberg and Orangeburg Counties*. Available at <http://www.scdot.org/getting/aadt.shtml>.
32. SCDOT 2006b, *2005 Average Annual Daily Traffic for Saluda and Newberry Counties*. Available at <http://www.scdot.org/getting/aadt.shtml>.
33. SCE&G 1991, *Environmental Assessment for Cope Power Plant, 1200 MW Pulverized Coal Project Located Near Cope, South Carolina*, Volumes I and II.
34. SCE&G 2006, *Power Plant Details*. Available at <http://www.sceg.com/en/about-sceg/power-plants/power-plant-details.htm#cope>.
35. SCORS (South Carolina Office of Research and Statistics) 2005, *2004 Local Government Finance Report*. Available at <http://www.ors.state.sc.us/economics/economics.asp>.
36. SNC (Southern Nuclear Operating Company) 2006, *Vogtle Early Site Permit Application – Environmental Report*. August. Available at <http://www.nrc.gov/reactors/new-licensing/esp/vogtle.html>.

37. Spignor, B. C. and Camille Ransom 1979, Abstract for *Report on Ground-Water Conditions in the Low Country Area, South Carolina*. Available at http://www.dnr.sc.gov/water/hydro/HydroPubs/Abs_wrc_R132.htm.
38. U.S. BEA (U.S. Bureau Economic Analysis) 2007a, *RIMS II Multipliers for Savannah River Site, SC Region 2*, Regional Economic Analysis Division, Economic and Statistics Administration, 2007.
39. U.S. BEA 2007b, *RIMS II Multipliers for Cope Generating Station Site, SC Region 2*, Regional Economic Analysis Division, Economic and Statistics Administration, 2007.
40. U.S. BEA 2007c, *RIMS II Multipliers for Saluda Site, SC Region 2*, Regional Economic Analysis Division, Economic and Statistics Administration, 2007.
41. USCB (U.S. Census Bureau) 2000a, Census 2000 Table DP-1, *Profile of General Demographic Characteristics for Augusta-Aiken, GA-SC MSA.* Available at <http://censtats.census.gov/pub/Profiles.shtml>.
42. USCB 2000b, Census 2000 Table DP1, *Profile of General Demographic Characteristics for Aiken and Barnwell Counties, South Carolina, and Richmond and Columbia Counties, Georgia*. Available at <http://censtats.census.gov/pub/Profiles.shtml>.
43. USCB 2000c, *Census 2000 Table DP1 – Profile of General Demographic Characteristics for Aiken City, South Carolina*. Available at <http://censtats.census.gov/pub/Profiles.shtml>.
44. USCB 2000d, *Census 2000 Table DP3 – Profile of Selected Economic Characteristics for Aiken and Barnwell Counties, South Carolina, and Richmond and Columbia Counties, Georgia*. Available at <http://censtats.census.gov/pub/Profiles.shtml>.
45. USCB 2000e, Census 2000 Table DP1, *Profile of General Demographic Characteristics for Aiken, Bamberg, Barnwell, Colleton, Lexington, and Orangeburg Counties*. Available at <http://censtats.census.gov/pub/Profiles.shtml>.
46. USCB 2000f, Census 2000 Table DP1, *Profile of General Demographic Characteristics for Columbia City, SC*. Available at <http://censtats.census.gov/pub/Profiles.shtml>.
47. USCB 2000g, *Census 2000 Table DP3 – Profile of Selected Economic Characteristics for Aiken, Bamberg, Barnwell, Colleton, Lexington, and Orangeburg Counties*. Available at <http://censtats.census.gov/pub/Profiles.shtml>.

48. USCB 2000h, Census 2000 Table DP1, *Profile of General Demographic Characteristics for Lexington, Newberry, Richland, and Saluda Counties*. Available at <http://censtats.census.gov/pub/Profiles.shtml>.
49. USCB 2000i, Census 2000 Table DP3, *Profile of Selected Economic Characteristics for Lexington, Newberry, Richland, and Saluda Counties*. Available at <http://censtats.census.gov/pub/Profiles.shtml>.
50. USCB 2002a, *South Carolina Census 2000 Profile. C2KPROF/00-SC. August*. Available at <http://www.census.gov/prod/2002pubs/c2kprof00-sc.pdf>.
51. USCB 2002b, *Georgia Census 2000 Profile. C2KPROF/00-GA. August*. Available at <http://www.census.gov/prod/2002pubs/c2kprof00-ga.pdf>.
52. USCB 2004, *Compendium of Public Employment: 2002. GC02(3)-2. September*. Available at <http://www.census.gov/govs/www/cog2002.html>.
53. USDA (U.S. Department of Agriculture) 2006, Bamberg and Orangeburg Counties. South Carolina Annual Statistics Bulletin Crops, Livestock, and Poultry 2004 – 2006. National Agricultural Statistics Service. Available at http://www.nass.usda.gov/Statistics_by_State/South_Carolina/Publications/Annual_Statistical_Bulletin/index.asp.
54. U.S. DOE 2005, *Savannah River Site End State Vision*, July 26. Available at <http://www.srs.gov/sro/pubact1.htm>.
55. USFA (U.S. Fire Administration) 2004, National Fire Department Census. Department of Homeland Security. Available at <http://www.usfa.dhs.gov/applications/census/>.
56. USFWS (U.S. Fish and Wildlife Service) 1990a, *Canby's Dropwort (Oxypolis canbyi) Recovery Plan*. Atlanta, Georgia. Available at http://ecos.fws.gov/docs/recovery_plans/1990/900410.pdf.
57. USFWS 1990b, *Harperella (Ptilimnium nodosum) Recovery Plan*. Newton Corner, Massachusetts. Available at http://ecos.fws.gov/docs/recovery_plans/1991/910305.pdf.
58. USFWS 1993, *Recovery Plan for Three Granite Outcrop Plant Species*. Jackson, Mississippi. Available at http://ecos.fws.gov/docs/recovery_plans/1993/930707.pdf.
59. USFWS 2007, *Listed endangered species in South Carolina: County listings*. Ecological Services, Charleston Field Office, Charleston, South Carolina. Available at http://www.fws.gov/charleston/docs/listed_endangered_species_in_sc.htm.

60. USGS (US Geological Survey) 2006, *Water Resources Data--South Carolina, Water Year 2005*, Volume 1. USGS-WDR-SC-05-1. Water Resources Division. Columbia, South Carolina. March 2006. Available at <http://sc.water.usgs.gov/AAR/scAARindex.html>.
61. U.S. NRC 1976, *Regulatory Guide 4.2, Preparation of Environmental Reports for Nuclear Power Stations*, Revision 2, July 1976.
62. U.S. NRC 1996, *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*, NUREG-1437, Volume 1, Office of Nuclear Regulatory Research, Washington, D.C., May 1996
63. U.S. NRC 1999, *Standard Review Plans for Environmental Reviews for Nuclear Power Plants*, NUREG-1555, October 1999.
64. U.S. NRC 2003, *SECPOP 2000: Sector Population, Land Fraction, and Economic Estimation Program*, Office of Nuclear Regulatory Research, U.S. NRC, Washington D.C., August 2003.
65. U.S. NRC 2004, *Procedural Guidance for Preparing Environmental Assessments and Considering Environmental Issues*, NRR Office Instruction No. LIC-203, Revision 1, May 24, 2004.
66. U.S. NRC 2005, *Environmental Impact Statement on the Construction and Operation of a Proposed Mixed Oxide Fuel Fabrication Facility at the Savannah River Site, South Carolina – Final Report.*, NUREG-1767, Volume I. Available at <http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1767/#pubinfo>.
67. WSRC (Westinghouse Savannah River Company) 2006, *Environmental Report for 2005*. WSRC-TR-2006-00007. Available at <http://sti.srs.gov/fulltext/WSRC-TR-2006-00007.pdf>

Sec 9.3 Ref 1

Saluda Hydro Relicensing – Cultural Resource Conservation Group

October 14, 2005

Meeting Location – SCE&G Training Center – Columbia, SC

FINAL ACG 11-3-05

Attendees:

Alison Guth	Kleinschmidt Associates
Bill Argentieri	SCE&G
Bill Green	TRC
Sean Norris	TRC
Steve Bell	Lake Watch
Randall Shealy	Lake Murray Historical Society
Karen Thompson	Capitol City/Lake Murray Country
George Duke	Lake Murray Homeowners Coalition
Ralph Crafton	Lake Murray Association
Wenonah Haire	Catawba Indian Nation
Sandra Reinhardt	Catawba Indian Nation
Marianne Zajac	Irmo-Chapin Recreation Commission
Chad Long	SHPO
Randy Mahan	SCANA Services
Jim Devereaux	SCE&G

Action Items:

- Issue draft Stage II Survey Report
TRC *September 2006*
- Post Stage 2 Survey updates on the Saluda Hydro Relicensing website.
Alison Guth *Ongoing*

Meeting Notes:

These notes summarize the major items discussed during the meeting and are not intended to be a transcript or analysis of the meeting. A PowerPoint presentation was used during this meeting and can be accessed at www.saludahydrorelicense.com.

Bill Green opened the meeting and welcomed the group, noting that the purpose of this initial meeting was to describe the processes behind the detection of items and places of cultural significance. He pointed out that this meeting would also describe what has been accomplished up to this point during Stage 1 Reconnaissance Surveys. He began by explaining that there were five primary mandated participants in the process which included FERC, SCE&G, State Historic Preservation Office (SHPO), Catawba Indian Nation Tribal Historic Preservation Office (CIN-THPO), and the Advisory Council on Historic Preservation. He noted that the Advisory Council on Historic Preservation was the National group that oversees Section 106 processes.

SCEG-455

Saluda Hydro Relicensing – Cultural Resource Conservation Group

October 14, 2005

Meeting Location – SCE&G Training Center – Columbia, SC

FINAL ACG 11-3-05

Bill Green pointed out that the Eastern Band of the Cherokee has expressed interest in the project. He also noted that 18 other Indian tribes have been notified. Bill Green explained that some tribes only want to be notified if burials or other significant objects are found.

Bill Green continued to follow the slides in the PowerPoint presentation mentioning the laws covering the process such as NEPA and Section 106 of the National Historic Preservation Act. He noted that Section 106 requires that “prior to the issuance of any license ... take into account the effect of the undertaking on any district, site, building, structure or object that is included in or eligible for inclusion in the National Register. The head of any such Federal agency shall afford the Advisory Council on Historic Preservation ... a reasonable opportunity to comment with regard to such undertaking.”

He noted that initially TRC had to define the undertaking, identify participants and coordinate with SHPO, and define the Area of Potential Effects (APE). He mentioned that discussions with SHPO, SCDNR, and the CIN-THPO, had already been carried out. He also added that the APE for this project was defined as 500 feet from full pool elevation on Lake Murray and 500 ft back from the bank of the lower Saluda River (LSR).

The discussion then began to center more around the details involved in the Stage 1 Reconnaissance Survey which has already been concluded. He mentioned that consultation with SHPO/THPO, Indian tribes and other consulting parties on ways to avoid, minimize, or mitigate the adverse effects was required under law. It was pointed out that the survey included an assessment of any adverse effects on cultural resources. He mentioned erosion as an example. Bill Green continued to note that usually agreement is achieved and they prepare a Memorandum of Agreement (MOA) as well as a Historic Properties Management Plan (HPMP).

Bill Green explained that the Stage 2 Intensive Survey would begin in the next few weeks. He clarified that Stage 2 would include all of the islands as well as the areas of Lake Murray and the LSR that were selected during the Stage 1 reconnaissance for further investigation.

George Duke inquired as to whether or not the Historic Properties Management Plan (HPMP) was going to be available to the public. After some discussion among the group it was determined that distribution of the HPMP was limited to agencies due to the sensitive nature of site locations. Chad Long suggested that the HPMP could provide direction for SCE&G to periodically update the public on the status of administering the HPMP.

George Duke then inquired as to what defined an archeological site. Bill Green replied that it usually applied only to sites that are over 50 years of age. The group continued to

Saluda Hydro Relicensing – Cultural Resource Conservation Group

October 14, 2005

Meeting Location – SCE&G Training Center – Columbia, SC

FINAL ACG 11-3-05

discuss various questions that were raised about historical sites, Such as what kind of impact erosion had on historical sites. It was noted that erosion posed a problem because it had the potential to remove artifact bearing soils at the site. Steve Bell inquired as to what defined a historical landscape. It was explained that anything from buildings to battle sites could be defined as a historical landscape, however typically the site in question had to be more than 50 years old unless deemed extremely significant.

Sean Norris then began discussion on what was found during the Stage 1 Surveys. He explained that prior to the survey, TRC met with SCE&G, SHPO, SCDNR, and CIN-THPO. He noted that during the meeting it became apparent that the entire shoreline of Lake Murray needed to be surveyed in order to identify lands that contain cultural resources. Sean showed the group the map of survey sites around Lake Murray. He noted that before TRC embarked on their surveys, their research indicated that there were 42 previously recorded archeological sites around the lake.

In conclusion, Sean noted that a total of 620 miles of shoreline along Lake Murray were assessed as well as 25 miles of riverbank on the Saluda, Little Saluda, lower Saluda rivers and major tributaries. He stated that 40 new archaeological sites were recorded as well as eight newly recorded structures. He explained that the oldest findings ranged from 8,000 to 10,000 years old up to Epting's Campground which was established in 1937. George Duke asked Sean to explain the meaning of "site". Sean replied that a site usually consisted of a ridge top or high area. These are areas where shovel tests were performed. He continued to note that when an artifact was found the site was assigned a number.

Sean mentioned that from the Stage 1 survey it was concluded that there are approximately 89 miles of shoreline that need to be further surveyed during Stage 2. He explained that during Stage 2 shovel tests will be performed, sites will be recorded and marked with GPS, and they will be assessed as not eligible, potentially eligible, or eligible for inclusion in the National Register. Sean also noted that each island will be surveyed in its entirety during Stage 2 as well.

George Duke inquired if the surveys were performed below the 360' line during Stage 1 Reconnaissance. Bill Green responded that they will survey the area up to where the lake level is at that time. George Duke also requested that updates on progress be reported. The group decided that the website would serve as a good place to post this information.

Bill Green noted that during Stage 2, some surveys need to occur on private property. In which case, letters will be sent out to land owners requesting permission to access the property. If landowners explicitly state that they do not want a survey conducted on their property, then they will not survey the property.

Bill Argentieri asked as to what actions were required from SCE&G in regards to the identified historic properties. Bill Green replied that most of the houses that were

Saluda Hydro Relicensing – Cultural Resource Conservation Group

October 14, 2005

Meeting Location – SCE&G Training Center – Columbia, SC

FINAL ACG 11-3-05

identified are ineligible for listing, except for Epting's Campground. However, Epting's Campground is not impacted by the Project.

Discussions also centered on preparing an historic properties brochure that describes the cultural resources around Lake Murray and could be placed in the Lake Murray Welcome Center. It was discussed that an artifacts display may be prepared for the Welcome Center as well.

The meeting came to a close with a decision to hold the next Cultural Resources meeting on September 8, 2006, after Stage 2 surveys are concluded.

The meeting adjourned around 11:00

*Sec 9.3 Ref 2***MEETING NOTES****SOUTH CAROLINA ELECTRIC & GAS COMPANY
SALUDA HYDRO PROJECT RELICENSING
CULTURAL RESOURCES CONSERVATION GROUP***Final JMS 09-22-06***Saluda Shoals Park
September 8, 2006****ATTENDEES:**

Bill Argentieri, SCE&G
Jeni Summerlin, Kleinschmidt Associates
Ken Styer, S&ME

Bill Green, S&ME
Beckee Garris, CIN
Rebekah Dobrasko, SHPO

ACTION ITEMS:

- Prepare a list of categorical exclusions
Bill Argentieri
- Find a pre-Lake Murray dam map
Bill Argentieri
- Contact Saluda Shoals Park about booking a room for the next meeting
Bill Green

DATE OF NEXT MEETING:

***Date: March 2, 2007
Location: TBA***

SCEG-454

MEETING NOTES

SOUTH CAROLINA ELECTRIC & GAS COMPANY SALUDA HYDRO PROJECT RELICENSING CULTURAL RESOURCES CONSERVATION GROUP

Final JMS 09-22-06

*Saluda Shoals Park
September 8, 2006*

MEETING NOTES:

These notes serve as a summary of the major points presented during the meeting and are not intended to be a transcript or analysis of the meeting.

Bill Green opened the meeting and welcomed the group, and noted that the purpose of this meeting is to: (1) update committee members on the results of the Stage II Cultural Resource investigations to date, (2) discuss/approve the draft mission statement, discuss goals for the Cultural Resources Conservation Group (CRCG), and (3) schedule the next meeting date (see attachment A for meeting agenda).

PowerPoint presentation on the results of the Stage II cultural resource investigations to date

Bill G. handed the floor over to Ken Styer and he briefly reviewed the results of the Stage I reconnaissance survey (click on the follow link to access the PowerPoint presentation

<http://www.saludahydrorelicense.com/documents/SaludaHydroCRCGMeeting.9-8-06.final.edited.ppt>)

During the Stage I survey 42 previously recorded archeological sites and 40 new sites were identified. Also, eight newly recorded historic structures were identified with one site eligible for the National Register of Historic Places (NRHP). He then briefly discussed the Stage II survey areas and noted that to date 80 islands and 75 shoreline areas of Lake Murray, and 2 islands and 1.5 miles of river bank in the Lower Saluda River have been examined. The remaining areas to be surveyed for the Stage II survey are 55 islands in Lake Murray, 6 shoreline areas in Lexington County, and 96 shoreline areas in Newberry and Saluda Counties. He noted that he was denied access to five shoreline areas and six islands.

The results of Stage II intensive survey to date are 77 newly recorded archeological sites, which include: 30 prehistoric sites ranging from Early Archaic to Late Woodland (10,000 to 1,000 years ago), 32 historic home sites from 19th and early 20th century, and 5 historic cemeteries. He noted that several research themes were developed from results of these investigations, including prehistoric and historic utilization of the Saluda River drainage, resource utilization, and trade and interaction.

PowerPoint presentation on the Tree House archaeological site investigations

Bill G. began discussing the Tree House archaeological site investigations on the Lower Saluda River. He noted that the site is about 12 acres in size and has deeply buried artifacts with excellent preservation. He then began to explain the stratigraphic profile of the Tree House dig and noted that the dark line on the graph represents soil from 15,000 years ago. He mentioned that they sampled soils at these depths to find possible artifacts that date back as much as 15,000 years ago. Bill G. noted that the Tree House could be one of the most important archeological sites in the Southeastern United States. The site has known occupations dating back more than 5,000 years ago. He noted that Tree House investigations on the Lower Saluda River will continue through winter 2006.

MEETING NOTES

SOUTH CAROLINA ELECTRIC & GAS COMPANY SALUDA HYDRO PROJECT RELICENSING CULTURAL RESOURCES CONSERVATION GROUP

Saluda Shoals Park
September 8, 2006

Final JMS 09-22-06

Discussion/approval of the draft mission statement

The group then began to discuss the following mission statement for the Cultural RCG. Beckee Garris noted and the group agreed that "prehistory" should be changed to "precontact". The group decided to allow RCG committee members to comment on the mission statement once more and should then be posted on the website as final.

The mission of the Cultural RCG is to provide recommendations that will be used in the creation of an Historic Properties Management Plan (HPMP) for the Saluda Hydro Project license application. The objective of the HPMP is to outline policies and procedures that will be used for avoiding, minimizing, or mitigating potential adverse effects on historic properties that are being affected or have the potential to be affected by project operations. The CRCG also will provide input regarding ongoing consultation under Section 106 of the National Historic Preservation Act, a list of Categorical exclusions for the project, and provide suggestions for creating public information and/or displays regarding the history and precontact of the Lake Murray area.

Bill G. reviewed the following goals of the Cultural RCG:

- General Recommendations for HPMP
- Ongoing consultation for Saluda Hydro Project
- List of categorical exclusions (in conjunction with Operations and Lake and Land Management RCGs)
- Creating public information and displays for the Project
- Other goals

There was a brief discussion about including categorical exclusions in the HPMP. Bill G. noted that categorical exclusions are activities that SCE&G performs that do not have the potential to affect historic properties. Bill Argentieri noted that he would help put together a list of categorical exclusions.

Public information/display on historical sites around the Saluda Hydro Project

The group discussed preparing public information and a display that describes cultural resources around the Saluda Hydro Project. It was suggested that this information include rules about trespassing on archeological sites (*Why looting is not a good idea*). The group also suggested informing local law enforcement agencies about the locations of these historical sites. It was also suggested that a pre-dam map that demonstrates the landscape before Lake Murray was constructed would make an educational display item. The group agreed that public information and/or a display of the archeological finds around the Saluda Hydro Project should be placed at Saluda Shoals Park, Lake Murray visitors center, and the Lexington museum. It was also suggested to include some information about these historical areas on the SCE&G website.

MEETING NOTES

**SOUTH CAROLINA ELECTRIC & GAS COMPANY
SALUDA HYDRO PROJECT RELICENSING
CULTURAL RESOURCES CONSERVATION GROUP**

Final JMS 09-22-06

*Saluda Shoals Park
September 8, 2006*

Next meeting

The next meeting is scheduled for March 2, 2007. Bill Green noted that the first draft of the Cultural Resource Investigation should be sent out in early January of 2007. He mentioned that this will give committee members the opportunity to read and comment on the report.

MEETING NOTES

**SOUTH CAROLINA ELECTRIC & GAS COMPANY
SALUDA HYDRO PROJECT RELICENSING
CULTURAL RESOURCES CONSERVATION GROUP**

Final JMS 09-22-06

*Saluda Shoals Park
September 8, 2006*

**Attachment A
Meeting Agenda for the Cultural Resource Conservation Group**

**Meeting Agenda for the Cultural Resource Conservation Group
Saluda Shoals Park
September 8, 2006
9:30 AM -12:00 Noon**

9:30 – 9:40 Welcome and introduction.

MEETING NOTES

**SOUTH CAROLINA ELECTRIC & GAS COMPANY
SALUDA HYDRO PROJECT RELICENSING
CULTURAL RESOURCES CONSERVATION GROUP**

**Saluda Shoals Park
September 8, 2006**

Final JMS 09-22-06

- 9:40 – 10:15 PowerPoint presentation on the results of the Stage II cultural resource investigations to date.
- 10:15 – 10:30 PowerPoint presentation on the Tree House archaeological site investigations.
- 10:30 – 10:45 Questions about the investigations
- 10:45 – 10:55 Break
- 10:55 – 11:10 Discussion/approval of the draft mission statement (see below).
- 11:10 – 11:40 Goals for the CRCG
- General Recommendations for HPMP
 - Ongoing consultation for Saluda Hydroelectric Project
 - List of categorical exclusions (in conjunction w/ Operations and Lake and Land Management RCGs)
 - Creating public information and displays for the project
 - Other goals
- 11:40 – 12:00 Questions and open discussion
- 12:00 Schedule next meeting and adjourn

Cultural Resource Conservation Group (Draft Mission Statement)

The mission of the Cultural RCG is to provide recommendations that will be used in the creation of an Historic Properties Management Plan (HPMP) for the Saluda Hydroelectric Project license application. The objective of the HPMP is to outline policies and procedures that will be used for avoiding, minimizing, or mitigating potential adverse effects on historic properties that are being affected or have the potential to be affected by project operations. The CRCG also will provide input regarding ongoing consultation under Section 106 of the National Historic Preservation Act, a list of categorical exclusions for the project, and provide suggestions for creating public information and/or displays regarding the history and prehistory of the Lake Murray area.

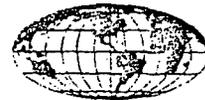
Sec 9.3 Ref 3

CONFIDENTIAL

PRELIMINARY

DRAFT FINAL REPORT
SITE SELECTION STUDY
PROPOSED NUCLEAR POWER PLANT
FOR SOUTH CAROLINA ELECTRIC & GAS COMPANY

Oct 4, 1974



DAMES & MOORE

5182-051-09

CONFIDENTIAL

PRELIMINARY

DRAFT FINAL REPORT
SITE SELECTION STUDY
PROPOSED NUCLEAR POWER PLANT
FOR SOUTH CAROLINA ELECTRIC & GAS COMPANY

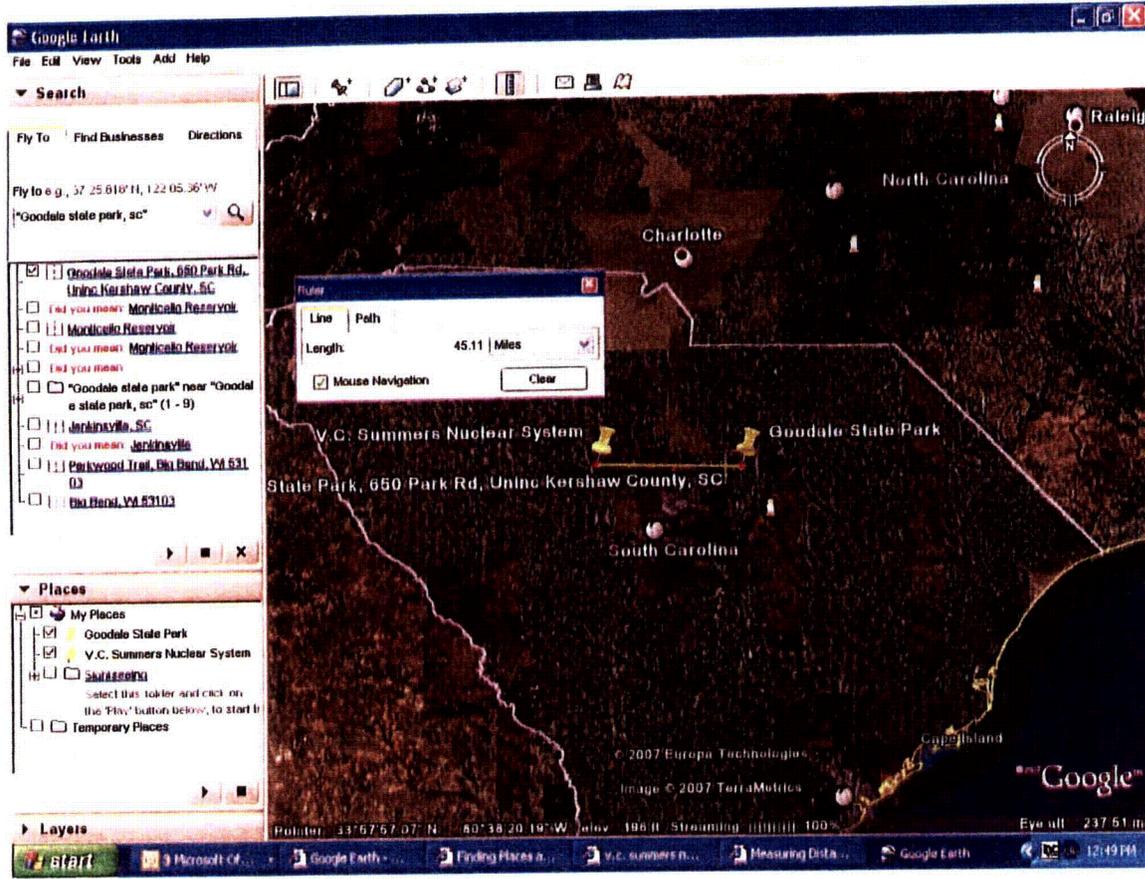
Oct 4, 1974



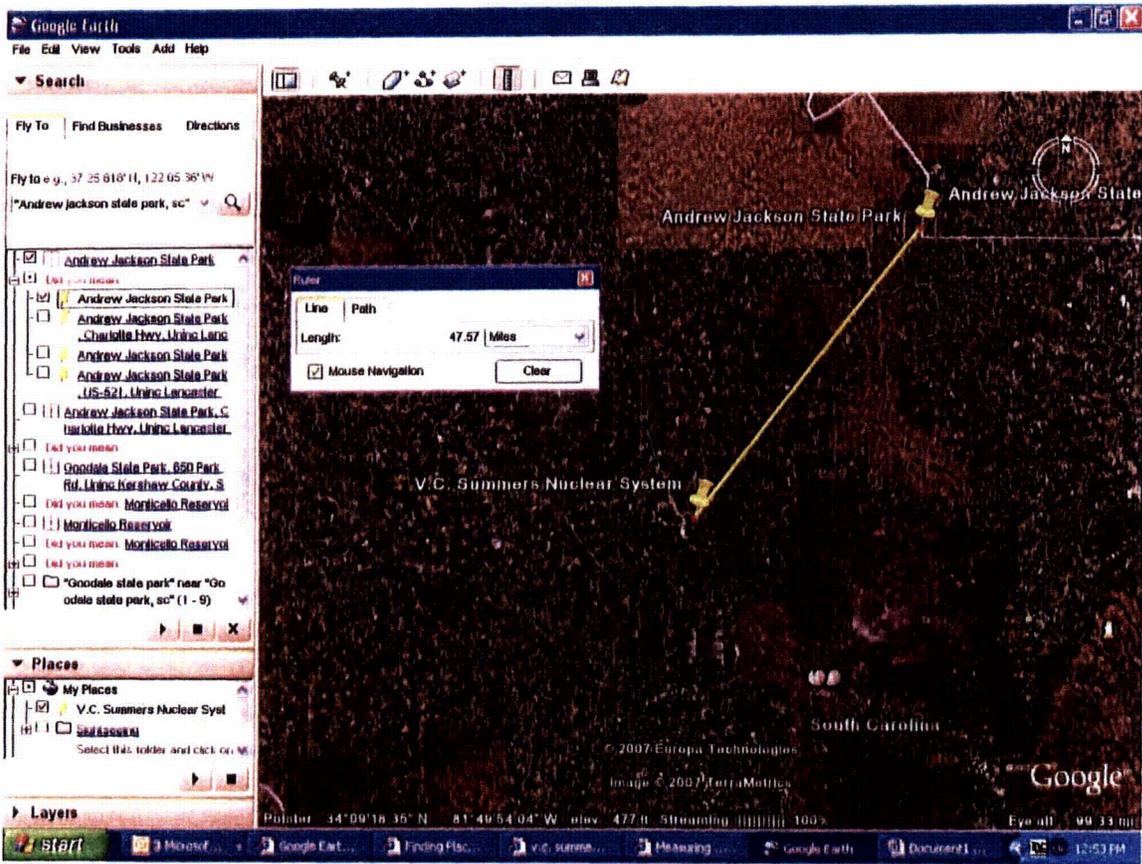
DAMES & MOORE

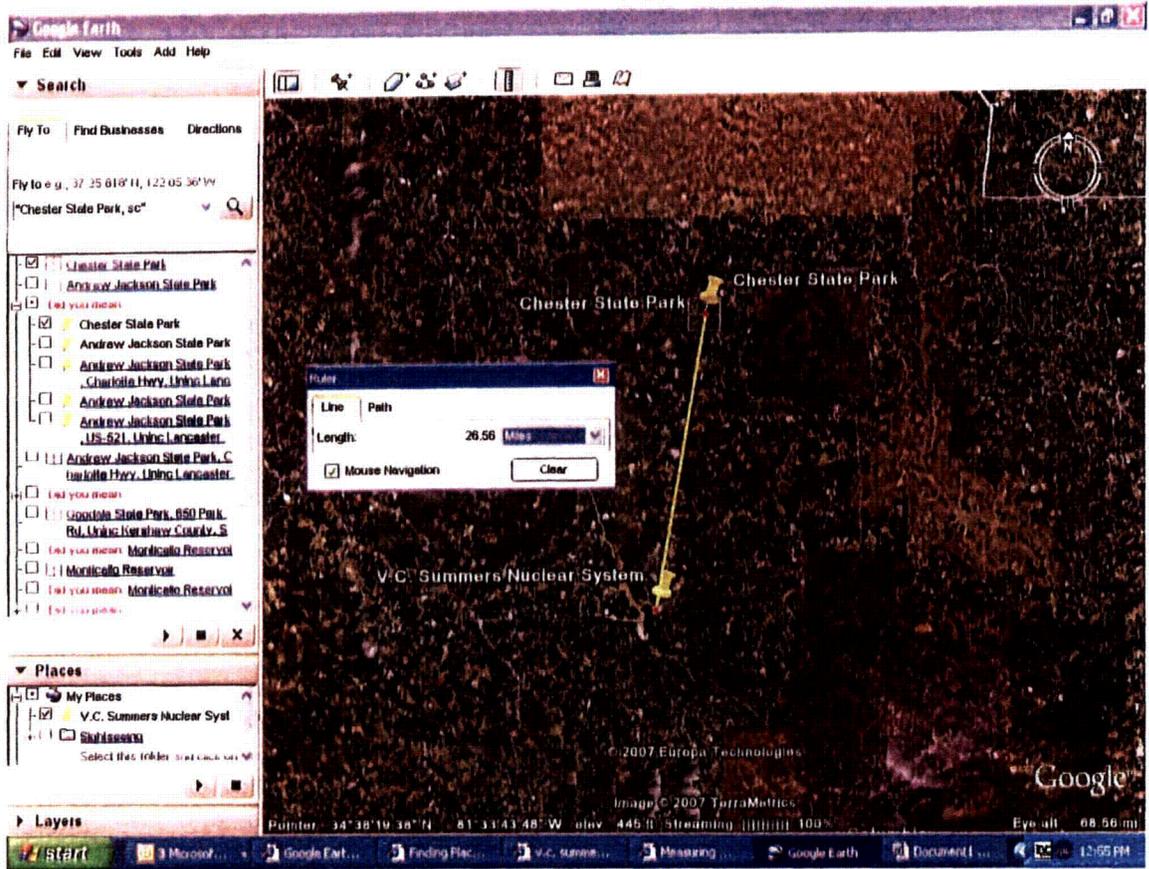
5182-051-09

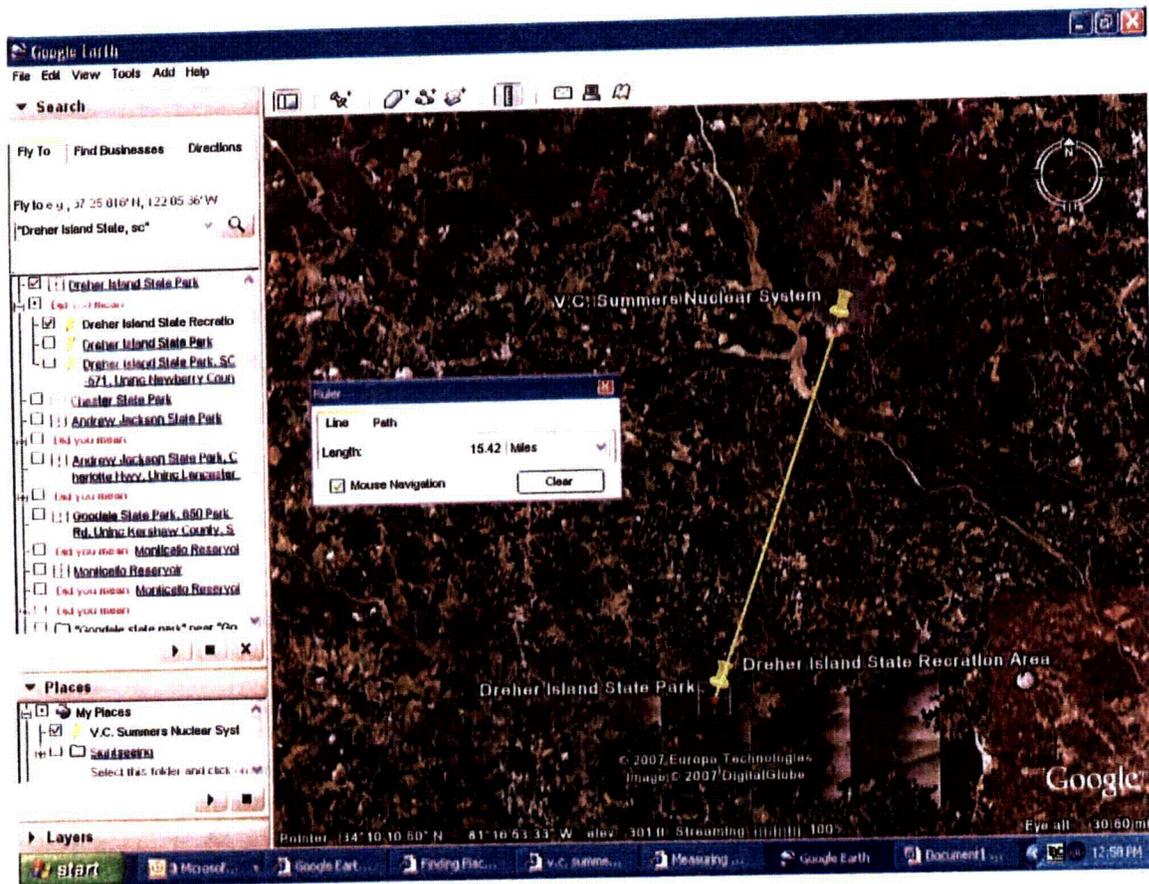
Google Earth 2007



See 9.3 Ref 5







Search

Fly To Find Businesses Directions

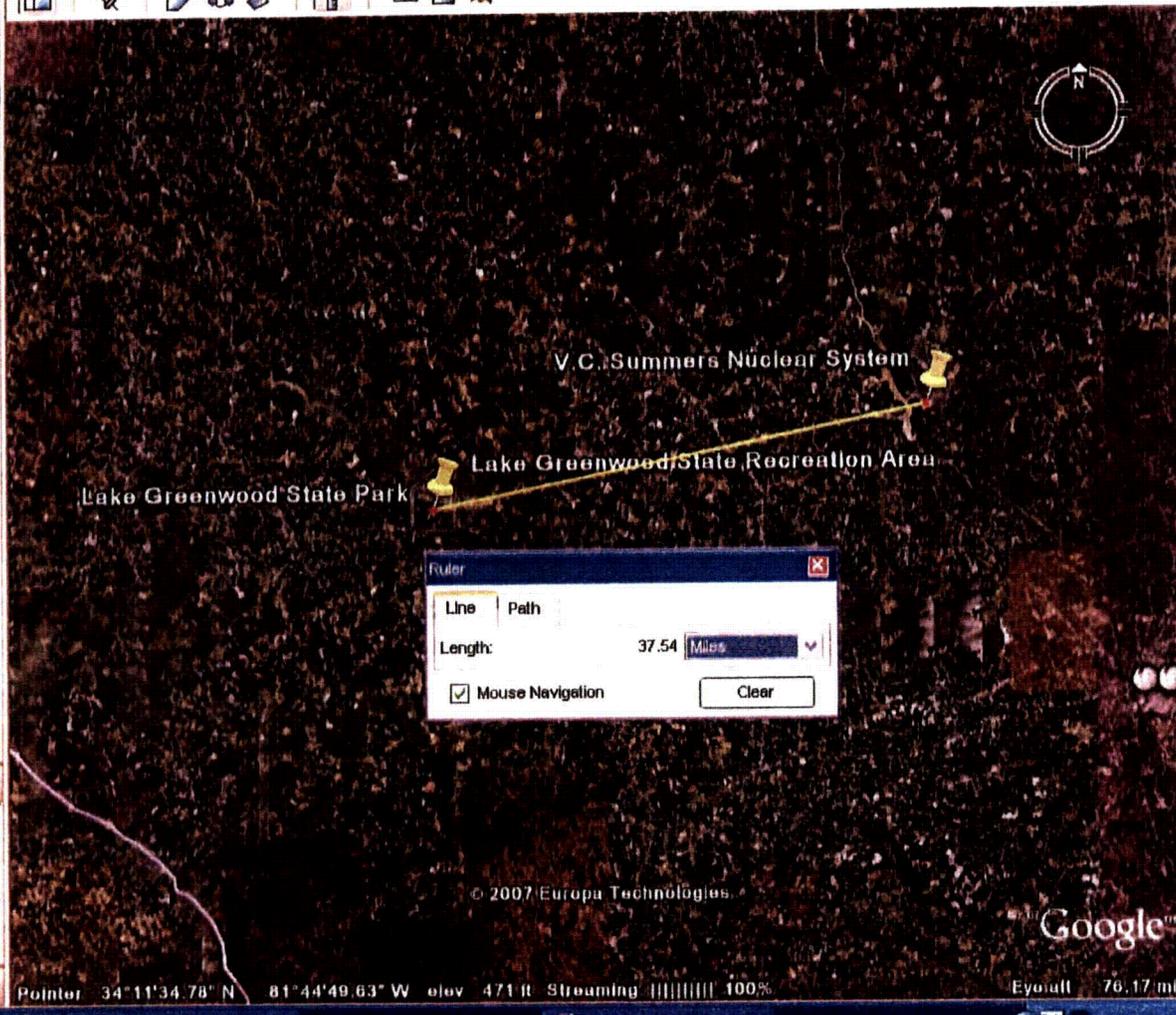
Fly to e.g., 37 25 818' N, 122 05 36' W

"Lake greenwood state, sc"

- ✓ Lake Greenwood State Park
- Did you mean
- ✓ Lake Greenwood State Rec
- ✓ Lake Greenwood State Park
- ✓ Lake Greenwood State Park
- ✓ Lake Greenwood State Park
- ✓ SC-702, Union Greenwood
- ☐ Dreher Island State Park
- Did you mean
- ☐ Chester State Park
- ☐ Andrew Jackson State Park
- Did you mean
- ☐ Andrew Jackson State Park, C
- ☐ barlote Hwy, Union Lancaster
- Did you mean
- ☐ Goodale State Park, 650 Park
- ☐ Rd, Union Kershaw County, S
- Did you mean: Monticello Reservoir
- ☐ Monticello Reservoir
- Did you mean: Monticello Reservoir

- Places
- My Places
 - ✓ V.C. Summers Nuclear Syst
 - ☐ Sightseeing
- Select this folder and click on

Layers



Ruler

Line Path

Length: 37.54 Miles

Mouse Navigation

Clear

Google Earth

File Edit View Tools Add Help

Search

Fly To Find Businesses Directions

Fly to e.g., 37.25.818° N, 122.05.36° W

"Lake Wateree State, sc"

- Lake Wateree State Park
- Did you mean:
 - Lake Wateree State Recreat
 - Lake Wateree State Park
 - Lake Wateree State Park, S C-101, Uninc Fairfield Count
 - Lake Wateree State Park, SC-101, Uninc Fairfield County, S
 - Did you mean:
 - Lake Wateree State Park
 - Did you mean:
 - Lake Greenwood State Park
 - Did you mean:
 - Dreher Island State Park
 - Did you mean:
 - Chester State Park
 - Andrew Jackson State Park
 - Did you mean:

Places

- My Places
 - V.C. Summers Nuclear Syst
 - Sightseeing

Layers

Pointer 33°37'35.66" N 81°13'00.09" W elev. 372 ft Streaming 100% Eye alt 157.82 mi

© 2007 Europa Technologies
Image © 2007 TerraMetrics

Google

start Microsoft Office O... Internet Explorer Google Earth Document 1 - Microsof... 1:03 PM

Google Earth

File Edit View Tools Add Help

Search

Fly To Find Businesses Directions

Fly to e.g., 37 25.818° N, 122 05 36° W

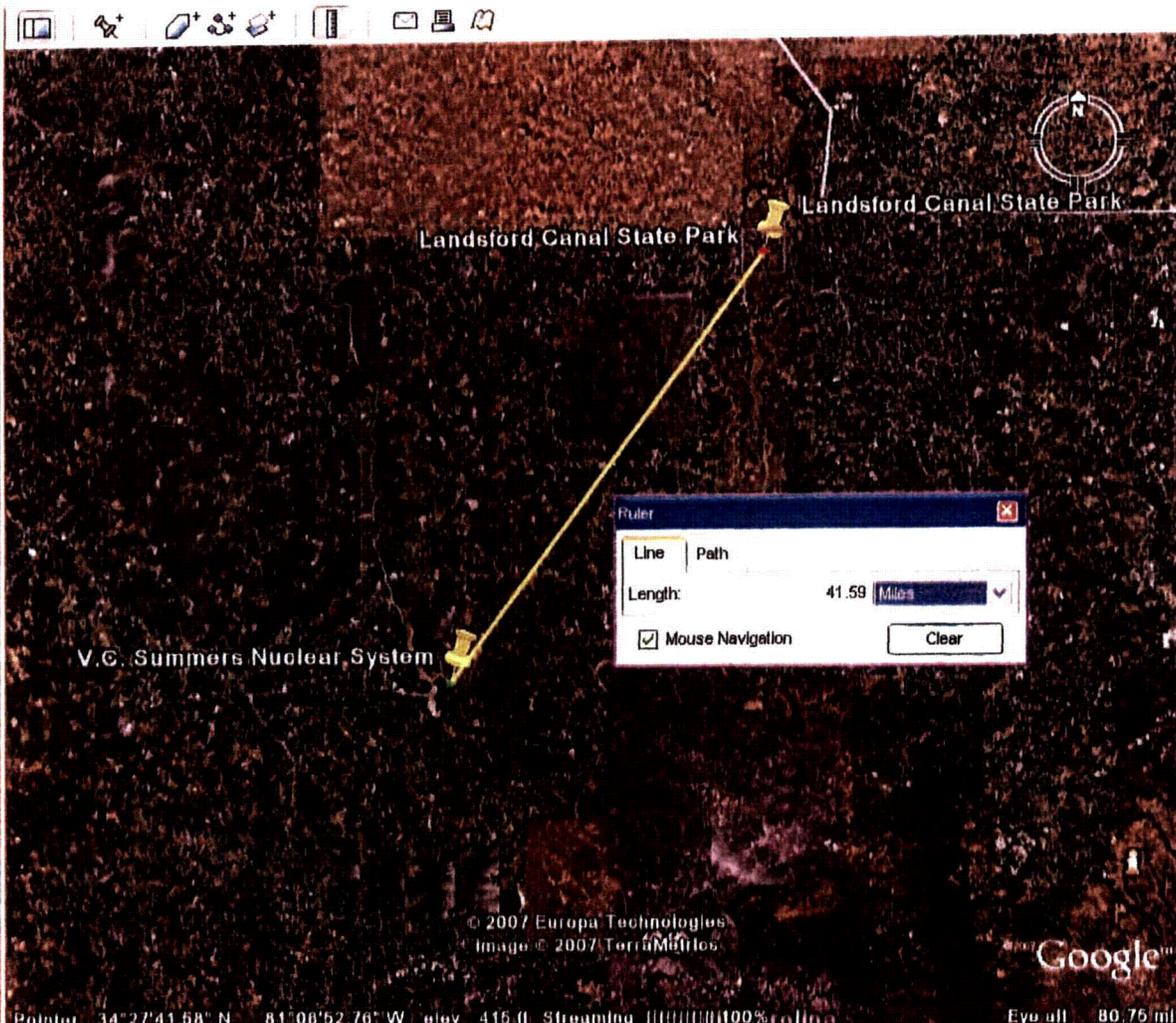
landsford canal state park, sc

- Landsford Canal State Park
- Lake Wateree State Park
- Did you mean:
 - Landsford Canal State Park
 - Lake Wateree State Recreat
 - Lake Wateree State Park
 - Lake Wateree State Park, S
 - C-101, Union Fairfield Count
 - Lake Wateree State Park, SC-101, Union Fairfield County, S
- Did you mean:
 - Lake Wateree State Park
- Did you mean:
 - Lake Greenwood State Park
- Did you mean:
 - Droher Island State Park
- Did you mean:
 - Chester State Park

Places

- My Places
 - V.C. Summers Nuclear Syst
 - Sightseeing
- Select this folder and click on

Layers



© 2007 Europa Technologies
Image © 2007 TerraMetrics

Google

Pointer 34°27'41.58" N 81°08'52.76" W elev 415 ft Streaming 100%

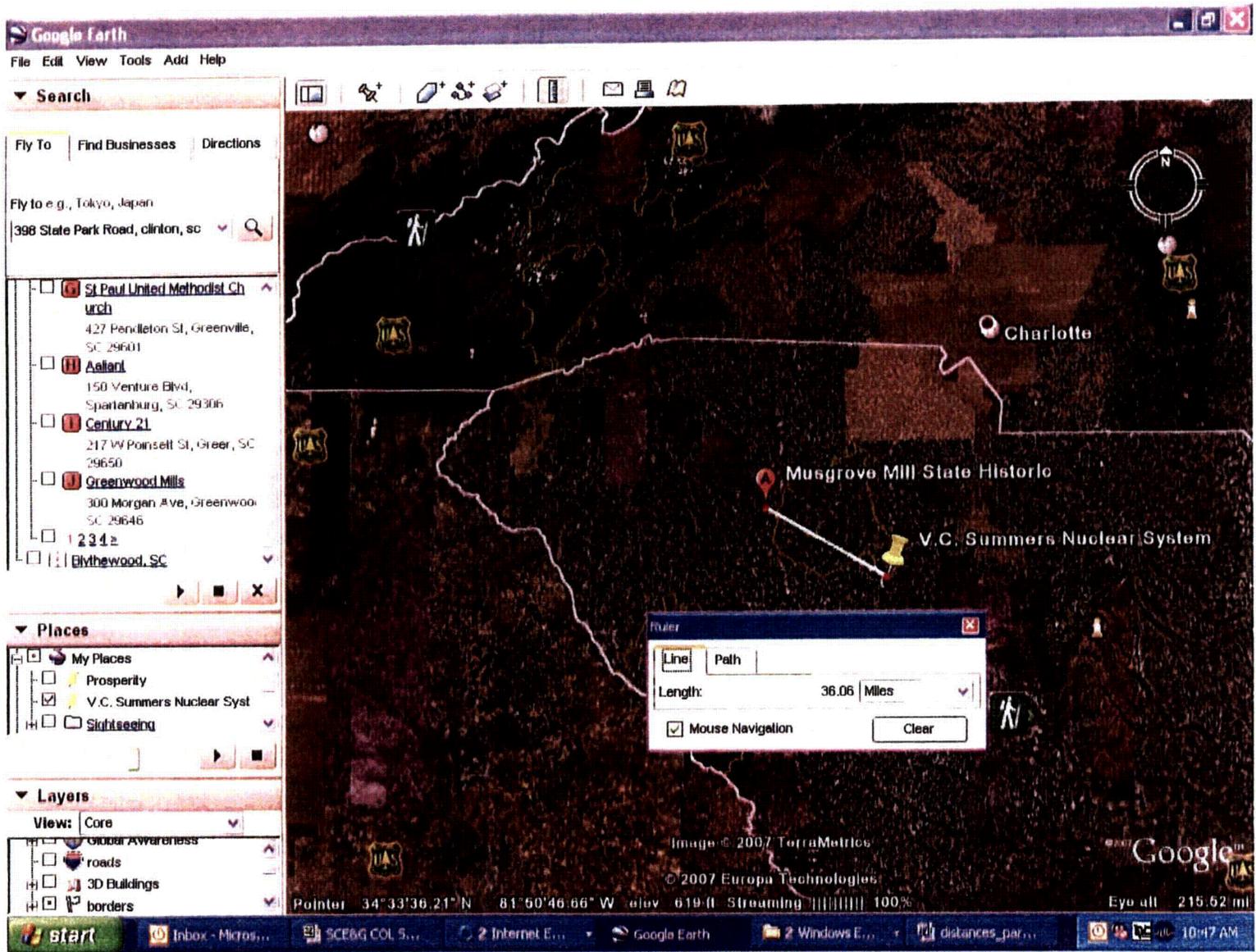
Eye alt 80.75 mi

start

Microsoft Office O... Internet Explorer Google Earth

Document1 - Microsol...

1:05 PM



Google Earth

File Edit View Tools Add Help

Search

Fly To Find Businesses Directions

Fly to e.g., Tokyo, Japan

2677 Sardis Rd, Union, SC

2677 Sardis Rd, Union, SC 29379

Places

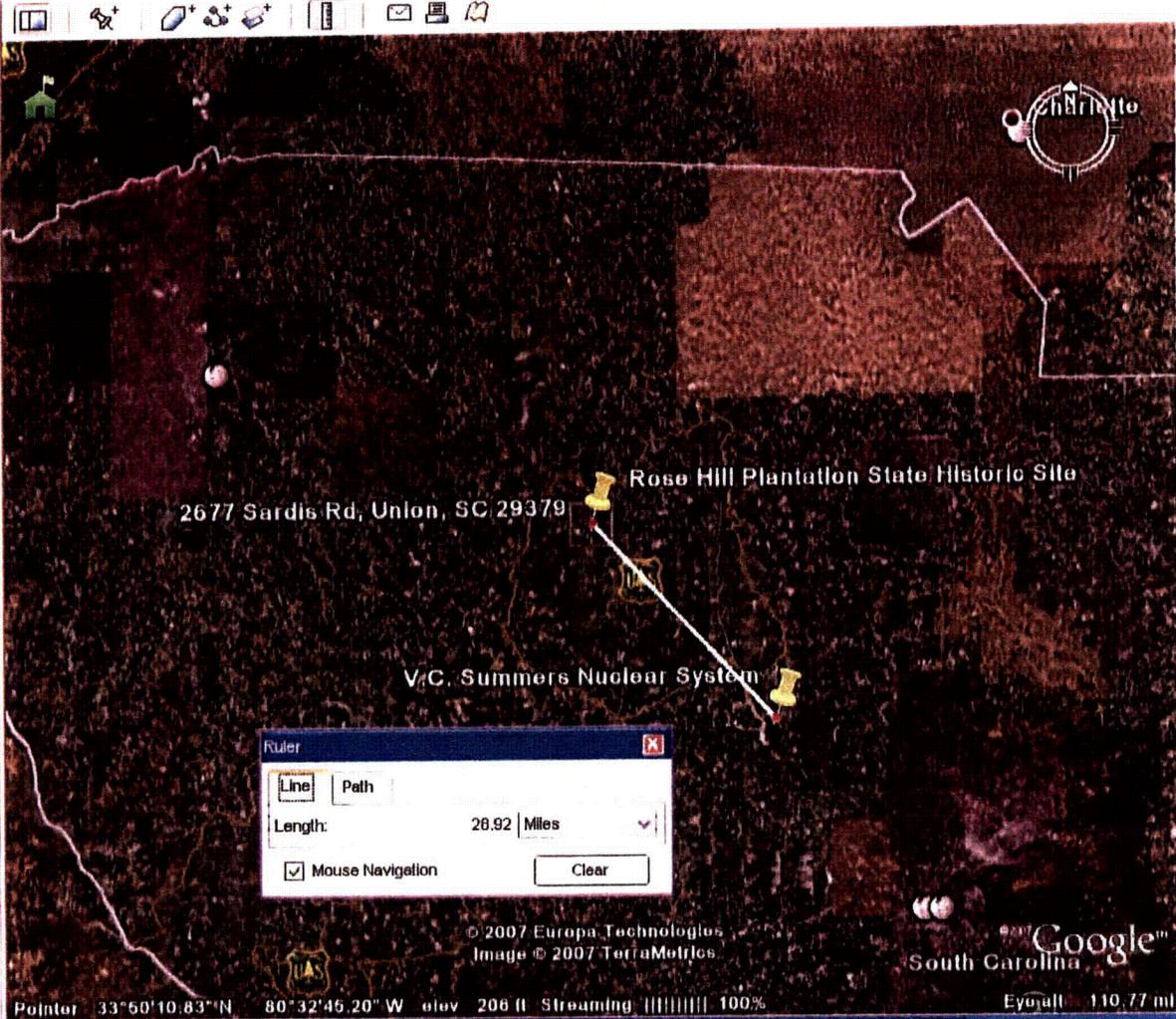
My Places

- Rose Hill Plantation State Histori
- Prosperity
- V.C. Summers Nuclear System
- Sight seeing
- Temporary Places

Layers

View: Core

- Global Awareness
- roads
- 3D Buildings
- borders
- Populated Places
- Alternative Place Names
- Dining



Ruler

Line Path

Length: 28.92 Miles

Mouse Navigation

Clear

Pointer 33°50'10.83"N 80°32'46.20" W elev 206 ft Streaming 100% Eyeball 110.77 mi

Google Earth

File Edit View Tools Add Help

Search

Fly To Find Businesses Directions

Fly to e.g., 37 25.818° N, 122 05.36° W

"Sesquicentennial state park, sc"

- Sesquicentennial State Park
 - Did you mean:
 - Sesquicentennial State Park
 - Sesquicentennial State Park
 - Sesquicentennial State Park, 9564 2 Notch Rd, Union, RI
 - Rose Hill Plantation State Park, 2677 Sardis Rd, Union, Union C.
 - Did you mean:
 - Did you mean:
 - Landsford Canal State Park
 - Lake Wateree State Park
 - Did you mean:
 - Lake Wateree State Park, SC, 101, Union, Fairfield County, S.
 - Did you mean:
 - Lake Wateree State Park
 - Did you mean:
 - Lake Greenwood State Park

Places

- My Places
 - V.C. Summers Nuclear Syst
 - Sightseeing

Layers

Pointer 34° 01' 09.08" N 80° 14' 07.15" W elev 167 ft Streaming 100% Eye alt 83.26 mi

V.C. Summers Nuclear System

Sesquicentennial State Park

Sesquicentennial State Park

Ruler

Line Path

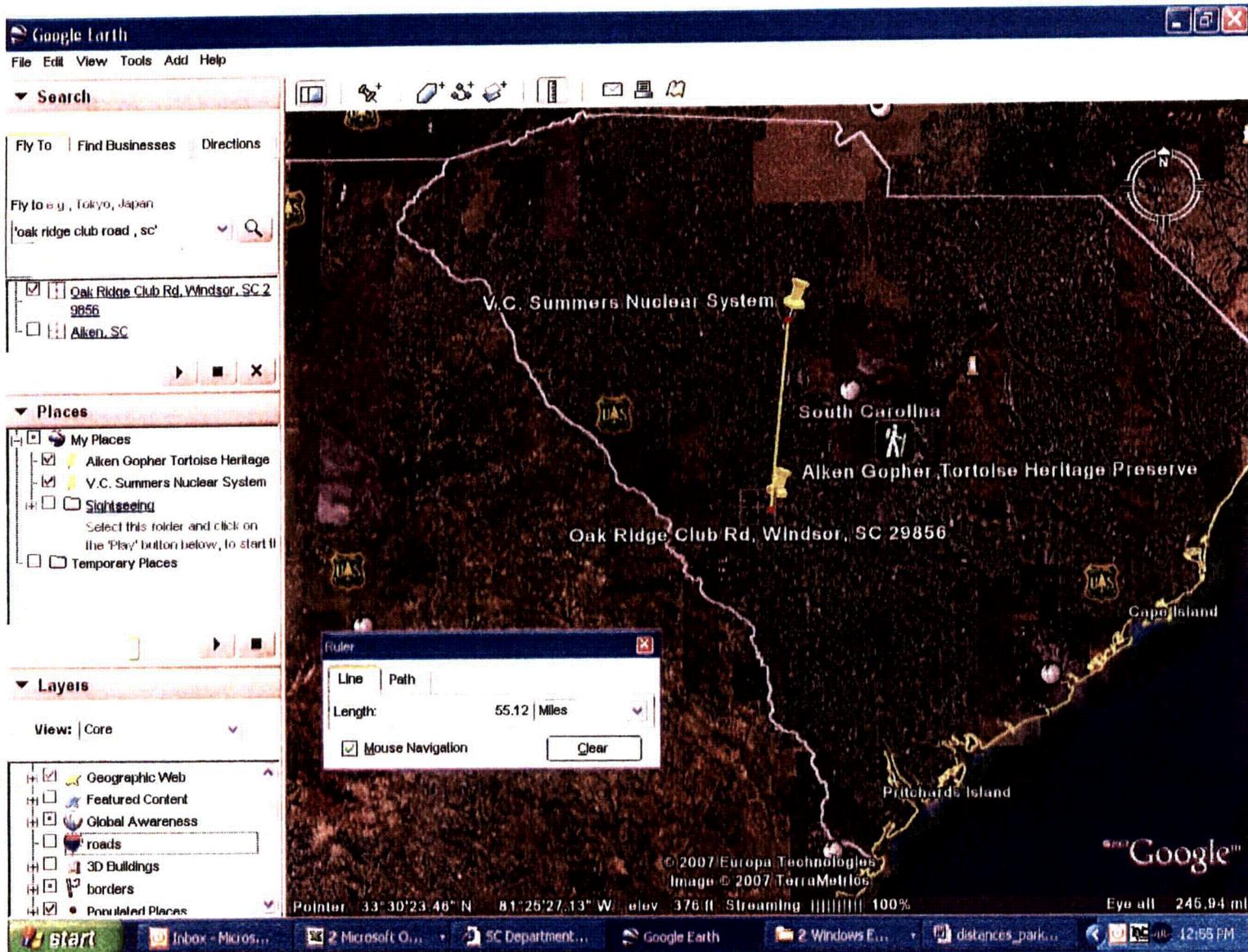
Length: 27.37 Miles

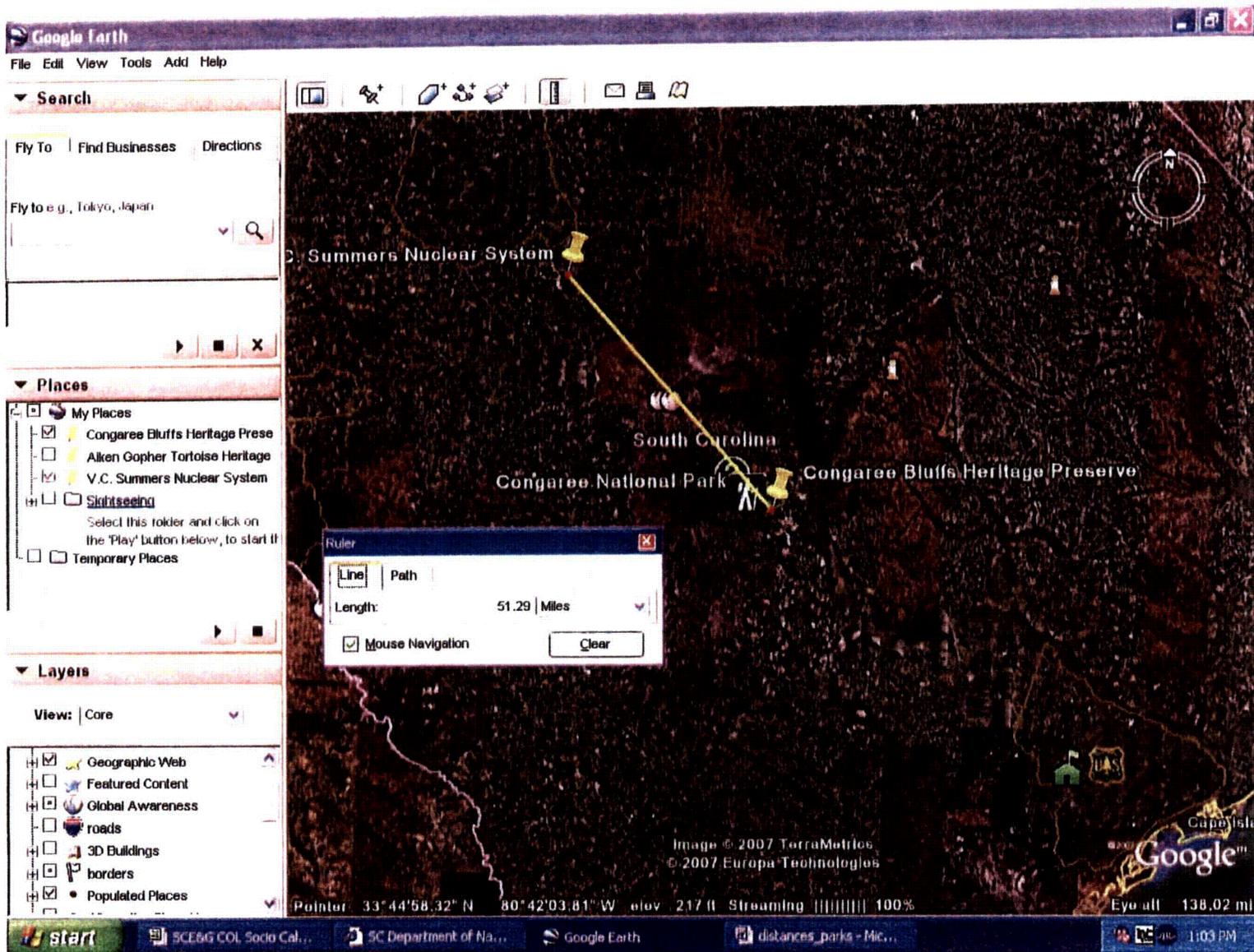
Mouse Navigation Clear

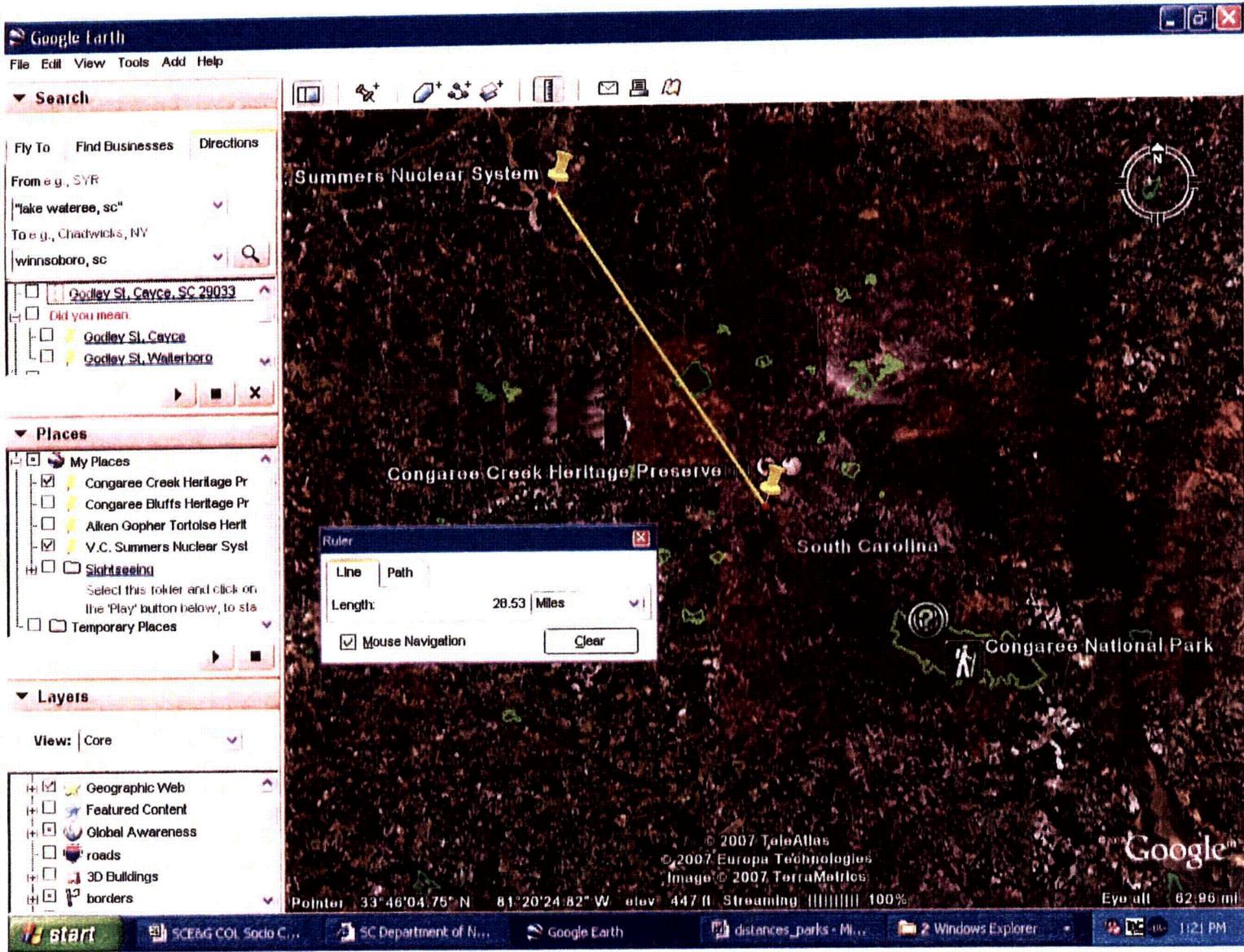
© 2007 Europa Technologies
Image © 2007 TerraMetrics

Google

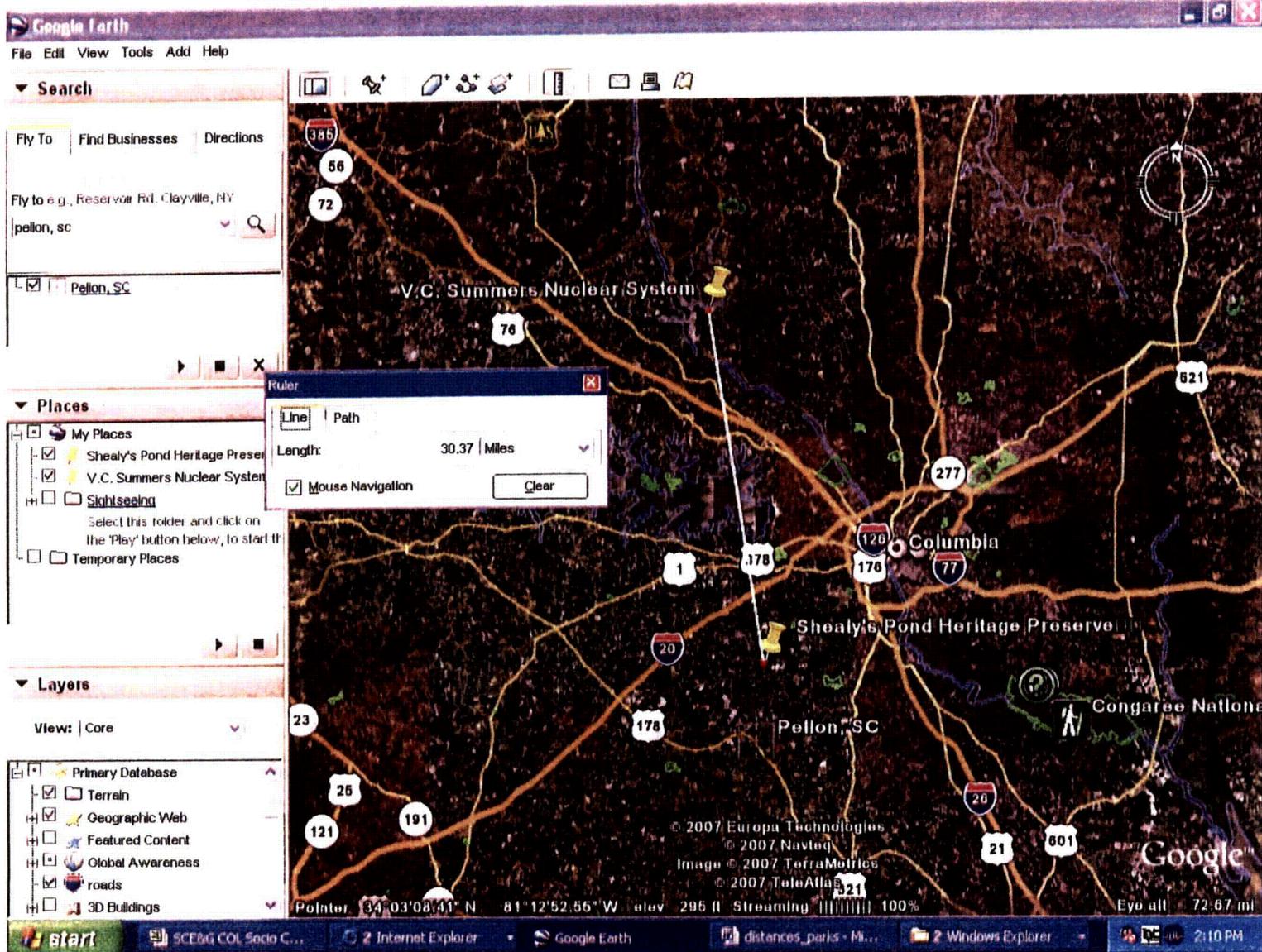
start Microsoft Office O... Internet Explorer Google Earth Document1 - Microsof... 1:06 PM











Google Earth

File Edit View Tools Add Help

Search

Fly To Find Businesses Directions

Fly to e.g., Reservoir Rd., Clayville, NY

reserve road, sc

- Reserve Rd., Cordesville, SC 29434
- Pelton, SC

Places

My Places

- Forty Acre Rock Heritage Preserve
- Shealy's Pond Heritage Preserve
- V.C. Summers Nuclear System
- Sightseeing
- Temporary Places

Layers

View: Core

- Primary Database
- Terrain
- Geographic Web
- Featured Content
- Global Awareness
- roads
- 3D Buildings

Shoaly's Pond Heritage Preserve

Forty Acre Rock Heritage Preserve

V.C. Summers Nuclear System

Cape Island

Pritchards Island

Image NASA
© 2007 Navteq
Image © 2007 TerraMetrics
© 2007 Europa Technologies

Point: 33°09'50.62" N 79°50'58.13" W elev 37 ft Streaming 100%

Eye alt 179.45 mi

Ruler

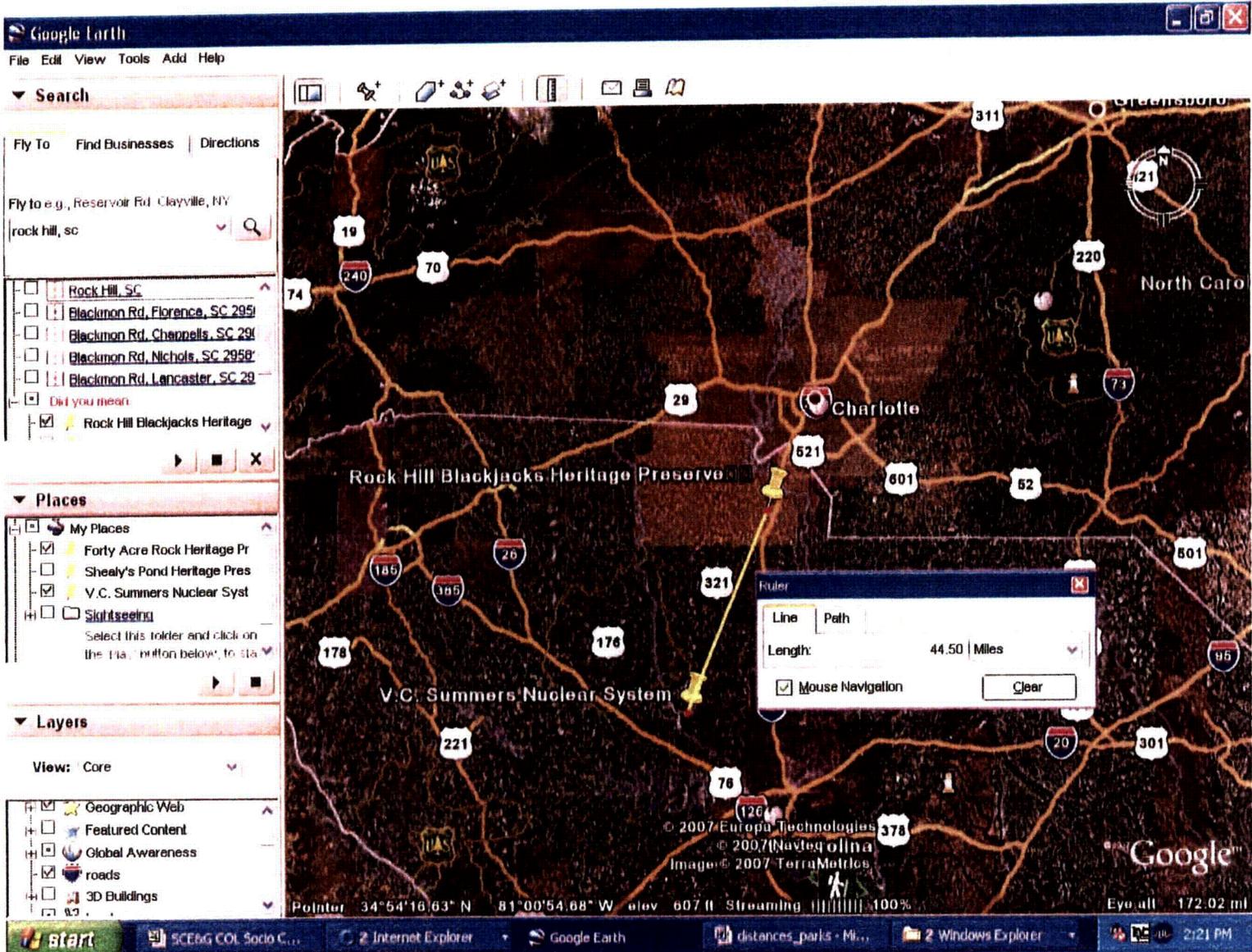
Line Path

Length: 93.28 Miles

Mouse Navigation

Clear

start SCE&G COL Socio C... 2 Internet Explorer Google Earth distances_parks - M... Windows Explorer 2:12 PM



Google Earth

File Edit View Tools Add Help

Search

Fly To Find Businesses Directions

Fly to e.g., Reservoir Rd, Clayville, NY

camden, sc

- Camden, SC
- Rock Hill, SC
- Blackmon Rd, Florence, SC 29501
- Blackmon Rd, Chappells, SC 2903
- Blackmon Rd, Nichols, SC 29581
- Blackmon Rd, Lancaster, SC 2972
- Did you mean:

Places

- My Places
 - Savage Bay Heritage Preserve
 - Forty Acre Rock Heritage Preserve
 - Shealy's Pond Heritage Preserve
 - V.C. Summers Nuclear System
 - Sightseeing
 - Temporary Places

Layers

45.05 Miles

Mouse Navigation

Clear

© 2007 Navteq
 Image © 2007 TerraMetrics
 © 2007 Europa Technologies

Google

Eye alt 231.14 m

Start SCEBG COL Socio C... 2 Internet Explorer Google Earth distances_parks - M... 2 Windows Explorer 2:26 PM



Google Earth

File Edit View Tools Add Help

Search

Fly To Find Businesses Directions

Fly to e.g., Reservoir Rd, Clayville, NY

lancaster, sc

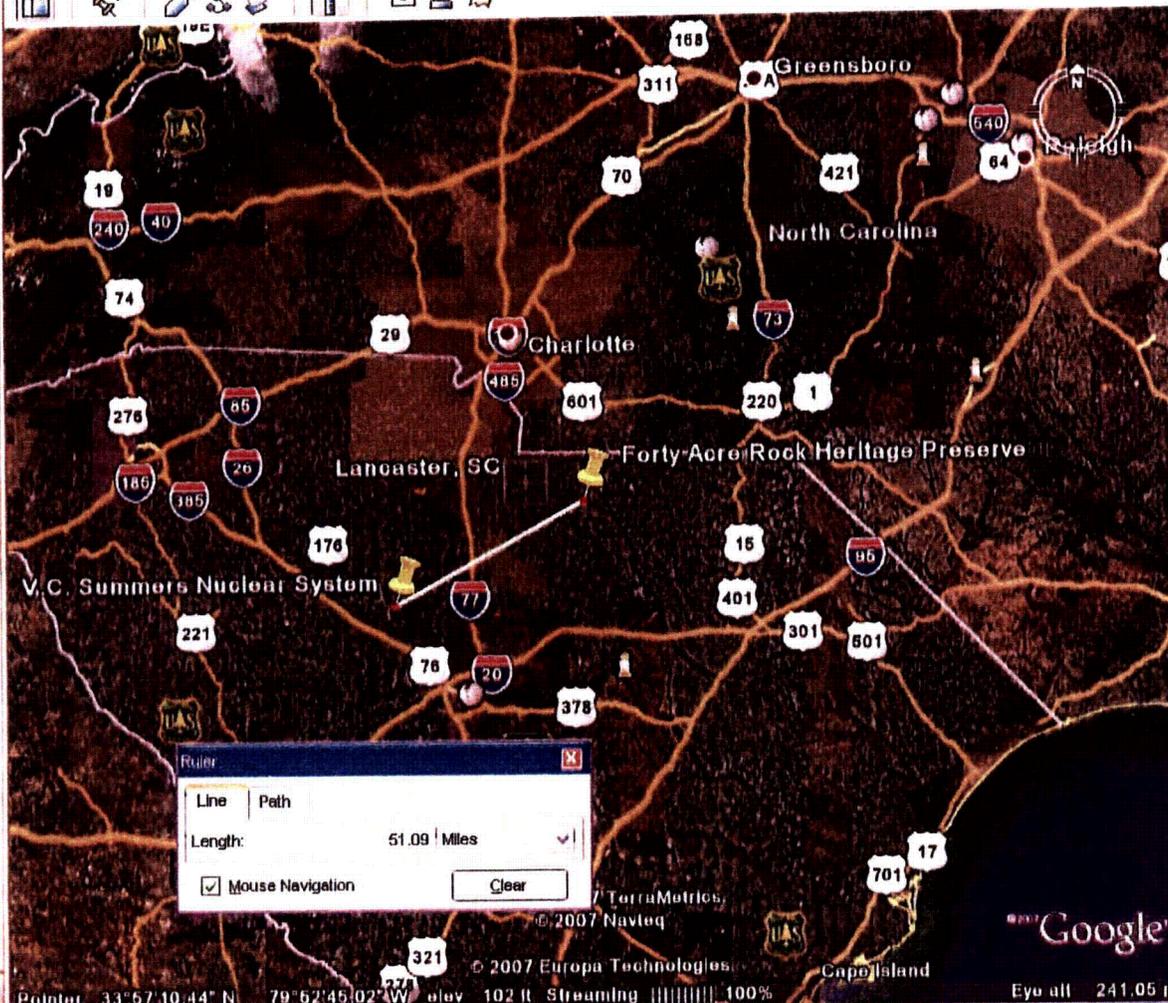
- Lancaster, SC
- Camden, SC
- Rock Hill, SC
- Blackmon Rd, Florence, SC 29501
- Blackmon Rd, Chappells, SC 2903
- Blackmon Rd, Nichols, SC 29501
- Blackmon Rd, Lancaster, SC 2972
- Did you mean:

Places

My Places

- Forty Acre Rock Heritage Prese
- Savage Bay Heritage Preserve
- Forty Acre Rock Heritage Preserve
- Shealy's Pond Heritage Preserv
- V.C. Summers Nuclear System
- Sightseeing
- Select this folder and click on the 'Play' button below, to start it
- Temporary Places

Layers



Search

Fly To Find Businesses Directions

Fly to e.g., 1600 Pennsylvania Ave, 20006
see swamp national monument, sc

- Congaree Swamp National Monum

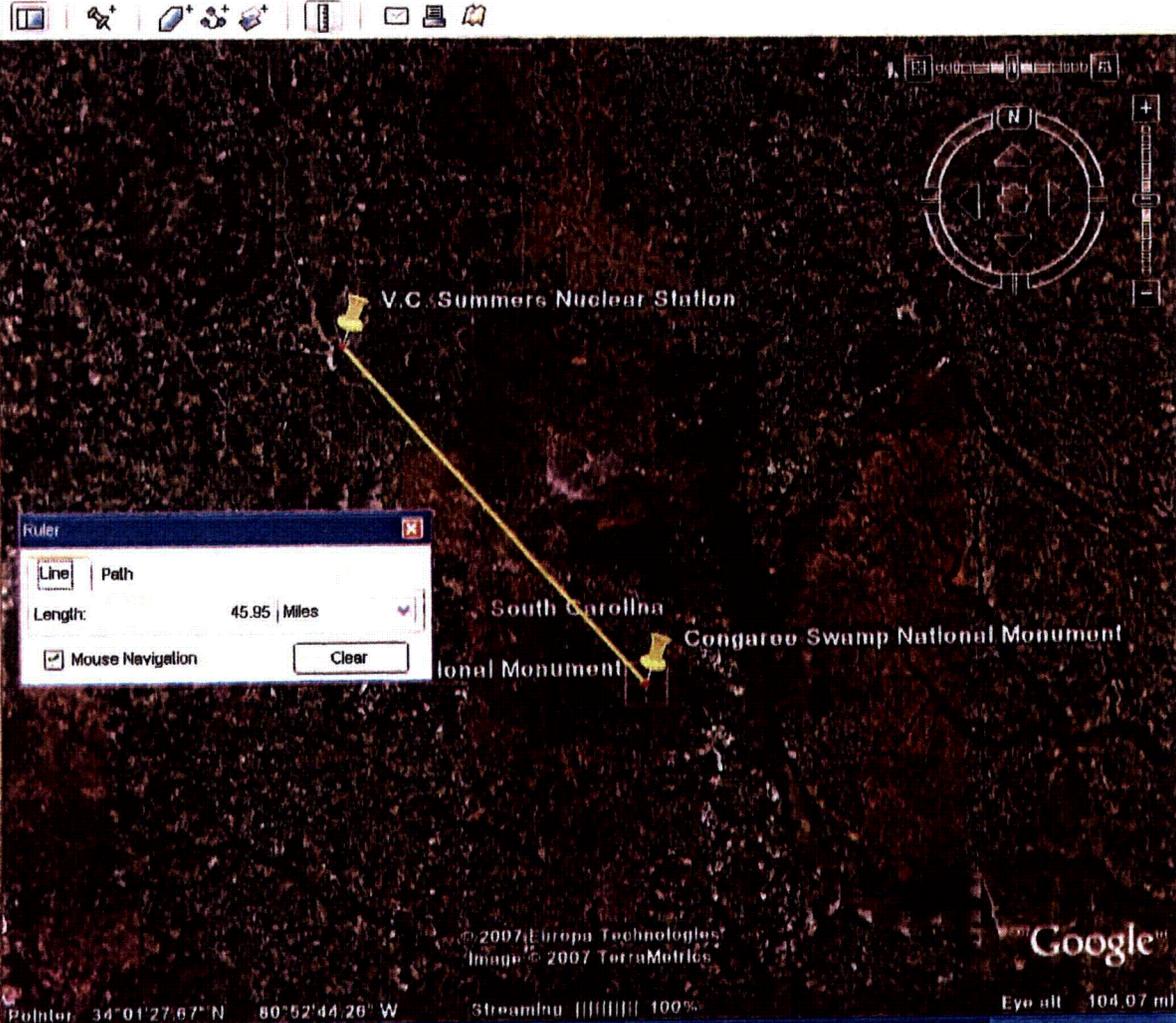
Places

- My Places
 - Congaree Swamp National Mon
 - V.C. Summers Nuclear Station
 - South Carolina
 - Temporary Places

Layers

View: Core

- Primary Database
 - Terrain
 - Geographic Web
 - Featured Content
 - Global Awareness
 - roads
 - 3D Buildings

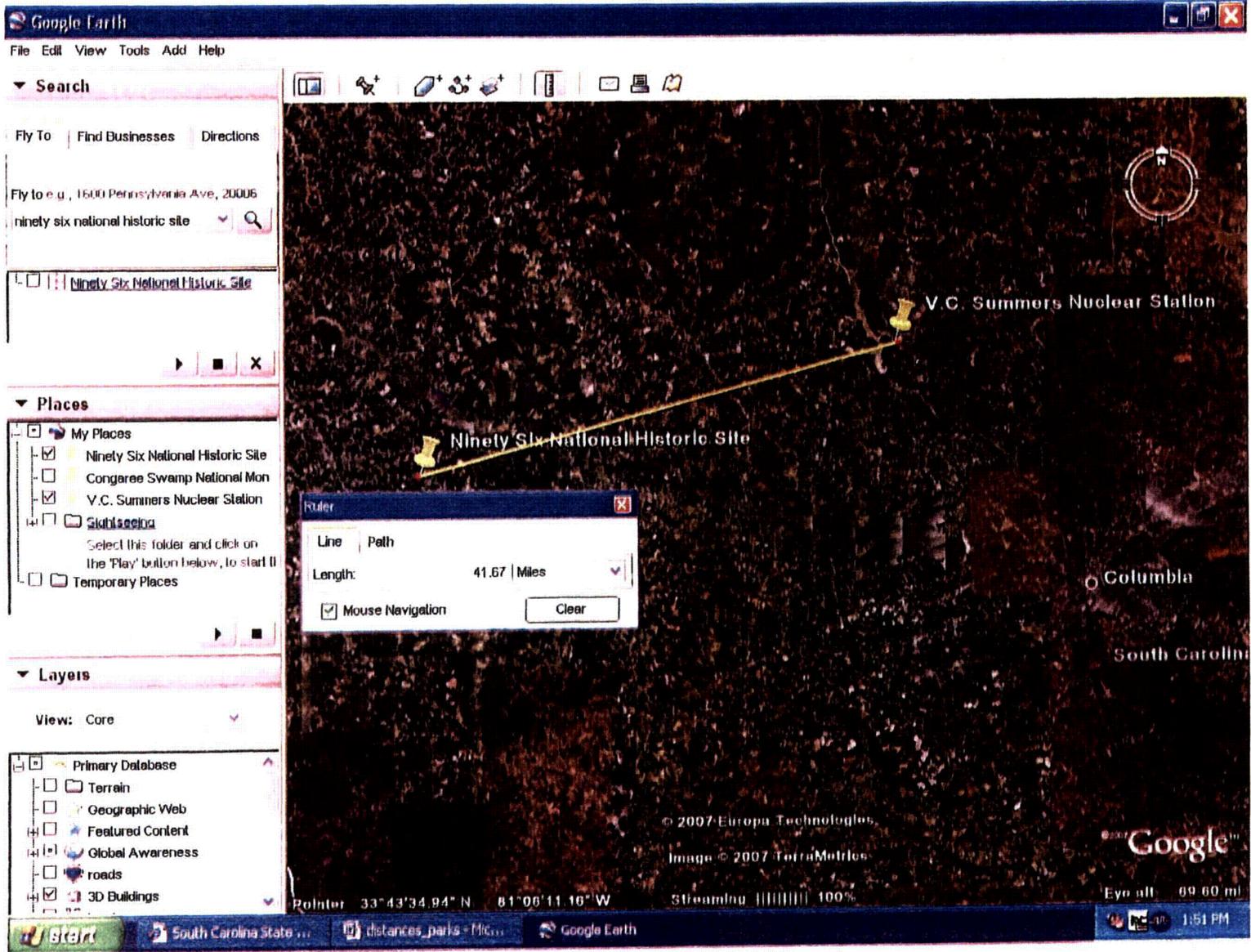


Ruler

Line Path

Length: 45.95 Miles

Mouse Navigation Clear



Search

Fly To Find Businesses Directions
Fly to e.g., 1600 Pennsylvania Ave, 20006
Sumter National Forest

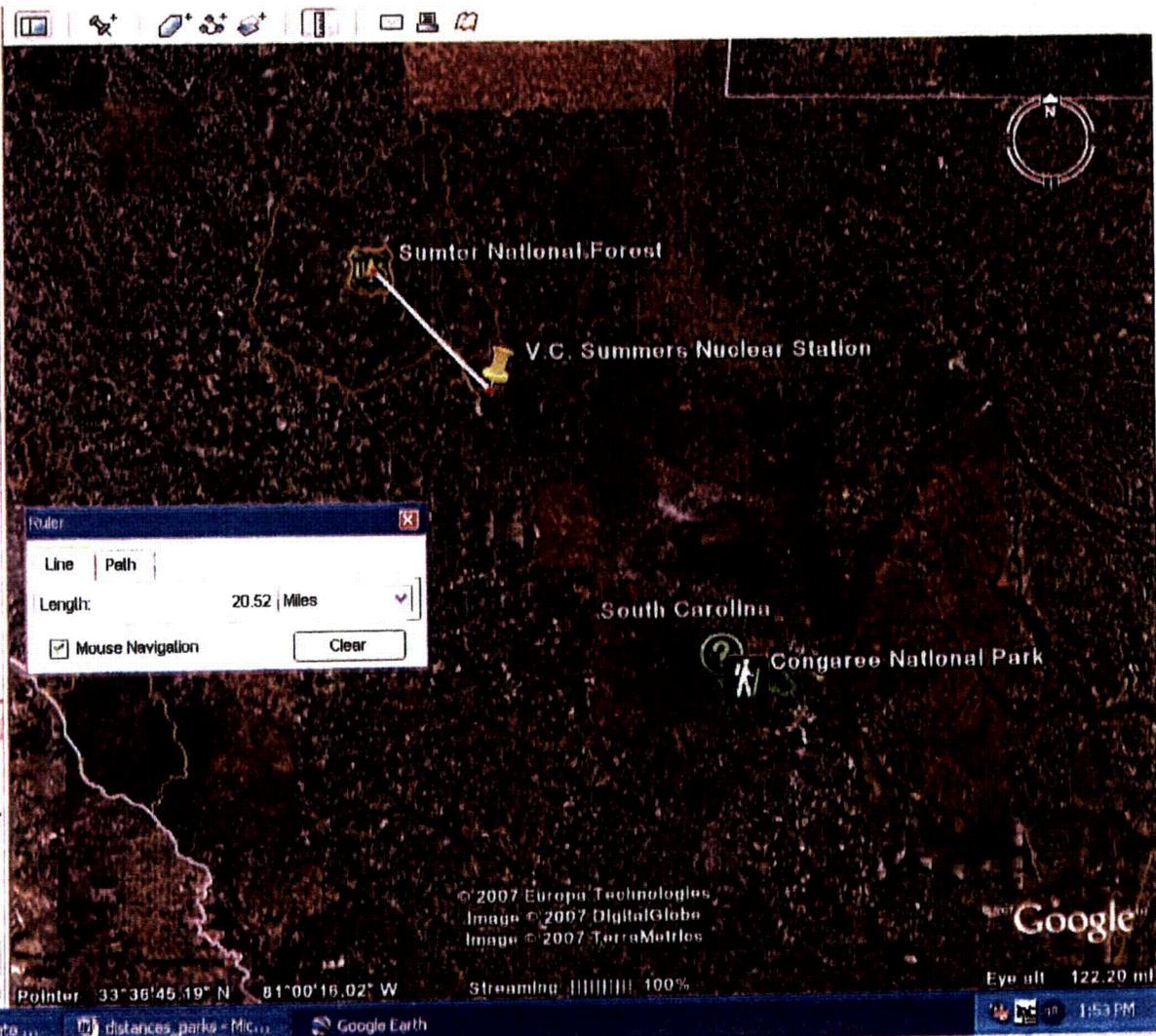
Francis Marion Sumter National Forest, 4931 Dried River Rd, Union, Richland County, SC

Places

- My Places
 - Sumter National Forest
 - Ninety Six National Historic
 - Congaree Swamp National
 - V.C. Summers Nuclear Station
 - South Carolina
 - Congaree National Park
- Temporary Places

Layers

- View: Core
- Transportation
 - Geographic Features
 - Travel and Tourism
 - Parks and Recreation Areas
 - Community Services
 - US Government
 - DigitalGlobe Coverage



Search

Fly To Find Businesses Directions

Fly to e.g., 1600 Pennsylvania Ave, 20006

fl state natural area, spartanburg

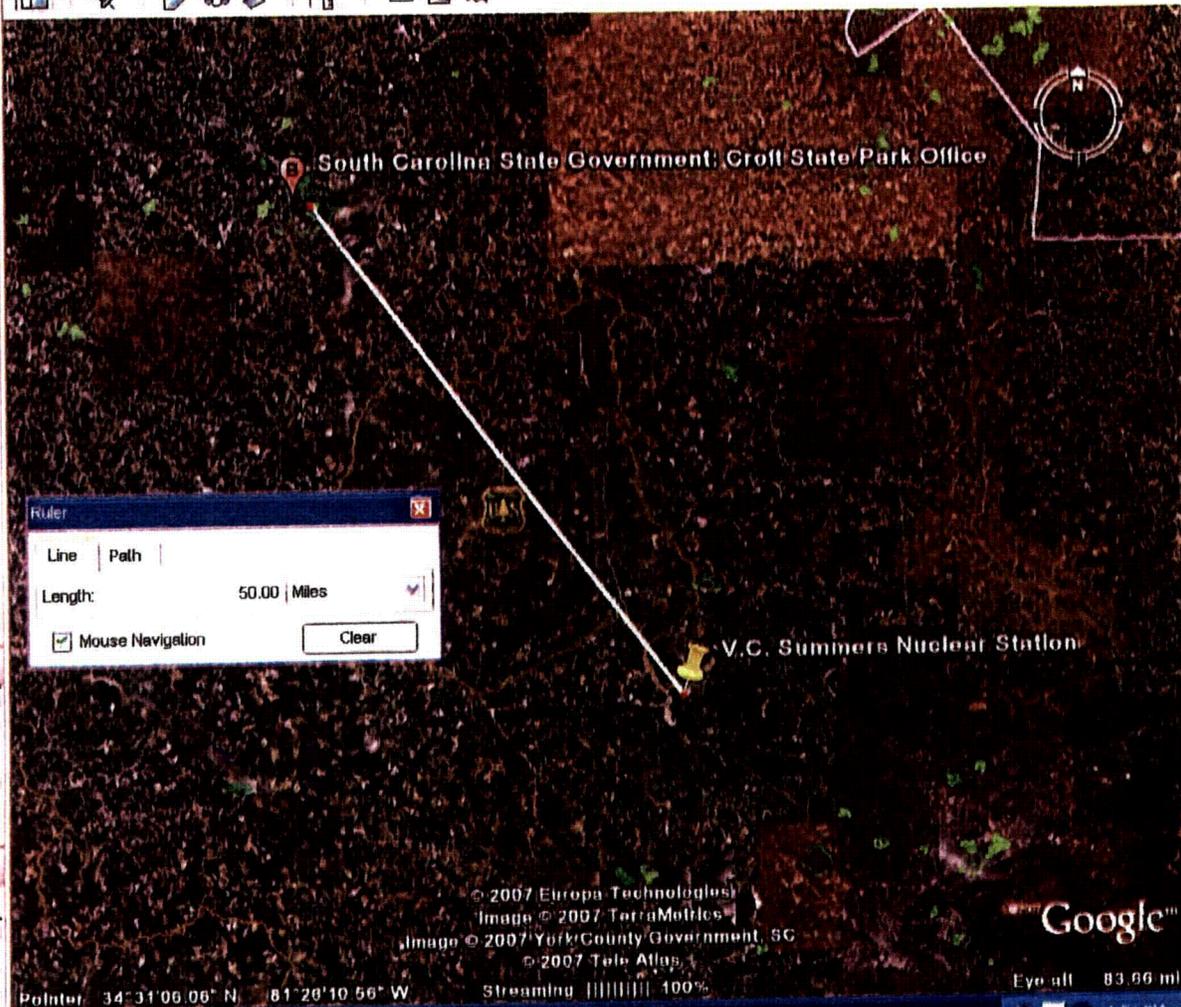
- 430 Croft Rd, Spartanburg, SC 29302
- South Carolina State Government: Croft State Park Office**
430 Croft Rd, State Park Rd, Spartanburg, SC 29302
- Wal-Mart Supercenter**
2151 E Main St, Spartanburg, SC 29307
- Pollock & Associates**
215 Magnolia St, Spartanburg, SC 29306
- Wofford College**
429 N Church St, Spartanburg, SC 29303

Places

- My Places
- Sumter National Forest
- Ninety Six National Historic
- Congaree Swamp National

Layers

- View: Core
- Transportation
 - Geographic Features
 - Travel and Tourism



Ruler

Line Path

Length: 50.00 Miles

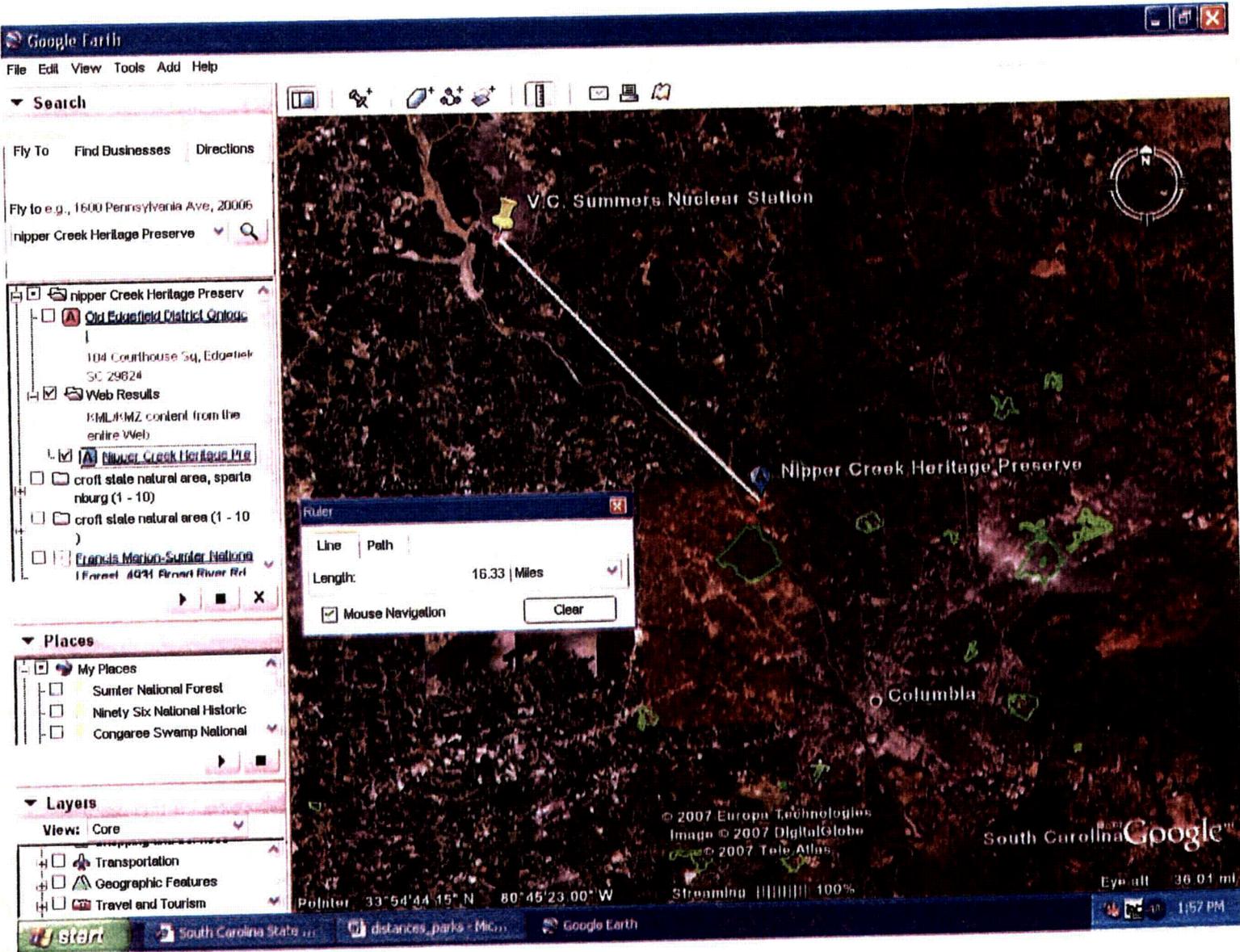
Mouse Navigation Clear

© 2007 Europa Technologies
 Image © 2007 TerraMetrics
 Image © 2007 York County Government, SC
 © 2007 Tele Atlas
 Streaming 100%

Google

Eye alt 83.66 mi

1:56 PM



Economics of entry – Candidate technologies

1. Gas-fired combustion turbine combined cycle
 - Current technology of choice
 - ~\$500/kW, 250-400 MW units
 - ~6,800 heatrate, 1-2 year build time
 - Lots of recent experience building
2. Advanced coal on threshold of viability
 - ~\$1,100/kW, 250-500 MW units
 - ~9,000 heatrate, 3-5 year build time
 - Not much recent experience w. building
3. Fuel cells – look like small efficient CC's
4. Advanced solar, desktop cold fusion, other miracles

Gas CC's and advanced coal are entry candidates

- Relative economics depend on assumptions about capital cost, carbon taxes, gas price escalation
- CCs lowest cost at first, but compound real escalation of gas prices dominates long-run making coal possibly cheaper
- Expect market to install what's cheapest when time comes
- Lowest cost option puts upper bound on market price
- New entrants assumed to have capacity factors of 70%, prices lower than entry threshold remaining 30% of time
- Dynamics of boom-bust will increase price volatility but not greatly affect average price levels over time

Sensitivity analysis focused on five long-term price drivers

Price Driver	Low	Base Case	High
General inflation	1.5%	3%	5%
Technology cost (\$/kW)	\$450 CC \$1,000 coal	\$500 CC \$1,100 coal	\$1,300 coal
Rate of tech advance	0.1%/yr	0.5%/yr	1.0%/yr
Gas price escalation	0%	1.1%/yr	2%/yr
Carbon tax equivalent	\$0	\$25/tonne C.	\$50/tonne C.

A sixth key uncertainty is the long term fuel-technology outlook... Will gas or coal technologies dominate new generation?

- If gas dominates the key driver will be the price of gas itself
- Carbon policy becomes less important in a gas-dominated world
- If coal dominates carbon policy will be a critical driver
- Also regional price differences in coal may tend to be stickier (see below)

Inflation assumptions

- Market prices for valuation and finance are typically nominal, not real
 - Inflation influences ongoing cash flows once an investment has been made
- Inflation affects entry price thresholds
- Inflation averages:
 - 1950-2000 → 4%/yr
 - 1990-2000 → 2.4%/yr
- Base case assumed to be 3%/yr
- Sensitivity cases are 1.5% for low, 5% for high

Capital cost assumptions

- Gas CC capital costs are uncertain within narrow range
 - Cost of manufacturing vs. price sold
 - Prices higher in boom cycle, lower in bust cycle
- Recent prices approximately \$500/kW, may be as low as \$450/kW in normal market
- Coal cost of highly environmentally controlled pulverized coal boiler was in \$1,500/kW range in past
- Technical advances in manufacturing and low demand brought prices to \$1,100/kW range
 - May go as low as \$1,000, or to \$1,300 for advanced units

Technical advance assumptions

- Technical advance rates work to lower capital cost and heat rates for new units
- Technical advances have been a key factor in past, but specifics for long-term are speculative
- 2050 is a long way off...
- Analysis used broad range of assumptions
 - 0.1% (we're close to as good as we'll ever get)
 - 0.5% (base case – meets aggressive objectives)
 - 1.0% (a lot can happen in 50 years)

Technical advance assumptions & implications

	Gas CC		Advance Coal	
	Capital Cost	Heatrate	Capital Cost	Heatrate
2002	\$500	7,000	\$1,100	9,000
2050 @				
0.1%/yr	\$477	6,672	\$1,048	8,578
0.5%/yr	\$393	5,503	\$865	7,075
1.0%/yr	\$309	4,321	\$679	5,556

Some changes sufficiently dramatic over time to represent fundamental changes in the technology, e.g., fuel cells

Escalation in fuel prices

- Coal prices declining with increased mining productivity and shrinking demand, assume 1%/yr decline in coal prices (to \$0.7 in 2050)
- Gas prices volatile but mild upward trend, assume real escalation of:
 - 2%/yr (as used by climate policy analysts)
 - 1.1%/yr (assumption of EIA Energy Outlook to 2020)
 - 0.0%/yr (technical progress keeps defeating resource depletion effects through drilling technology, new resource discoveries, and LNG in a world awash with natural gas)

Implications of gas price assumptions

Real price outlook

	Gas Price
2002	\$3.0
2050 @	
0.0%/yr	\$3.0
1.1%/yr	\$5.1
2%/yr	\$7.8

Carbon tax assumptions

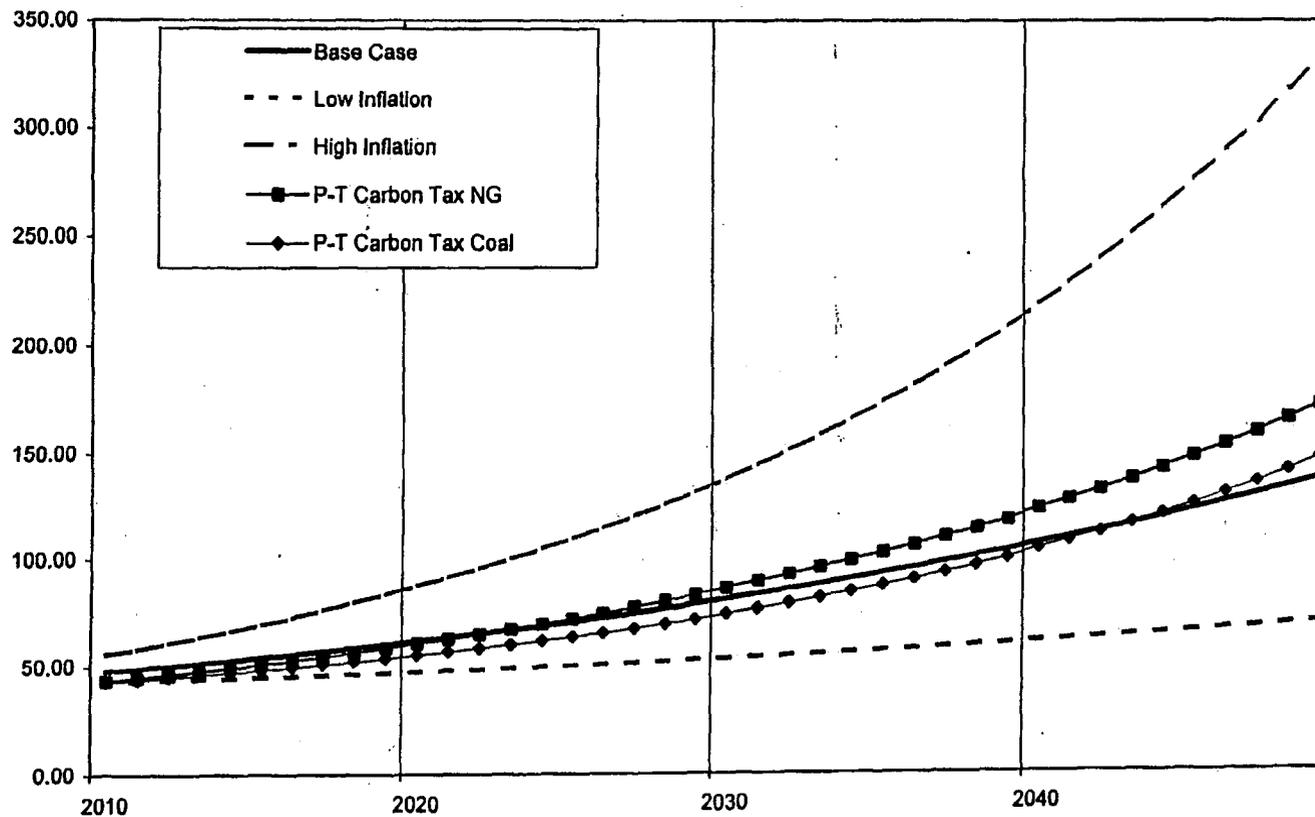
- Climate change a worldwide concern
- Difficult to imagine U.S. will not participate eventually
- Many forms of policy (cap & trade, taxes, offset) result in a shadow price on emissions affecting generating costs and thus market prices
- We use a tax as a proxy for as yet undefined policy
- Tax assumptions based on large proprietary study with joint participation of industry and environment groups
- \$25/tonne C. in 2010 (+2%/yr esc.) approaches 650ppm in 2100 atmospheric concentration target (base case)
- Need \$50/tonne to hit 550ppm target (high case)
- May never happen (\$0/tonne is low case)

Carbon tax assumptions: An alternative approach

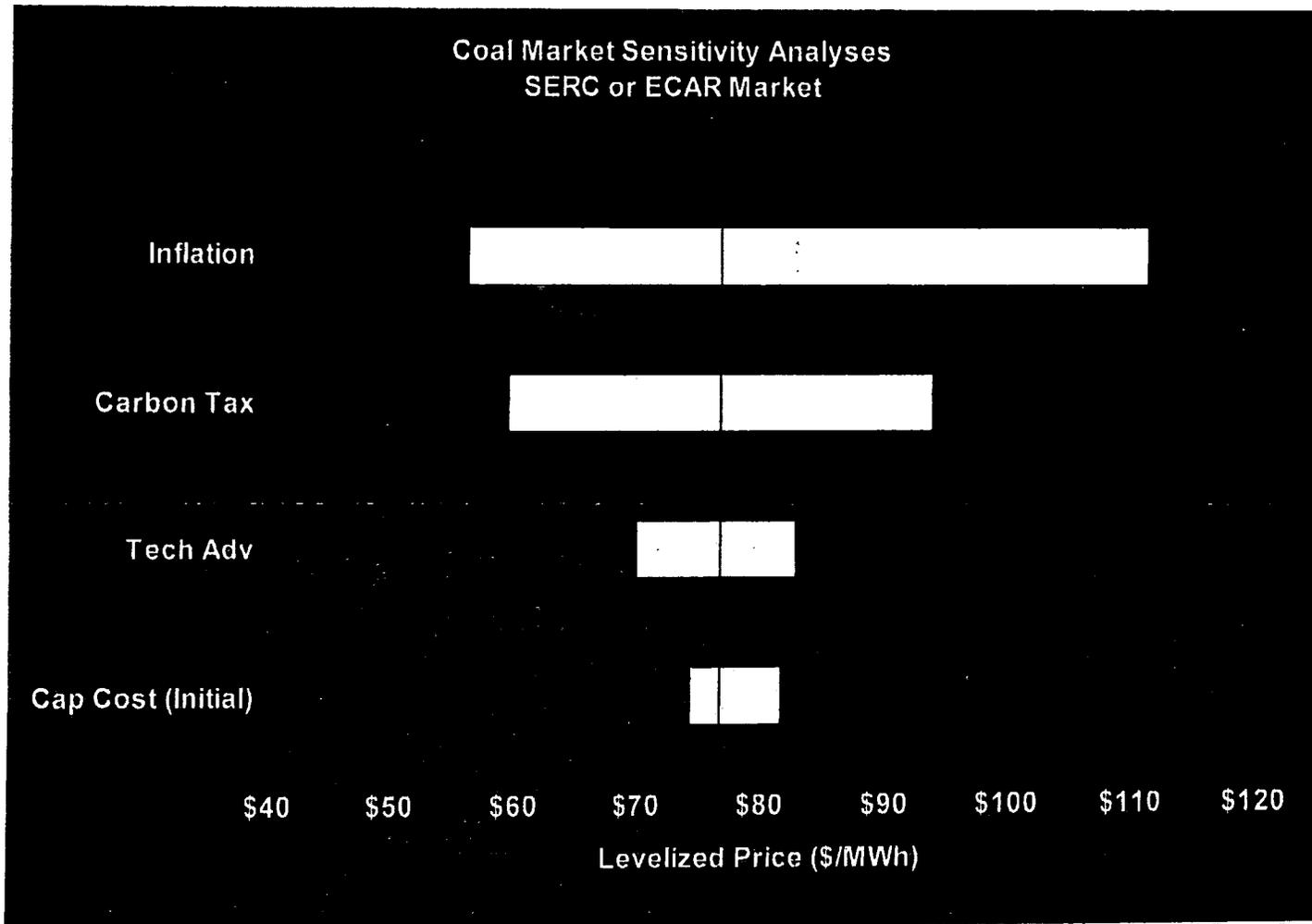
- An interesting idea is offered by Stephen Peck (former EPRI VP) and Thomas Teisberg (University of Virginia)
- “A Long Term Permit Program for Long Term Climate Change Mitigation”, Peck and Teisberg
 - Start the tax small (~\$6.50/ton) and escalate more steeply (to over \$200/ton {2010 dollars} in 2070)
 - Escalation rises at the real interest rate (5%) plus the rate of natural carbon depletion from the atmosphere (1%) - 6% real
 - Effect is to make an emitter indifferent over time as to when reduction occurs...
- The levelized price falls reasonably within the range of assumptions made above

The Peck-Teisberg carbon tax is consistent with other approaches...

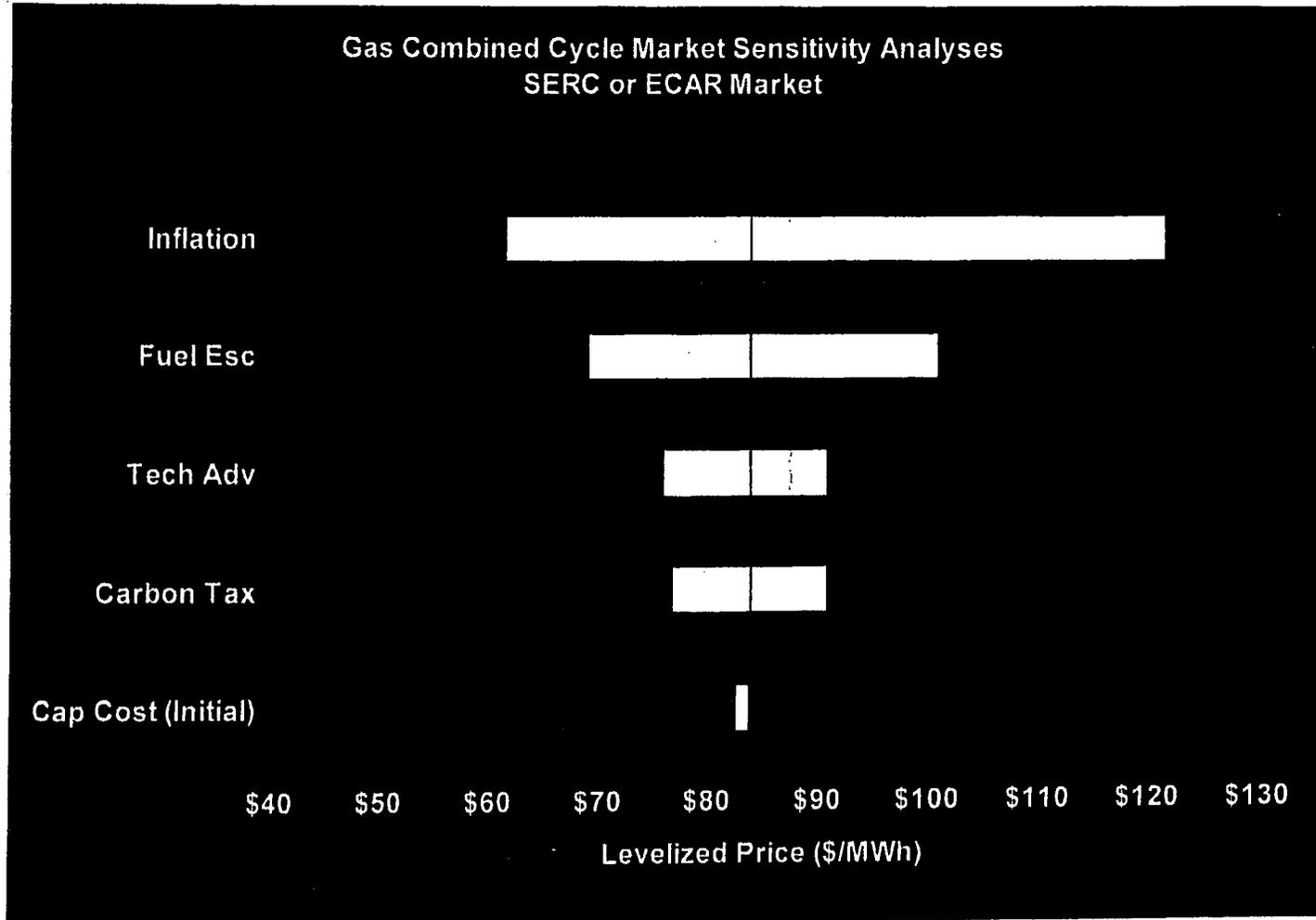
Annual Price Projections by Selected Scenarios:
Positioning the Peck-Teisberg Carbon Tax



Tornado diagrams show relative importance of key price drivers for advanced coal unit



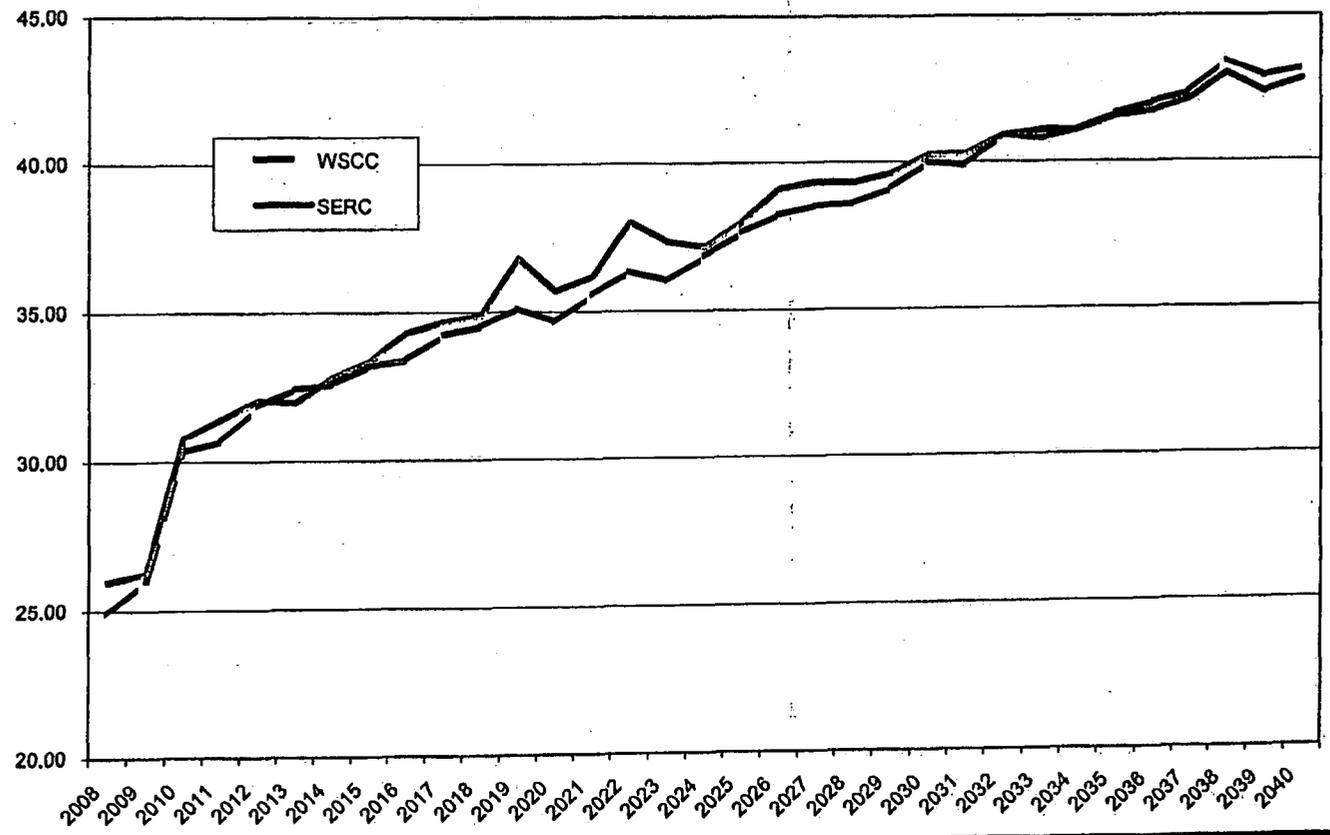
Tornado diagrams show relative importance of key price drivers for gas CC



Regional findings

By 2050, there is little basis to expect permanent, material differences in prices between the three regions

Annual Price Comparisons (Real \$) WSCC and SERC



Regional findings II

- Key drivers are mostly region-neutral
 - inflation
 - gas price escalation
 - capital costs of new units
 - rate of technical advance
 - climate policy
- Possible exceptions - risk factors
 - coal price differentials - expected slightly lower in the West
 - due to PRB coal influence
 - technology capital costs - expected slightly higher in the West
 - allow for permanent stickiness due to land, water, labor tightness
 - transmission constraints in the West
 - plant in Idaho, load in California...
- Disequilibrium factors
 - may cause short term constraints of various kinds, but are unlikely to persist fifty years regardless of origin...
 - they can play a role in early years of the plant life cycle...

Regional Findings III

Coal Price Differentials

- In the medium term, if gas prices escalate, and carbon tax stays low, advanced coal technology could begin to dominate new generation
- Western coal is generally cheaper than Eastern coal (Powder River influence), so this differential could be important
- WSCC electric prices could then begin to fall relative to the Eastern regions
 - There is potentially close to a 20% gap by 2010, as much as 12% by 2025, shrinking thereafter as demand pressures close the coal price gap
- In this scenario WSCC looks less attractive, at least for a time...

Regional Findings IV

Technology Costs and Constraints

- It may be more expensive to build capacity in the West
 - historical pressures on land use, labor scarcity, water use, etc...
 - this could tend to drive prices up
 - for a transitional period, or...
 - perhaps permanently
- At the same time, there is today a more serious transmission problem in the West than in ECAR or SERC
 - plant site in Idaho, key load in California
 - in the East, the sites are much better connected
 - if construction pressures remain for plants, they'll be even worse for T-lines
- In the medium term the transmission constraints may dominate
- Its hard to imagine, on the other hand, a permanent gap...

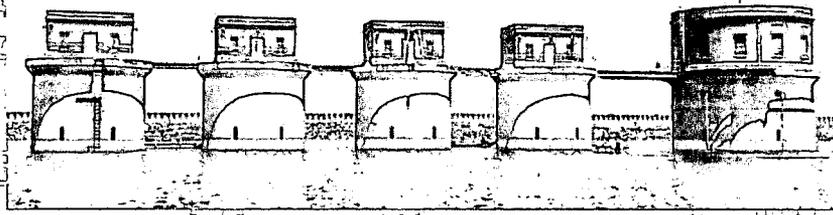
Disequilibrium conditions

- Overall, it is unlikely that permanent disequilibrium conditions can be sustained in any region over fifty years...
- There is some potential for “boom-bust” cycles in capacity addition in any of the regions, over the next fifty years
 - This will result in some short term oscillation of the electricity price around the long term trend, but on average the trend should prevail
 - In the long term needed capacity will get into the regions, although not necessarily smoothly year-by-year
- Still today’s constraint environment will persist for a time
 - transmission “stickiness” in the West...
 - coal prices in the West...
- Best guess:
 - Disequilibrium will play a role early in plant life cycle (through 2020-25)
 - After that regional differences will begin to smooth out

Detailed results

	Base Case		Inflation				Price of Fuel		Technical Advance				Carbon Tax			
	2002	2002	Gas	Gas	Coal	Coal	Gas	Gas	Gas	Gas	Coal	Coal	Gas	Gas	Coal	Coal
	2002	2002	2002	2002	2002	2002	2002	2002	2002	2002	2002	2002	2002	2002	2002	2002
Capital Cost (\$/kW)	500	1,100	500	500	1,100	1,100	500	500	500	500	1,100	1,100	500	500	1,100	1,100
O&M Cost (\$/MWh)	4.00	8.00	4.00	4.00	8.00	8.00	4.00	4.00	4.00	4.00	8.00	8.00	4.00	4.00	8.00	8.00
Heat Rate (btu/kWh)	7,000	9,000	7,000	7,000	9,000	9,000	7,000	7,000	7,000	7,000	9,000	9,000	7,000	7,000	9,000	9,000
Availability (percent)	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%
Gas Price (\$/mmbtu)	3.00	1.20	3.00	3.00	1.20	1.20	3.00	3.00	3.00	3.00	1.20	1.20	3.00	3.00	1.20	1.20
Rate of Tech. Advances	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.5%	0.1%	1.0%	0.1%	1.0%	0.5%	0.5%	0.5%	0.5%
General Inflation Rate	3.0%	3.0%	1.5%	5.0%	1.5%	5.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
Fuel Price Escalation (real)	1.1%	-1.0%	1.1%	1.1%	-1.0%	-1.0%	0.0%	2.0%	1.1%	1.1%	-1.0%	-1.0%	1.1%	1.1%	-1.0%	-1.0%
carbon content	NG	Coal	NG	NG	Coal	Coal	NG	NG	NG	NG	Coal	Coal	no tax	NG	no tax	Coal
2010	\$45	\$48	\$40	\$53	\$42	\$55	\$43	\$48	\$45	\$46	\$48	\$48	\$42	\$48	\$40	\$55
2020	\$63	\$62	\$49	\$89	\$47	\$87	\$56	\$70	\$65	\$60	\$64	\$59	\$58	\$68	\$50	\$73
2030	\$88	\$80	\$58	\$150	\$53	\$137	\$72	\$104	\$95	\$80	\$86	\$73	\$81	\$95	\$62	\$98
2040	\$123	\$105	\$71	\$253	\$60	\$218	\$95	\$156	\$137	\$106	\$118	\$91	\$111	\$134	\$78	\$133
2050	\$171	\$139	\$85	\$428	\$69	\$349	\$124	\$232	\$200	\$141	\$163	\$115	\$154	\$189	\$97	\$181
Price Growth Rate	3.4%	2.7%	1.9%	5.4%	1.2%	4.7%	2.7%	4.0%	3.8%	2.9%	3.1%	2.2%	3.3%	3.5%	2.2%	3.0%
Levelized Price	\$83.74	\$76.64	\$61.43	\$121.36	\$56.12	\$111.20	\$68.85	\$100.87	\$90.87	\$75.86	\$82.81	\$69.78	\$76.60	\$90.88	\$59.49	\$93.78

Sec 9.3 Ref 8



INITIAL CONSULTATION DOCUMENT



Lake
Murray

Saluda Hydroelectric Project
Relicensing

FERC No. 516



SCE&G
A SCANA COMPANY

Kleinschmidt
Energy & Water Resources Consultants

**SOUTH CAROLINA ELECTRIC &
GAS COMPANY**
COLUMBIA, SOUTH CAROLINA

SALUDA HYDRO
FERC PROJECT NO.516

SALUDA HYDRO
INITIAL CONSULTATION DOCUMENT

APRIL 2005

Prepared by:

Kleinschmidt
Energy & Water Resource Consultants

SOUTH CAROLINA ELECTRIC & GAS COMPANY
COLUMBIA, SOUTH CAROLINA

SALUDA HYDRO
FERC PROJECT NO. 516

SALUDA HYDRO ICD

APRIL 2005

Kleinschmidt
Energy & Water Resource Consultants

**SOUTH CAROLINA ELECTRIC & GAS COMPANY
COLUMBIA, SOUTH CAROLINA**

**SALUDA HYDRO
FERC PROJECT NO. 516**

SALUDA HYDRO ICD

INTRODUCTION

South Carolina Electric & Gas Company (SCE&G) is initiating the process of *relicensing* (see glossary for definitions of italicized terms) the Saluda Hydro Project (Project) (Federal Energy Regulatory Commission [FERC] Project No. 516). The current operating *license* expires on August 31, 2010. This Initial Consultation Document (ICD) provides information relative to all project resources to interested state and federal *resource agencies*, non-governmental organizations and interests (NGOs), and the general, unaffiliated public for review and comment. This comment period officially begins the Stage 1 Consultation efforts required under the traditional licensing process pursuant to FERC regulation in 18 Code of Federal Regulations (CFR) § 4.38. Due to the complexity of the Project, SCE&G is using what is termed an Enhanced Traditional Relicensing Process.

This ICD for Saluda Hydro provides information relative to the site, the Project Works (structures, equipment, and facilities), and current and future operations. There are three distinct phases in the enhanced traditional licensing process, of which preparation of the ICD is the first. SCE&G anticipates working closely and cooperatively with all interested parties through each stage of the process in order to address and resolve collaboratively, as many issues as possible. The information in this document is presented in the order suggested in FERC's regulations for relicensing major projects at 18 CFR § 4.51 as follows:

- Section A: Project Design
- Section B: Project Operations and Resource Utilization
- Section C: Project History
- Section D: Project Costs (not included in this document)
- Section E: Project Environmental Resources
- Section F: General Design Drawings of Primary Project Works
- Section G: Project Maps

**SOUTH CAROLINA ELECTRIC & GAS COMPANY
COLUMBIA, SOUTH CAROLINA**

**SALUDA HYDRO
FERC NO. 516**

SALUDA HYDRO ICD

TABLE OF CONTENTS

A.	PROJECT DESIGN.....	1
1.0	PROJECT STRUCTURES	1
1.1	Reservoir	1
1.1.1	Saluda Dam, Spillway, and Spillway Gates.....	2
1.1.2	Intake Towers and Penstocks.....	3
1.1.3	Powerhouse.....	4
1.1.4	Tailrace Water Level.....	5
1.1.5	Bypass Reach.....	5
2.0	PROJECT GENERATING EQUIPMENT.....	6
2.1	Turbines	6
2.2	Generators.....	6
2.3	Exciters	6
2.4	Governors.....	7
2.5	Power Transformers.....	7
3.0	PROJECT TRANSMISSION LINE.....	8
4.0	MISCELLANEOUS EQUIPMENT	9
5.0	MCMEEKIN STATION.....	10
6.0	PROJECT DRAWINGS AND RECORDS.....	11
B:	PROJECT OPERATIONS AND RESOURCE UTILIZATION.....	15
7.0	RESOURCE UTILIZATION	15
7.1	Project Modification for Consideration	15
7.2	Streamflow and Water Regime Information.....	16
7.2.1	Flow Rates and Duration Curves	16
7.3	Project Operation	17
7.3.1	Description of Power Operation	17
7.3.1.1	Typical Operations.....	17
7.3.1.2	Flood Control Operations	18
7.3.2	Description of Non-Power Operations.....	18
7.3.3	Project Operations during a New License Term.....	19
7.3.4	Project Maintenance.....	19
7.4	Project Safety.....	19
7.4.1	Dam and Safety Inspections, Instrumentation Monitoring.....	19
7.4.2	Back-Up Dam	20
7.4.3	Warning Systems	20
7.4.4	Emergency Action Plan	21
7.4.5	Public Safety Plan.....	22
C:	THE SALUDA HYDROELECTRIC PROJECT HISTORY.....	36
E:	ENVIRONMENTAL RESOURCES.....	40

Table of Contents (con't)

8.0	GEOLOGY AND SOILS	40
8.1	Geological Setting of the Saluda Dam.....	40
8.2	Late Paleozoic Orogeny Deformation Patterns.....	41
8.3	Tectonic History of the Saluda Dam Area.....	43
8.4	Soils.....	46
8.5	Climate.....	47
9.0	WATER QUALITY.....	49
9.1	Applicable Water Quality Standards	49
9.2	Lake Murray Water Quality Conditions	53
9.2.1	Tributaries to Lake Murray.....	53
9.2.2	Lake Murray.....	57
9.2.2.1	Past Studies	57
9.2.2.2	Metals	61
9.2.2.3	Pathogens	61
9.2.2.4	Phosphorous.....	62
9.2.2.5	Trophic Status	62
9.2.2.6	DO and Temperature – Lake Murray.....	63
9.2.2.7	Current Studies.....	66
9.2.3	Saluda Dam Tailwater.....	68
9.2.3.1	Past Studies – SCDHEC Reports.....	69
9.2.3.2	DO Enhancement of the Project Turbine Releases.....	69
9.2.3.3	Water Uses	70
10.0	AQUATIC RESOURCES	87
10.1	Lake Murray.....	87
10.2	Saluda River.....	87
10.3	Fisheries Resources.....	88
10.3.1	Lake Murray.....	88
10.3.2	Lower Saluda River Fishery	97
10.3.2.1	Fisheries Community	97
10.3.2.2	Resident Fish.....	98
10.3.2.3	Trout Stocking	99
10.3.2.4	Trout Growth Studies on the Lower Saluda River.....	100
10.3.2.5	Fish Consumption Advisories.....	102
10.3.2.6	Fisheries Management Goals.....	102
10.3.2.7	Anadromous Fish	104
10.3.2.8	Catadromous Fish	106
10.3.2.9	Fish Restoration	107
10.3.2.10	Macroinvertebrates	107
10.3.2.11	Mussels	109
10.3.2.12	Threatened and Endangered Species	109
11.0	BOTANICAL RESOURCES	119
11.1	Upland Habitat.....	119
11.1.1	Lake Murray.....	119
11.1.2	Lower Saluda River	120
11.1.3	Islands	121
11.1.4	Wetlands	122
11.1.5	Threatened and Endangered Botanical Specis.....	127
11.1.6	Invasive Aquatic Plants.....	129
12.0	WILDLIFE RESOURCES.....	132

Table of Contents (con't)

	12.1	Threatened and Endangered Wildlife Species	133
13.0		CULTURAL RESOURCES	152
	13.1	Cultural Resource Studies	152
	13.2	Archaeological Overview	154
	13.3	Historical Overview	156
	13.4	Historic Resources Within the Project	158
	13.5	Protection and Preservation	158
		13.5.1 National Historic Preservation Act Compliance	158
	13.6	Properties Affected by Project Operations or Developments	159
	13.7	Management Plans	159
14.0		RECREATION RESOURCES	163
	14.1	Regional Resources	163
	14.2	Project Resources	164
		14.2.1 Lake Murray	165
		14.2.2 Saluda River	165
		14.2.3 Recreation Sites	166
	14.3	Existing Use	168
		14.3.1 Market Area	168
		14.3.2 Existing Use and Activites	169
15.0		LAND USE AND AESTHETICS	171
	15.1	Existing Land Use	171
	15.2	Aesthetics Resources	173
16.0		SOCIOECONOMICS	175
	16.1	Demographics	175
	16.2	Economy	176
	16.3	Social Infrastructure	177
	16.4	Access and Transportation	178
F:		GENERAL DESIGN DRAWINGS OF PRIMARY PROJECT WORKS	195
G:		PROJECT MAPS	201

LIST OF TABLES

Table A-1: Saluda Project Standard Numbers (FERC Project No. 516).....12

Table E-1: Major Wastewater Dischargers and Number of Minor Dischargers in the Watersheds of Lake Murray (downstream from Greenwood Dam)72

Table E-2: Number of Locations and How Water Uses Were Supported Based on the 1995 and 1998 SCDHEC Reports.....73

Table E-3: Percent Contributions to the Upper Regions of Lake Murray of Total Phosphorus Loadings and Mean Stream Flows Found Conducting CE-QUAL-W2 Model (Ruane, 2004).....74

Table E-4: Fish Species Typical of Lake Murray and the Lower Saluda River110

Table E-5: Spring Electrofishing Data Collected in the Lower Saluda River by SCE&G (1996-2001).....113

Table E-6: Fall Electrofishing Data Collected in the Lower Saluda River by SCE&G (1995-2000)115

Table E-7: Comparison of Saluda Trout Growth Study Results Versus Other Southeastern Hydropower Tailwaters (Kleinschmidt, 2003)117

Table E-8: Bioassessment Metrics for the 5 Saluda River Hester Dendy Stations Downstream from the Lake Murray Hydroelectric Dam, Operated by South Carolina Electric and Gas Company. Lexington County, SC. 01 July, 2004 (Shealy, 2004).....118

Table E-9: Listing of Botanical Species Found Within the Saluda Project Area138

Table E-10: All State and Federally Listed Threatened and Endangered Species for the Counties Surrounding the Saluda Hydroelectric Project147

Table E-11: Mammals Commonly Found In and Around Lake Murray148

Table E-12: Reptiles (Terrestrial and Aquatic) and Amphibians Commonly Found In and Around Lake Murray149

Table E-13: Bird Species Commonly Found at Lake Murray150

Table E-14: Cultural Resources Identified at the Saluda Project161

Table E-15: Public Recreation Sites in the Project Area180

Table E-16: Marinas on Lake Murray182

Table E-17: Private Marinas and Landings on Lake Murray184

Table E-18: Study Area Population Trends, 1990-2000: Average Annual Percent Change ...187

Table E-19: Demographic Characteristics of Residents of Lexington, Newberry Richland and Saluda Counties and South Carolina in 2000.188

Table E-20: Economic Characteristics of Residents of Lexington, Newberry Richland and Saluda Counties and South Carolina in 2000189

Table E-21: Employment by Sector: Lexington, Newberry, Richland, and Saluda Counties in 2000.....190

LIST OF FIGURES

- Figure A-1: Project Location Map
- Figure B-1: January Flow Duration Curve
- Figure B-2: February Flow Duration Curve
- Figure B-3: March Flow Duration Curve
- Figure B-4: April Flow Duration Curve
- Figure B-5: May Flow Duration Curve
- Figure B-6: June Flow Duration Curve
- Figure B-7: July Flow Duration Curve
- Figure B-8: August Flow Duration Curve
- Figure B-9: September Flow Duration Curve
- Figure B-10: October Flow Duration Curve
- Figure B-11: November Flow Duration Curve
- Figure B-12: December Flow Duration Curve
- Figure B-13: Annual Flow Duration Curve
- Figure E-1: Aeromagnetic Map of South Carolina
- Figure E-2: Generalized Geologic Map of South Carolina
- Figure E-3: Map of Eastern Piedmont Fault Zones and TERRANES
- Figure E-4: Saluda River from Its Confluence with the Little Saluda River to the Saluda Hydroelectric Dam, Including Lake Murray and Mile Markers Showing Distance Upstream from Dam
- Figure E-5: Total Phosphorous Concentrations at the Dam Forebay of Lake Murray – 1972 to 1998
- Figure E-6: Longitudinal Contour Plot of DO in Lake Murray from May 1998
- Figure E-7: Longitudinal Contour Plot of DO in Lake Murray from June 1998
- Figure E-8: Longitudinal Contour Plot of DO in Lake Murray from July 1998
- Figure E-9: Longitudinal Contour Plot of DO in Lake Murray from August 1998
- Figure E-10: Longitudinal Contour Plot of DO in Lake Murray from September 1998
- Figure E-11: Longitudinal Contour Plot of DO in Lake Murray from October 1998
- Figure E-12: Percent Exceedance for DO in the Saluda Dam Tailwater – All Hourly Data from the Low DO Period (Approximately July 1 to November 15 of each year)
- Figure E-13: Aquatic Plants in the Lower Saluda (Aulbach, 2004)
- Figure E-14: Public Access and Recreation Sites around Lake Murray

Table of Contents (con't)

- Figure E-15: Capital City Boat Registrations (SCBCB, 2004; Mead and Hunt, 2002, as modified by Kleinschmidt)
- Figure E-16: Lake Murray Boat Counts (Source: The Louis Berger Group, Inc., 2002, cited in Mead and Hunt, 2002b)
- Figure E-17: Land Cover in the Vicinity of Lake Murray
- Figure F-1: General Plan of Powerhouse and Tailrace Area
- Figure F-2: Powerhouse – Downstream Plan and Elevation
- Figure F-3: Cross Sections through Dam and Conduits
- Figure F-4: Rock Berm Typical Sections and Details
- Figure F-5: Spillway Gates – Plan and Sections
- Figure G-1: General Map of Project Area
- Figure G-2: Detail Map of Project Area (1)
- Figure G-3: Detail Map of Project Area (2)

LIST OF APPENDICES

- Appendix A: Literature Cited
- Appendix B: Additional Information for the Saluda Hydroelectric Project
- Appendix C: Glossary
- Appendix D: Service List
- Appendix E: Lake Murray Water Quality Report

Z:\SCO\455\020\Final Saluda ICD (2005-3-28;ACG;CLB).doc

A. PROJECT DESIGN

The Saluda *Hydroelectric Project* is located on the Saluda River and lies within the boundaries of Richland, Lexington, Saluda, and Newberry Counties of South Carolina, near the towns of Irmo and Chapin, approximately 10 miles west of the city of Columbia. The 2,420 square mile *watershed* area, drained by the Saluda River and its tributaries above Saluda Dam, provides water for the project's impoundment, Lake Murray, and the Saluda *Hydroelectric Plant*. The location of the Project is shown on Figure A-1.

1.0 PROJECT STRUCTURES

The Saluda Hydroelectric Project includes Lake Murray, the Saluda Dam and its *spillway*, the back-up Saluda Berm¹, Saluda *Powerhouse*, intake towers and associated penstocks. Descriptions of individual Project components are provided below. Details for Project standard numbers are reported in Table A-1.

1.1 Reservoir

Lake Murray covers a normal maximum water surface area of approximately 75 square miles or approximately 48,000 acres. The normal maximum water surface (pool) elevation is 360' Plant Datum (PD)². Lake Murray is 41 miles long and about 14 miles wide at its widest point, and upon its completion, provided storage for as much as 763 billion gallons of water. It has a shoreline of approximately 691 miles, including islands.

The lake shoreline is irregular and coursed by many creek beds and drainage ways cut through the terrain (FERC 2002). Inflow is generally cooler than the upper strata of lake water, and often carries high sediment loads. The lake undergoes thermal *stratification* annually, typically July through November, with the thermocline occurring between 20 and 40 feet deep. The *reservoir* serves as a source of drinking water for the communities in and around Columbia, West Columbia, Lexington and Newberry.

¹ As will be discussed further at a later point in the ICD, a backup dam is currently under construction immediately downstream of the original, earthen Saluda Dam. It is scheduled to be complete in 2005.

² This equates to an elevation of 358.5' based on the 1988 North American Vertical Datum (NAVD).

The lake contains approximately 2,200,000 *acre-feet* of *gross storage* (FERC 1984) and has a useable storage capacity of 1,056,000 *acre-feet* of water at 360 feet PD. The average annual discharge from the Dam (*“Dam” is capitalized when referring to the Saluda Dam*) is 1,930,000 *acre-feet*, and the turnover time³ for the lake is about 13 to 14 months (FERC 2002).

1.1.1 Saluda Dam, Spillway, and Spillway Gates

The Saluda Dam is an earth fill dam with an additional steel sheet pile wall on the upstream edge of the crest. From the foundation bottom to the top of the sheet pile wall is 213 feet. The Saluda Dam is nearly a mile and a half long. The maximum width of the Dam at the bottom, from upstream edge to downstream edge, is 1,210 feet, and is 36 feet at the crest. A state highway, SC Route 6, is built along the top of the Dam. About 500 feet from the south end of the Dam is the beginning of a concrete spillway equipped with six welded steel *Tainter gates*, four of which are 37' 6" long x 25' 0" high with sill elevations of 340' PD, and two of which are 44' 0" long x 32' 0" high with sill elevations of 330' PD. The discharge from the spillway enters the 2,900-foot long man-made channel, which empties into the Saluda River below the powerhouse. In 2002, construction began on a new berm immediately downstream of and adjacent to the existing Dam. The selected remediation consists of constructing a combination Roller Compacted Concrete (RCC)⁴ and Rock Fill⁵ dam along the downstream toe of the existing Dam. The RCC Berm is founded on bedrock and the Rockfill Berm is founded on residual soil. This seismic remediation project involves the

³ The time it takes water entering the project from above to travel through the project and be discharged through the penstocks and into the lower Saluda River – also sometimes referred to as “residence time.”

⁴ The RCC portion of the backup berm at Saluda Dam is designed as a concrete gravity dam, and is approximately 2,300 feet long, with a crest elevation of 372.0 NAVD. The RCC berm has a maximum base width of approximately 140 feet. The upstream face of the RCC berm is vertical and incorporates precast concrete finish panels. The downstream face is stepped, using precast finish panels on the vertical faces of the 6 foot high steps. The crest width of the RCC berm varies from 25 feet to 40 feet, and the downstream face slope varies from 0.55H:1V to 0.42H:1V. The RCC berm is founded on competent bedrock, with a conventional mass concrete foundation, constructed on bedrock, in some areas.

⁵ The rockfill portions of the backup berm at Saluda Dam consist of a north rockfill berm approximately 2,500 feet long, and a south rockfill berm approximately 3,300 feet long. Both the north and south rockfill berms have a crest width of 20 feet at elevation 372.0 NAVD. The north rockfill berm has a maximum width (at the base) of approximately 300 feet, and the south rockfill berm has a maximum base width of approximately 375 feet. Both are constructed as a zoned rockfill with a central clay transition zone (core) and internal sand and gravel filters. The outer rockfill shells are constructed with 1.5H:1V outer slopes.

placement of 1.3 million cubic yards of RCC and 3.5 million cubic yards of Rockfill. When completed, the new back-up dam will be 213 feet high with the RCC Berm section, in the center, approximately 2,300 feet long and the Rockfill berm sections, on the north and south ends, a total of approximately 5,700 feet long. The maximum upstream to downstream width of the foundation of the back-up berm is approximately 150 feet for the RCC and 337 feet for the Rockfill sections. The maximum crest (top of berm) is 40 feet for the RCC section and 20 feet for the Rockfill section. Additional material will be added to the downstream slope of the original Saluda Dam to provide a base for two additional lanes of SC Route 6.

1.1.2 Intake Towers and Penstocks

Water is supplied to the powerhouse through five intake towers, four of which are 30 feet in diameter and 223 feet in height, and the fifth which is 60 feet in diameter and 223 feet high. The intake towers are connected to the Dam at the top by an aerial cableway. The 30' diameter intake towers for Units 1, 2, 3, and 4 each have two Broome Roller Gates - 9' x 14'. The 60' diameter intake tower for Unit 5 contains six Broome Roller Gates, each 10' x 10'. Connecting the intake towers and the powerhouse are five penstocks. The 16-foot diameter penstocks for Units 1, 2, 3, and 4 are each 1091 feet long and at the *turbine* inlet of each is a 16-foot diameter S. Morgan Smith electrically operated butterfly valve. Water entering the Unit 5 Intake Tower passes first through a 491-foot length of open concrete arch conduit, then through a 227-foot divided length of arch conduit containing two 14-foot diameter penstocks followed by a 42-foot length bifurcation, and finally through a 364-foot section of single, 20-foot diameter penstock to the powerhouse.

1.1.3 Powerhouse

The Saluda Hydro Powerhouse is constructed of concrete, steel and brick, and is 57 feet wide, 250 feet long and 100 feet high, with a reinforced concrete extension for Unit 5, which is 68 feet wide and 77 feet long. The original powerhouse, containing Units 1 to 4, is of conventional indoor-type design, while the extension is of a fully outdoor design with the generator enclosed in a weather-tight housing on an open deck. Auxiliary equipment is located on the turbine floor inside (FERC 1984).

The powerhouse contains 4 generating units. Three units have a nameplate rating at 32.5 MW each and the fourth at 42.3 MW totaling 207.3 MW. The exterior unit located to the south of the existing powerhouse is the fifth unit and is rated at 67.5 MW. At 180 feet of *head*, the system can produce 202.6 MW of power (FERC 2002) and has a licensed⁶ *capacity* of 202.6 MW. The combined *hydraulic* capacity of all five hydro units at normal gate opening is 18,000 *cubic feet per second* (cfs). The hydraulic capacity of each of the Units 1 to 4 is 3,000 cfs, and the hydraulic capacity of Unit No. 5 is 6,000 cfs.

Water is supplied through 5 intake towers upstream of the Dam and routed through individual penstocks to the powerhouse turbines (FERC 2002). Unit Nos. 1 through 4 take water from near the bottom of the lake at a depth of about 190 feet, while Unit No. 5 takes water from a depth of about 80 feet. All Units have had additional vents installed to improve *dissolved oxygen* (DO) concentrations in the turbine discharges from the Project. Additionally, Unit No. 5 is fitted with hub baffles to enhance air intake efficiency.

The emergency spillway is 500 feet from the south end of the Dam and includes a concrete structure with six steel tainter gates (FERC 2002). Water from the spillway follows a man-made channel which connects with the Saluda River approximately three quarters of a mile downstream of the Dam. The

⁶ The generating equipment does not operate under ideal conditions for which they were most efficiency designed. Therefore, this explains the lower licensed capacity rating of 202.6 MW versus the nameplate rating of 207.3 MW.

spillway gates may be raised to prevent the lake level from exceeding 360 feet PD. At a flood level of 370 feet, the spillway capacity is approximately 154,000 cfs. Under *Probable Maximum Flood (PMF)* conditions, the spillway outflow is projected to be about 197,000 cfs.

1.1.4 Tailrace Water Level

The water level in the *tailrace* typically fluctuates between 171 and 181 feet PD due to the intermittent operation of the hydro plant (FERC 2002). Normal *tailwater* level is 177 feet PD, corresponding to a total head of 180 feet. At flood stage, with the spillway fully open, the tailwater could rise to an elevation of 202 feet PD or higher.

1.1.5 Bypass Reach

There is no *bypass reach* associated with this Project.

2.0 ***PROJECT GENERATING EQUIPMENT***

The Project generating equipment consists of the following:

2.1 Turbines

Units 1, 2, 3, and 4 are S. Morgan Smith Francis-type turbines each rated at 55,650 HP at 180' head. Synchronous speed is 138.5 RPM.

Unit 5 is a Baldwin-Lima-Hamilton Francis-type turbine rated at 98,300 HP at 156' head. Synchronous speed is 128.6 RPM.

2.2 Generators

Units 1, 2, and 4 are 3-phase, 60-cycle, 13,800 V, 40,625 KVA, 0.8 power factor Westinghouse generators. Unit 3 is a 3-phase, 60-cycle, 13,800 V, 47,000 KVA, 0.9 power factor Westinghouse generator. These four units are conventional indoor-type design.

Unit 5 is a 3-phase, 60-cycle, 13,800 V, 75,000 KVA, 0.9 power factor General Electric generator. Unit 5 is fully outdoor design with the generator enclosed in a weather-tight housing on an open deck.

2.3 Exciters

Units 1-4 are each equipped with an exciter and a Permanent Magnet Generator (PMG), both direct connected above the generator rotor.

Unit 5 is equipped with an AC exciter and rotating rectifier.

2.4 Governors

Units 1-4 have governors that are interconnected in pairs.

Unit 5 has its own governor actuator and pressure tank.

2.5 Power Transformers

Units 1, 3, and 4 power *transformers* are 3-phase, 41,667/46,667 KVA with 55°/65° C temperature rise, type O.I.W.C., 115/13.2 KV. The Unit 2 power transformer is 3-phase, 40,000 KVA with 55° C temperature rise, type O.I.W.C., 115/13.2 KV.

The power transformer for Unit 5 is 3-phase, 76,785/86,000 KVA, type F.O.A., 115/13.2 KV with 55°/65° C temperature rise.

3.0 *PROJECT TRANSMISSION LINE*

There is no *transmission* line associated with the Saluda Hydroelectric Project. The electric power is generated at 13,200 *volts* and is transformed to 115 KV. The power enters the Applicant's transmission system through the nearby Saluda Substation, which is not a part of the Project.

4.0 MISCELLANEOUS EQUIPMENT

Miscellaneous equipment includes a 175-ton, traveling Bedford bridge crane and all accessory electrical equipment, including instrumentation, batteries, switchgear, etc.

5.0 McMEEKIN STATION

McMeekin Station is a coal fired power plant located adjacent to the hydro powerhouse on the north side of the Saluda River (FERC 2002). It is operated by SCE&G, but is not part of the Project. Cooling water for the McMeekin condensers is taken from and returned to the Saluda penstocks.

6.0 PROJECT DRAWINGS AND RECORDS

Drawings of Project structures and features are provided in Section G.

Table A-1: Saluda Project Standard Numbers (FERC Project No. 516)

DESCRIPTION		NUMBER OR FACT				
Project Location		10 mi west of City of Columbia; Richland, Lexington, Saluda and Newberry Counties				
Spillway		4@37ft 6in long x 25ft high w/sill elevation of 340 msl				
Gates	Width	2@44ft long by 32ft high w/sill elevation of 330 msl				
Reservoir	Normal level	2,100,000 acre-feet				
Minimum daily average flow in the river		285 cfs (measured @ USGS gauging station near Riverbanks Zoo)				
Construction type		concrete block, brick, steel				
Construction type		reinforced concrete				
		Unit 1	Unit 2	Unit 3	Unit 4	Unit 5
Intake towers						
	Diameter	30 ft	30 ft	30 ft	30 ft	60 ft
	Height	223 ft	223 ft	223 ft	223 ft	223 ft
Penstocks						
	Diameter	16 ft	16 ft	16 ft	16 ft	20 ft
	Length	1091 ft	1091 ft	1091 ft	1091 ft	1124 ft
TURBINES						
Rated net head (gross static)						
Rated maximum discharge capacity						
		Unit 1	Unit 2	Unit 3	Unit 4	Unit 5
Draft tube invert elevation		158.5 ft msl	158.5 ft msl	158.5 ft msl	158.5 ft msl	151.12 ft msl
HP Rating at 180ft head		55,650 (32,500 kW)	55,650 (32,500 kW)	55,650 (32,500 kW)	55,650 (32,500 kW)	
HP Rating at 156ft head		98,300 (67,500 kW)				
Synchronous speed (rpm)		138.5	138.5	138.5	138.5	128.6
Type		Francis-type	Francis-type	Francis-type	Francis-type	Francis-type
Manufacturer		S. Morgan Smith	S. Morgan Smith	S. Morgan Smith	S. Morgan Smith	Baldwin-Lima-Hamilton
GENERATORS						
Annual generation		245 million kWh or 245,200 Mwh				
		Unit 1	Unit 2	Unit 3	Unit 4	Unit 5

DESCRIPTION**NUMBER OR FACT**

Manufacturer	Westinghouse	Westinghouse	Westinghouse	Westinghouse	General Electric
Name plate rating (202,600 kW for the Project)					
Power factor	0.8	0.8	0.9	0.8	0.9
Voltage	13,800 V				
Number of phases	3	3	3	3	3
Frequency	60-cycle	60-cycle	60-cycle	60-cycle	60-cycle
Output	32,500kW	32,500kW	42,300kW	32,500kW	67,500kW
KVA	40625	40625	47000	40625	75000

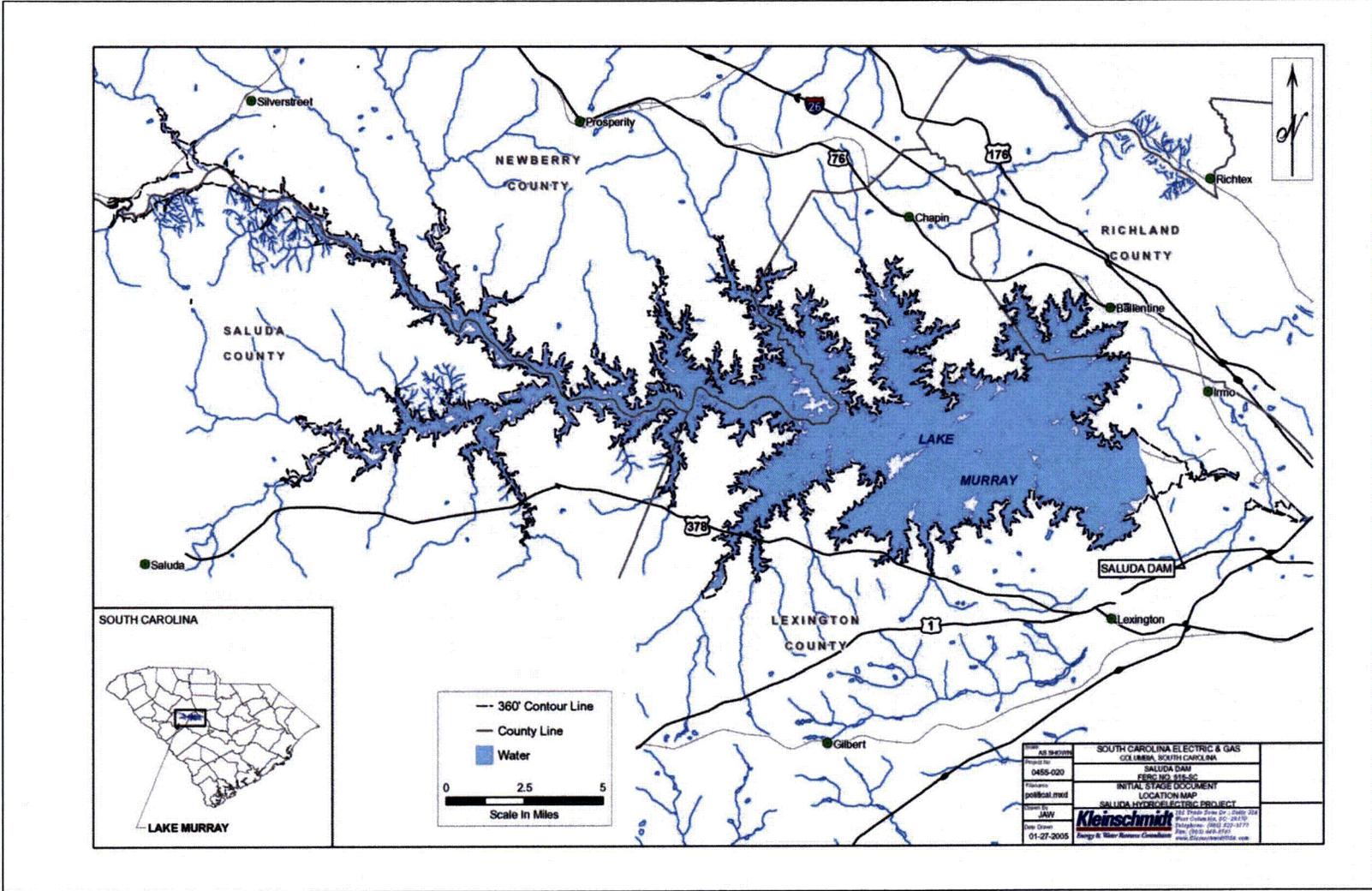
TRANSFORMERS

Number	5
Voltage	13.2/115-kV

FLOOD FLOWS

Other info:	
Maximum generating capacity	207,300 kW
Total Capacity	202,600 kW
Discharge at rated capacity	18,000 cfs

Figure A-1: Project Location Map



AS 940204	SOUTH CAROLINA ELECTRIC & GAS
0488-020	COLUMBIA, SOUTH CAROLINA
political.mxd	SALUDA DAM
	FERC NO. 616-SC
	INITIAL STAGE DOCUMENT
	LOCATION MAP
	SALUDA HYDROELECTRIC PROJECT
Prepared by:	Kleinschmidt
Drawn by:	JAW
Date:	01-27-2005
	121 Third Avenue, Suite 200 Bluffton, SC 29910 Telephone: (803) 820-1575 Fax: (803) 468-8722 www.kleinschmidt.com

B: PROJECT OPERATIONS AND RESOURCE UTILIZATION

7.0 RESOURCE UTILIZATION

SCE&G uses its existing resources in as efficient a manner as reasonably possible. SCE&G conducts annual maintenance at the Saluda Project to ensure the efficiency of the units. Existing resources are periodically evaluated to determine if Project upgrades are needed. The Project has a hydraulic design flow of 18,000 cfs, exceeding the average annual flow of 2,595 cfs. This flow capacity, combined with the storage capability of Lake Murray, allows the Project to make effective use of essentially all net inflows to the site.

In accordance with FERC regulations, and in order to ensure the efficient management of Project waters, a resource utilization study was conducted by SCE&G as a part of the relicensing process. At a minimum, a reconnaissance level study must be performed to demonstrate that the project is in conformance with a comprehensive development plan for the waterway. A flow utilization equal to or greater than the 25 percent exceedance flow, as based on the annual *flow duration curve*, is typically used as an indicator that the project is making comprehensive use of the resource. The 25 percent flow exceedance value approximates the average annual flow at the project location. Based on the flow duration curve developed for the site, the 25 percent exceedance flow was determined to be about 2,000 cfs.

7.1 Project Modification for Consideration

Currently, beyond completing the construction of the backup dam, SCE&G is not proposing any specific engineered modifications of Saluda Hydro. However, during the relicensing process, in response to issues and concerns, SCE&G expects that it will find it necessary to examine Project modifications that might enhance the operational, environmental and economic value of Saluda Hydro.

7.2 Streamflow and Water Regime Information

7.2.1 Flow Rates and Duration Curves

The monthly and annual flow regime data was collected from USGS gages located along the LSR. Gage number 02169000 is located on the Saluda River near Columbia. It has remained in this location from the time it was first installed in 1925. The contributing drainage area for this gage is 2,520 square miles and has an average annual flow of 2,569 cfs. A second gage, number 02168504, was installed along the Lower Saluda by USGS in 1988. This gage records data immediately downstream from the Saluda Dam. One can make comparisons of flows from Lake Murray based on the data retrieved from these gages. This data has shown that from the time period of 1980 to 2003, flows from Lake Murray have varied from a low of 185 cfs to a recorded high of 24,000 cfs. Flow measured from gage number 02168504 has an annual average of 2,595 cfs. The contributing drainage area is 2420 square miles. Monthly and annual duration curves were made for the project using the mean daily flow data from the respective gages. The data from the two gages were combined to form the graphs shown in Figures B-1 through B-13. The data from the gages was pro-rated to their respective contributing drainage areas to make the mean daily flow site-specific. The period of record for the data that is used in these graphs dates from 1979 through 2003. Since gage number 02168504, directly downstream from the Dam, was installed in 1988, data from gage 02169000 was used and pro-rated to that particular drainage area.

7.3 Project Operation

7.3.1 Description of Power Operation

7.3.1.1 Typical Operations

Saluda Hydro occupies a specific, very important niche in SCE&G's generating portfolio in that it is a facility in the SCE&G system that provides *reserve capacity*. Reserve capacity means the Project generators are typically online and synchronized to the electrical grid and can increase output immediately in response to a major generator or transmission *outage* and can reach full output within 15 minutes to comply with the North American Electric Reliability Council's Control Performance Standard.

Electric *load-generation* balancing, and management of local voltages and system frequency on a bulk power system, is done in real time. Generators sometimes fail, and generation failures may be unpredicted and sudden, upsetting the *load-generation* balance. Because electricity cannot be stored, any sudden reduction in generation cannot be handled by an inventory, as might happen in most other kinds of business. Instead, generation losses must be met by reserve generation that can be dispatched instantly, before voltage sags or frequency excursions lead to local or widespread blackouts. SCE&G is a member of the Virginia-Carolinas Southeastern Electric Reliability Council sub-region (VACAR), whose members are bound in a reserve-sharing agreement by which each has agreed to assist any other member in generation emergencies. SCE&G must employ its reserves (Saluda Hydro) to meet its own generation emergencies before calling on assistance from other VACAR members, but it also must be constantly ready to provide reserve generation to other VACAR members to meet SCE&G's contractual reserve obligations.

Because of SCE&G's obligations as a member of VACAR, Saluda Hydro operations are particularly important. This is due to the fact that Saluda can operate almost instantly in response to system emergencies. System emergencies, an unfortunate by-product of electrical power generation, can best be described as follows: any unplanned or unscheduled event that threatens, without prompt initiation of generation, to adversely impact system operations or reliability. The Saluda Hydro Project's greatest single value in support of SCE&G's system obligations is to provide this reserve generation in order to meet system emergencies. Emergencies can be initiated within SCE&G's system, or in the regional grid for which SCE&G is bound by cooperative agreement. In case of an out-of-system emergency Saluda Hydro must be able to supply approximately 200 *megawatts* (MW) (Saluda Hydro's rated capacity is 202 MW). What might trigger a system emergency will vary from day-to-day. On a mild day during off-peak hours, a large plant can trip off without necessarily causing a system emergency. Conversely, at peak time, or during a particularly hot or cold day, the tripping off of even a small unit may constitute an emergency. It also may depend upon the regional grid circumstances at the time of the initiating event. In the case of any system emergency, Saluda Hydro may be dispatched for up to full capacity generation for minutes or even hours.

7.3.1.2 Flood Control Operations

Saluda Hydro is not operated as a flood control reservoir. However, in times when tropical storms and hurricanes are predicted to affect inflow to the reservoir, operations of Saluda Hydro are increased to maintain the operating level of Lake Murray.

7.3.2 Description of Non-Power Operations

In addition to power production, the Saluda Hydro Project provides other benefits to the region and immediate vicinity, including recreational and environmental benefits.

7.3.3 Project Operations during a New License Term

SCE&G intends to use Saluda Hydro as a reserve capacity facility under the terms of a new license.

7.3.4 Project Maintenance

Under normal operations, Project plant personnel consist of a plant supervisor and an operations and maintenance crew. Crews are typically onsite for 8 hours a day Monday through Friday, and the plant is monitored 24 hours a day through SCE&G's system control. All Project personnel are trained in regulatory compliance, safety, dam surveillance, and emergency action procedures.

7.4 Project Safety

A combination of federally imposed requirements and voluntary measures conducted by SCE&G provide a high level of safety at the Saluda Hydroelectric Project. The FERC conducts annual inspections of the Project; they also require independent safety inspections, annual spillway gate tests, and the maintenance of an updated Emergency Action Plan. SCE&G performs regular Project inspections and monitors various types of instrumentation at the Dam. A backup dam is being constructed to prevent massive downstream flooding in the unlikely event of a seismically-induced primary dam failure. A siren warning system is in place to alert residents and businesses of a dam emergency; another system informs recreational users along heavily used stretches of the river that the water level is rising due to changes in plant operation. Buoys, signs, and fences are placed throughout the Project as part of the Public Safety Plan on file with the FERC.

7.4.1 Dam and Safety Inspections, Instrumentation Monitoring

Every year, an inspection is performed by a representative of the FERC to insure safety of a project's features and operation. Another inspection is required

every five years by an independent consultant approved by the FERC. Mandatory annual spillway gate testing ensures the ability to regulate flooding. Also, any modifications to the Project or significant operational changes are required to be submitted to the FERC.

SCE&G conducts a number of regular in-house inspections of the Dam and plant, and a monitoring program indicates any changes in the conditions at the Project. Numerous network *piezometers*, saturation wells, drains, weirs, and other apparatuses at the Dam and spillway permit the measurement of hydraulic pressures, *seepage* or leakage, and any movement of the water-retaining structures. These instrumentation readings are recorded in a surveillance report; their measurement frequency, as with regular Project inspections, varies from daily to annually.

7.4.2 Back-Up Dam

Studies have concluded that an occurrence of a seismic event of the magnitude of the 1886 Charleston earthquake could cause extensive liquefaction of the earthen dam, potentially resulting in great loss of life and property. Although the possibility of such an event is remote, SCE&G is required to prepare for it. SCE&G is accomplishing this by building a back-up dam behind the 1.5 mile primary Dam. Constructed of composite rock-fill and roller compacted concrete, this new dam is designed to withstand the forces associated with a seismically induced primary Dam failure, and subsequently to serve as the new primary dam. The construction phase of this project began in August 2002 and is scheduled to be completed in the spring of 2005. Due to construction requirements for the new dam, a temporary *drawdown* of Lake Murray was necessary to reduce loads on the existing Dam.

7.4.3 Warning Systems

SCE&G has installed an early warning system consisting of ten large sirens below the Dam. In the unlikely event of a dam failure, this system would

be activated to alert people in areas that could be flooded to seek information from television or radio media sources for further instruction. A brochure containing evacuation routes and emergency preparedness information is mailed to businesses and residents in these areas on an annual basis. The information contained in the brochure can also be obtained from SCE&G's website.

SCE&G also owns and operates a warning system on the Saluda River below the Dam, consisting of sirens, strobe lights, and warning signs in two locations frequented by river users: the Hope Ferry boat ramp near Saluda Shoals Park, and upstream of the zoo at the Mill Race rapids. Operational changes at the hydroelectric plant cause fluctuations in the river levels. As the river level rises, level transducers automatically activate the sirens and strobe lights to alert people on or near the river that the flows are increasing. Prominent warning signs posted near the strobe lights warn people that the activation of the sirens and/or the light signals potentially dangerous conditions caused by a rising water level.

7.4.4. Emergency Action Plan

In accordance with FERC requirements, SCE&G developed and maintains an Emergency Action Plan (EAP). The purpose of an EAP is to determine the results of a dam failure, and create procedures to minimize the loss of life and property. Breach parameters, peak discharges, depth of flow, and travel time are part of the dambreak analyses. Inundation maps coordinate the results of the breach analyses with topographic maps to determine the time and extent of flooding. Breach analyses must be and have been performed for two situations: "fair weather," with *normal operating* condition and maximum normal reservoir level; and flood, where the maximum inflow condition is attained prior to the onset of dam failure.

The EAP contains essential elements, including a notification flowchart showing a priority of who is to be notified, and by whom. The detection, evaluation, and classification component determines the events that indicate an emergency is happening, as well as the extent of the situation (failure has

occurred, conditions for potential failure exist, etc): The responsibilities section lists who will carry out various duties of the EAP. Responsibilities of the licensee include contacting the emergency and local agencies, who then have the duty of warning and evacuating affected areas. Preparedness consists of actions taken prior to a potential emergency to avoid or reduce the effects of a failure, such as spillway gate operational procedures. Inundation maps show areas requiring evacuation and the time available to do so. Appendices contain supporting information used to create the EAP, perform the breach analyses, and develop the inundation map.

7.4.5 Public Safety Plan

Public safety measures include warning signs near hazardous areas of the Project, buoys in the *impoundment* to serve as navigational aides or notify of dangerous conditions, and restraining devices such as fences around the powerhouse and downstream Project area. The Public Safety Plan, currently being updated, contains descriptions and locations of these public safety devices.

Figure B-1 Saluda Project FERC No. 516, South Carolina Electric & Gas Co., January Flow Duration Curve

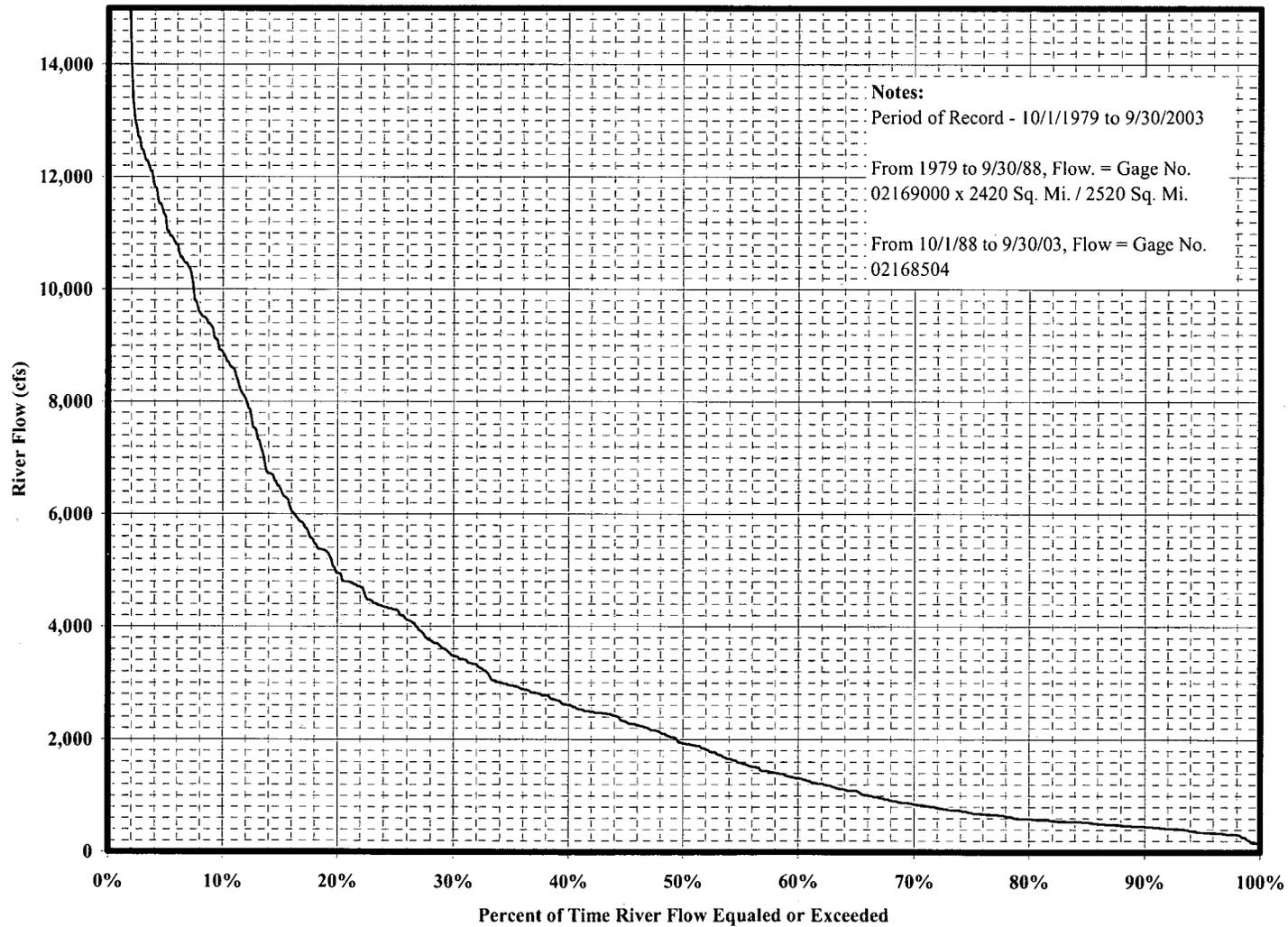


Figure B-2 Saluda Project FERC No. 516, South Carolina Electric & Gas Co., February Flow Duration Curve

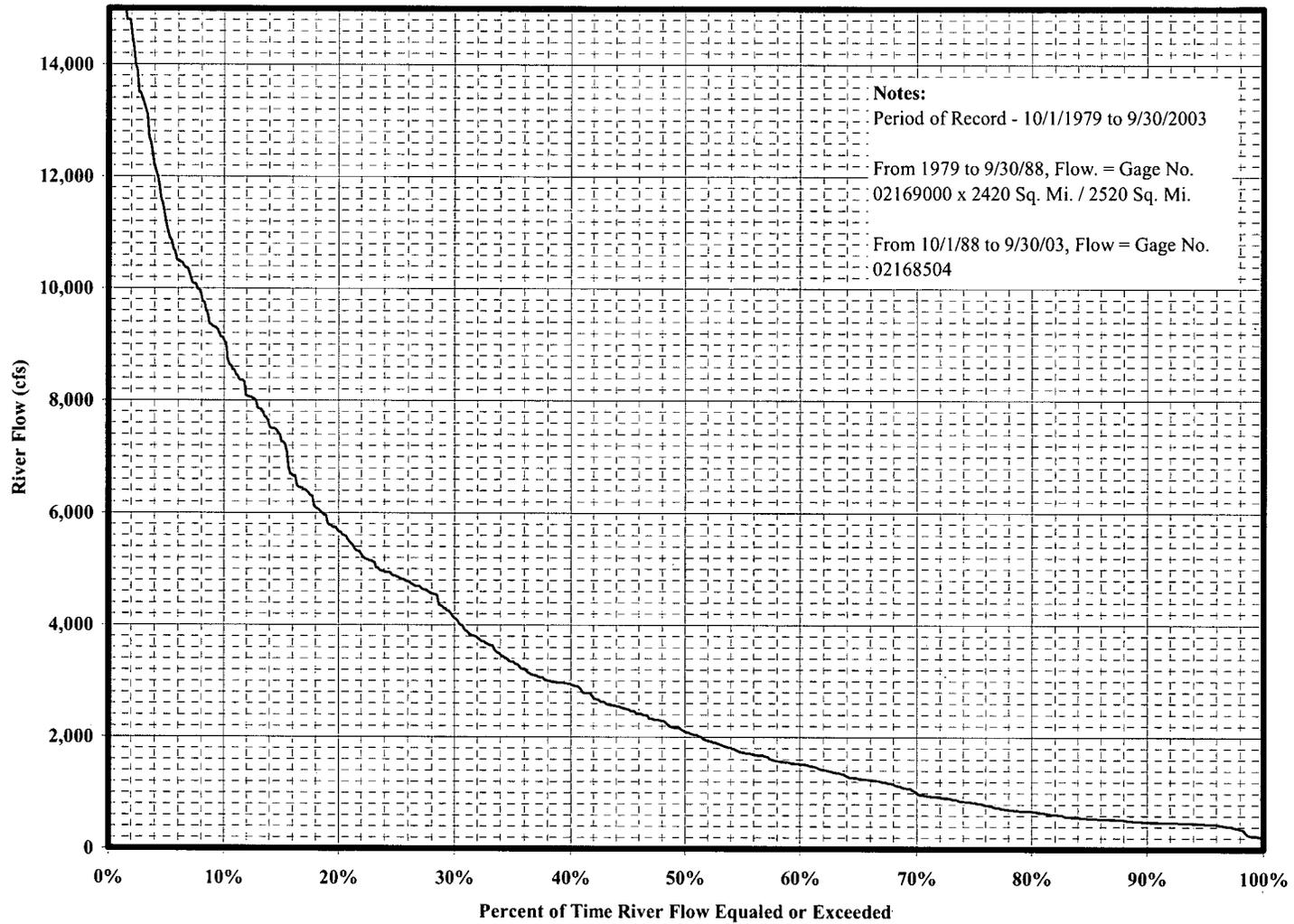


Figure B-3 Saluda Project FERC No. 516, South Carolina Electric & Gas Co., March Flow Duration Curve

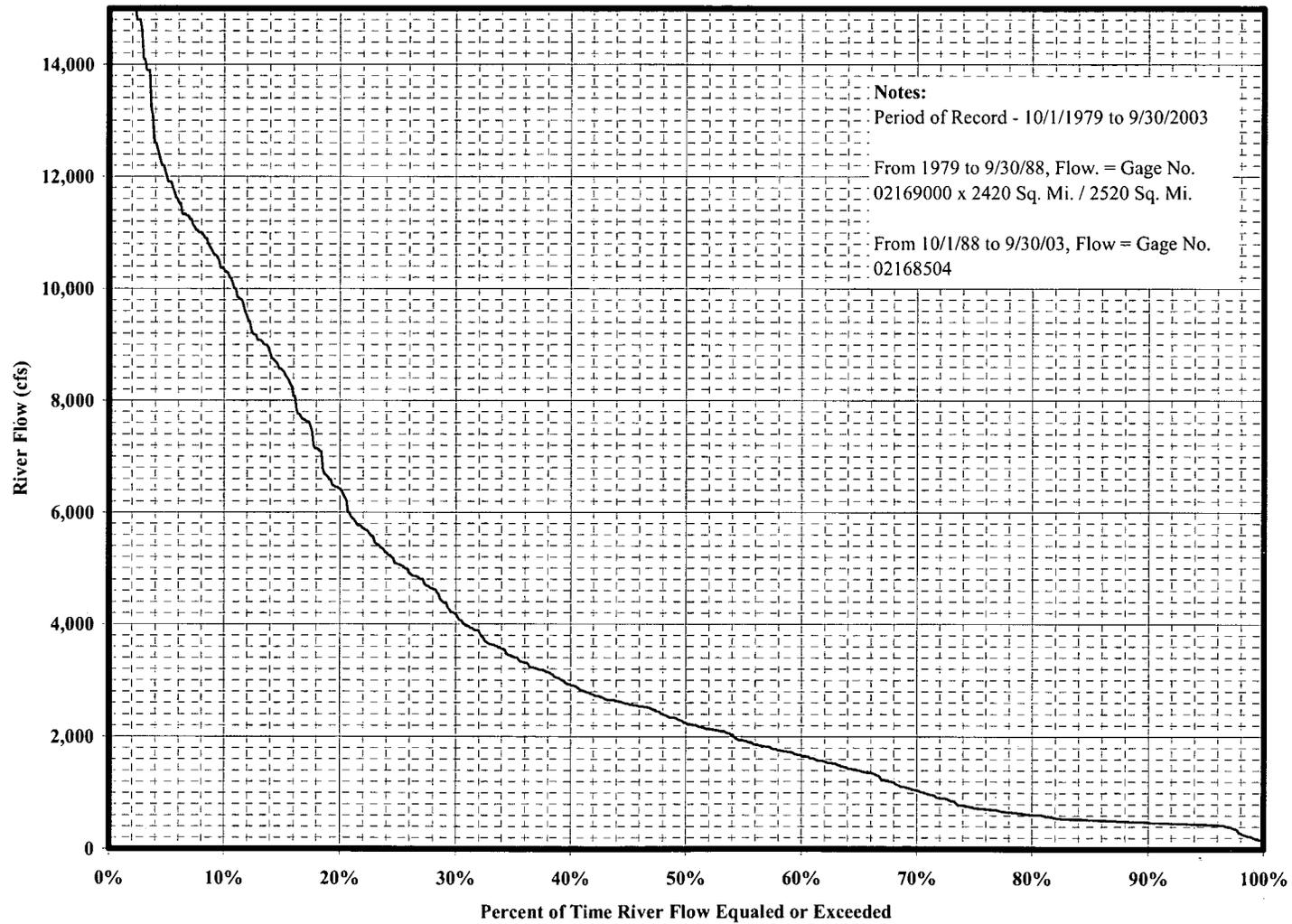


Figure B-4 Saluda Project FERC No. 516, South Carolina Electric & Gas Co., April Flow Duration Curve

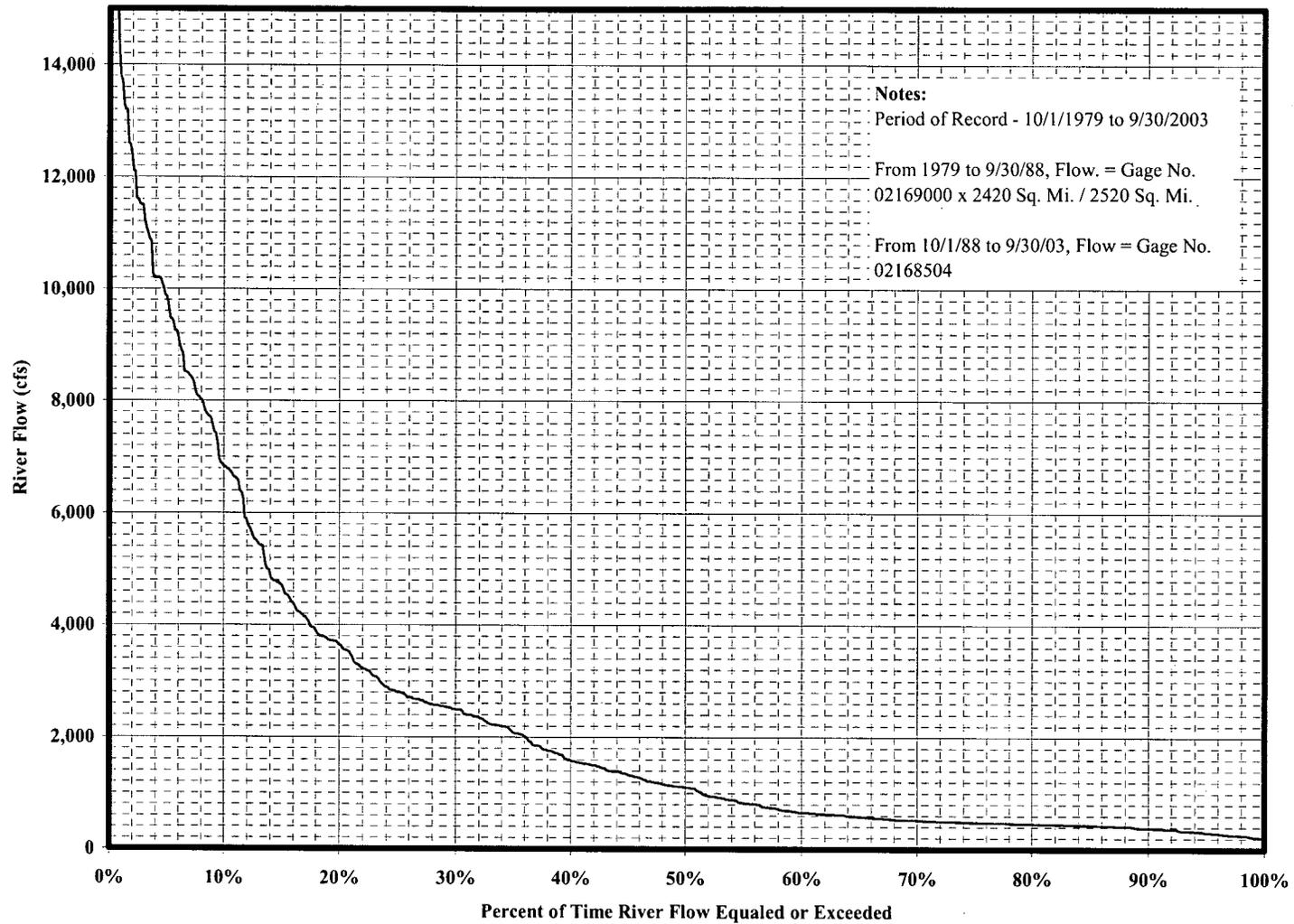


Figure B-5 Saluda Project FERC No. 516, South Carolina Electric & Gas Co., May Flow Duration Curve

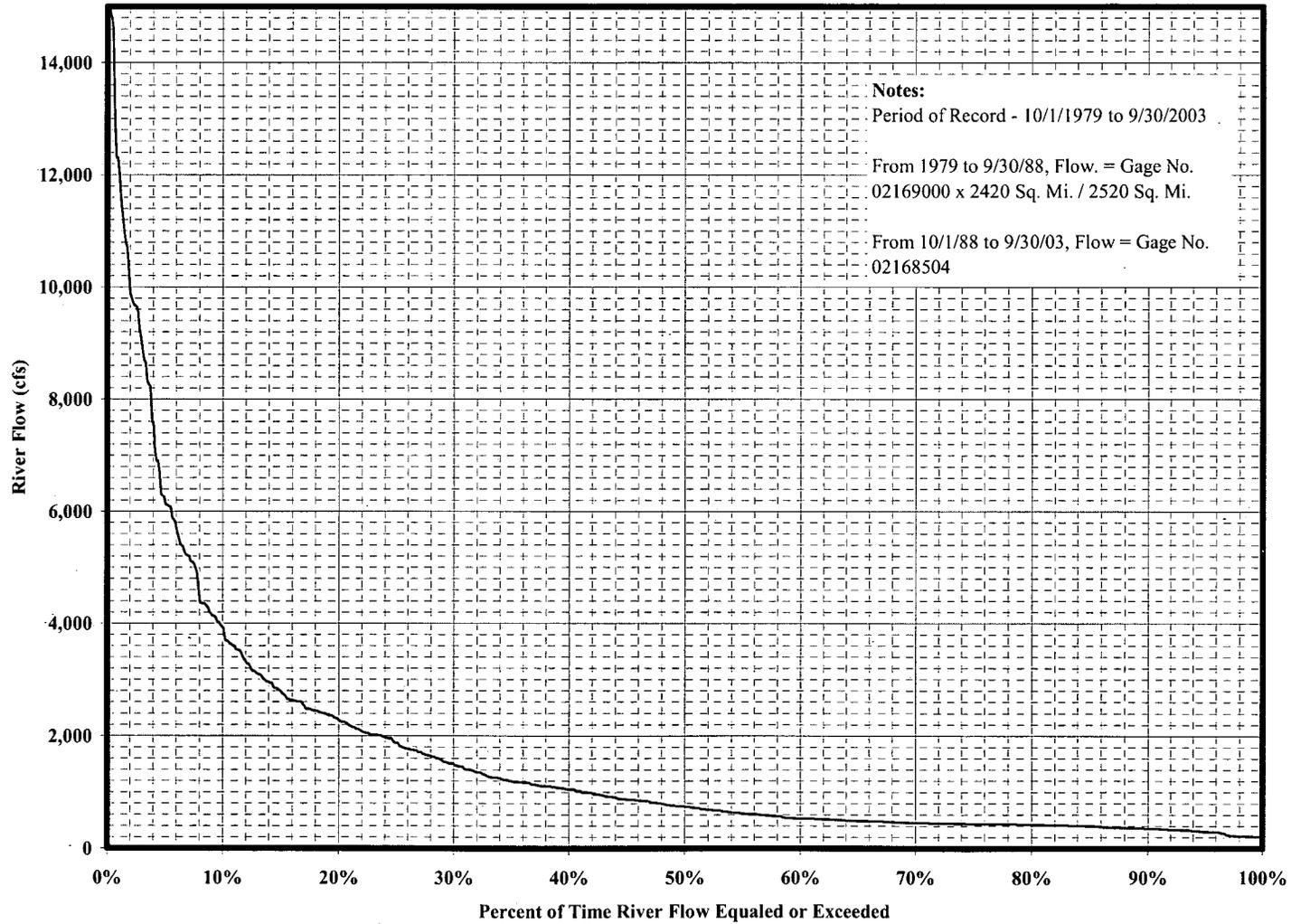


Figure B-6 Saluda Project FERC No. 516, South Carolina Electric & Gas Co., June Flow Duration Curve

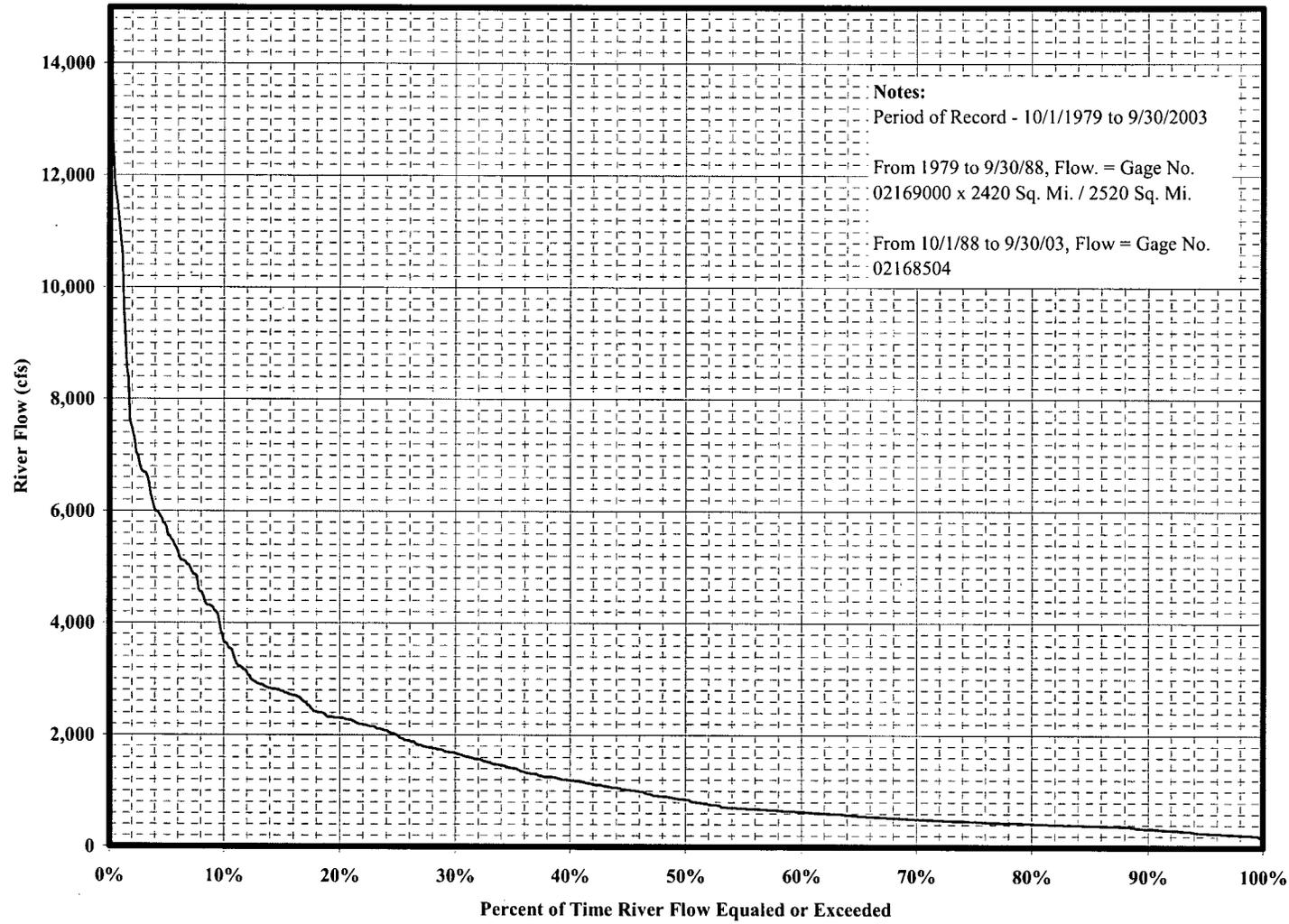


Figure B-7 Saluda Project FERC No. 516, South Carolina Electric & Gas Co., July Flow Duration Curve

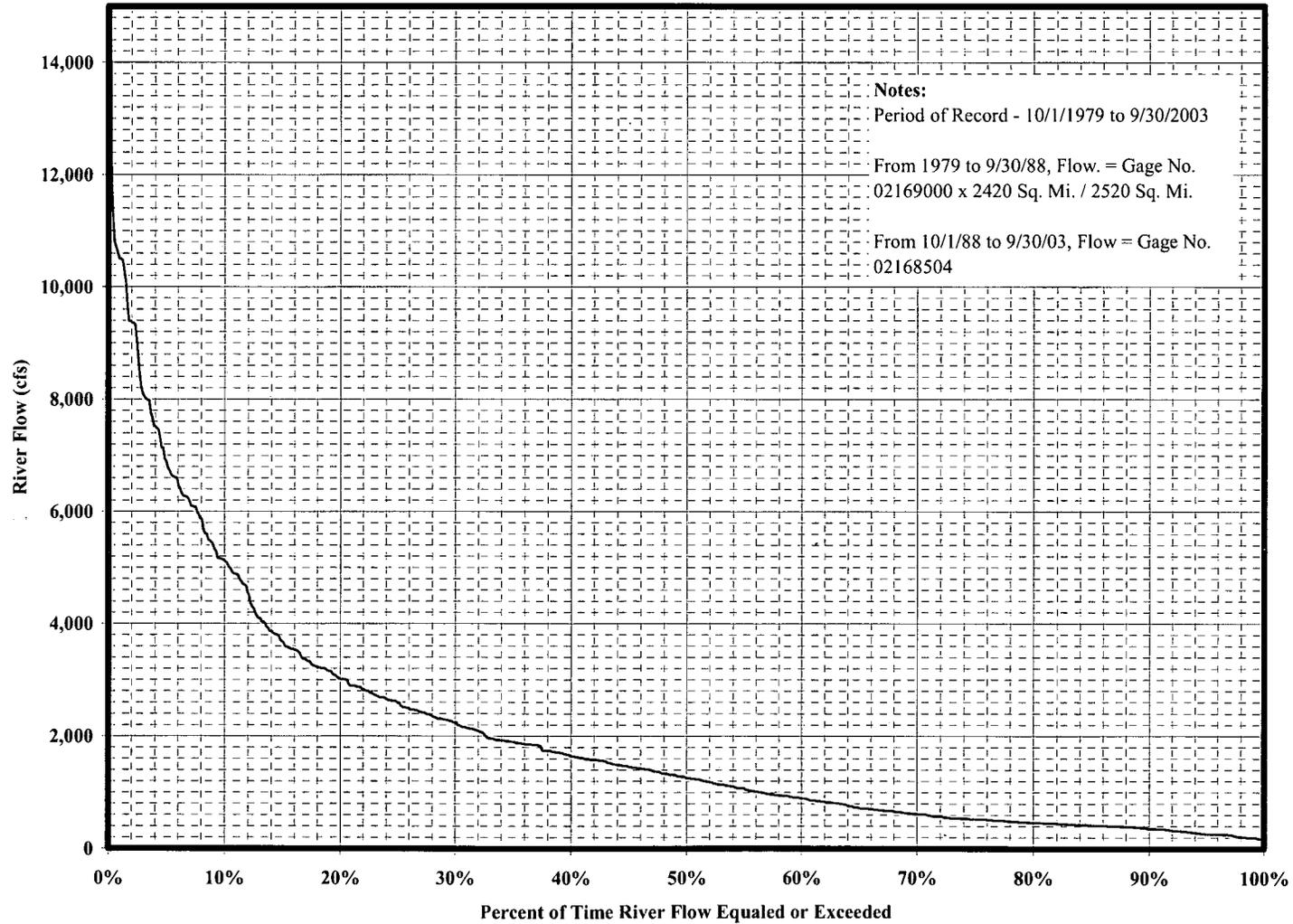


Figure B-8 Saluda Project FERC No. 516, South Carolina Electric & Gas Co., August Flow Duration Curve

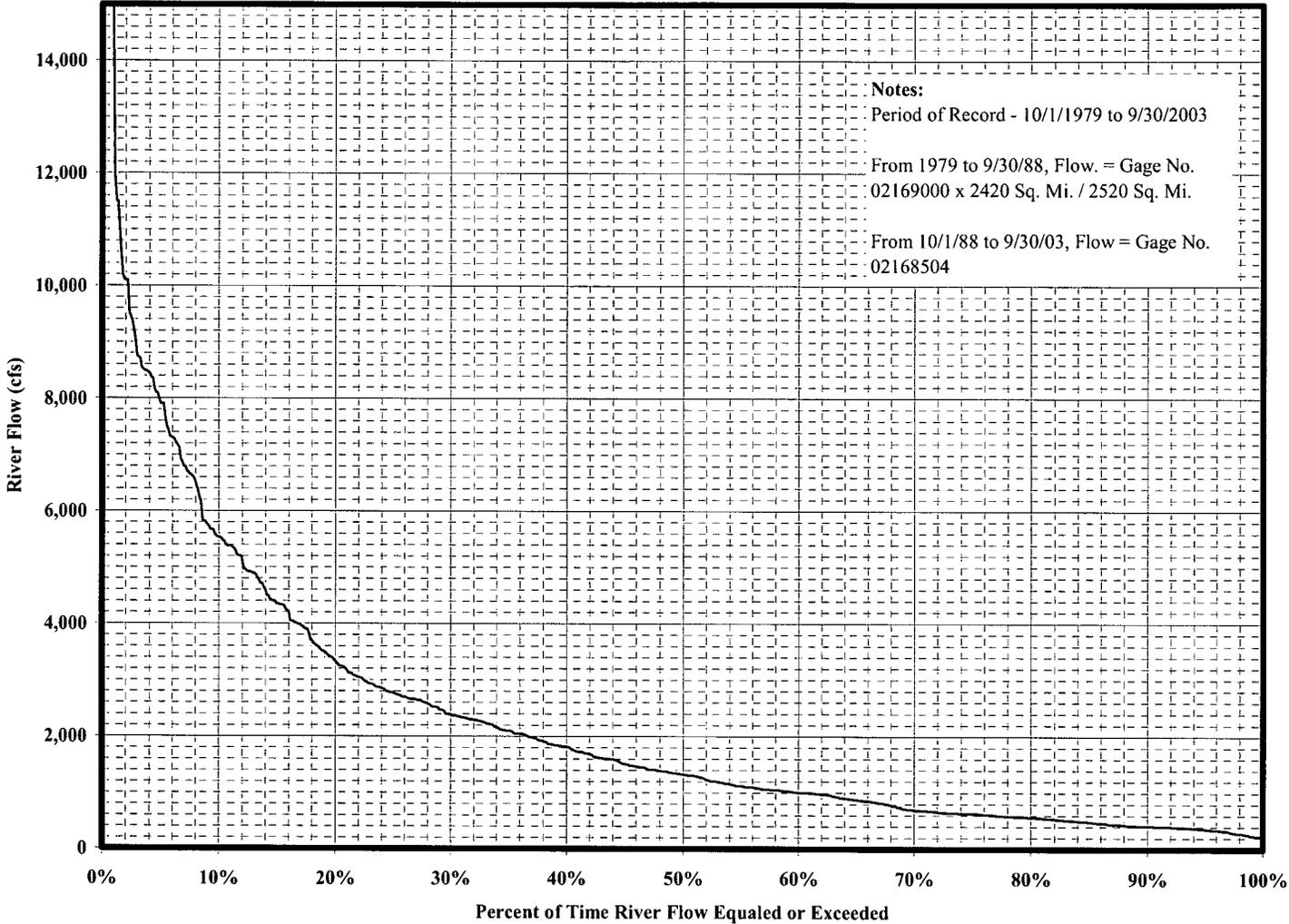


Figure B-9 Saluda Project FERC No. 516, South Carolina Electric & Gas Co., September Flow Duration Curve

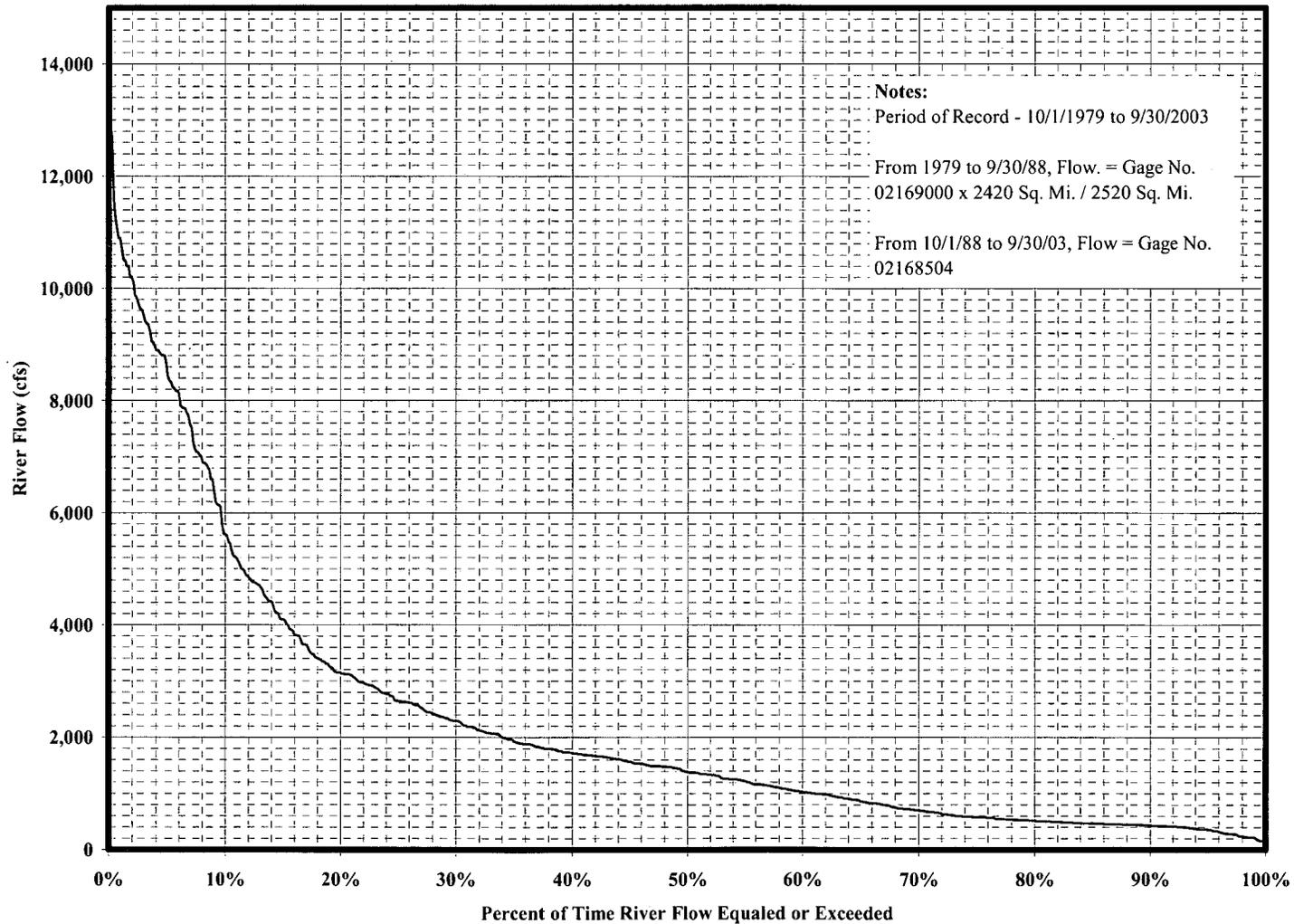


Figure B-10 Saluda Project FERC No. 516, South Carolina Electric & Gas Co., October Flow Duration Curve

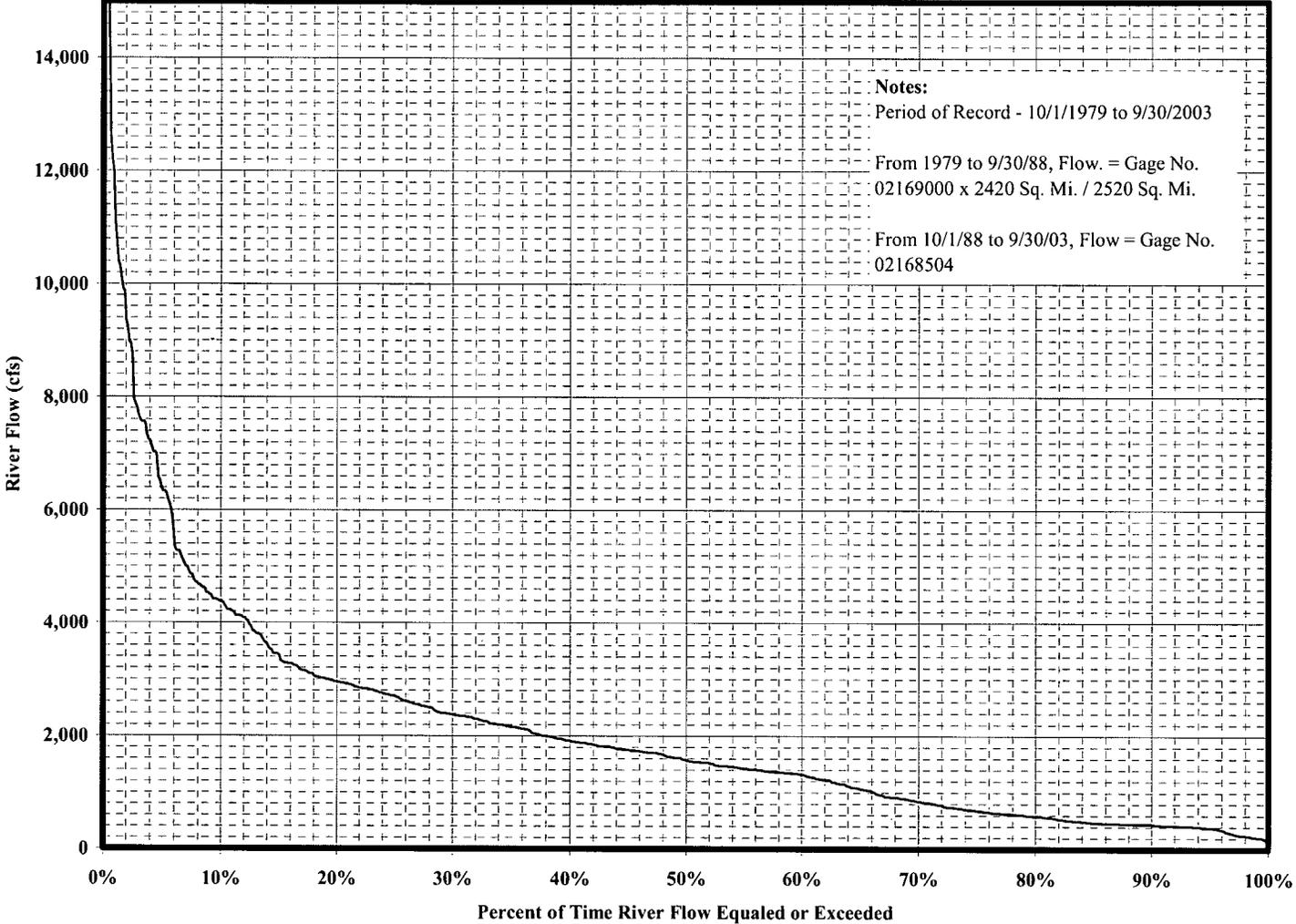


Figure B-11 Saluda Project FERC No. 516, South Carolina Electric & Gas Co., November Flow Duration Curve

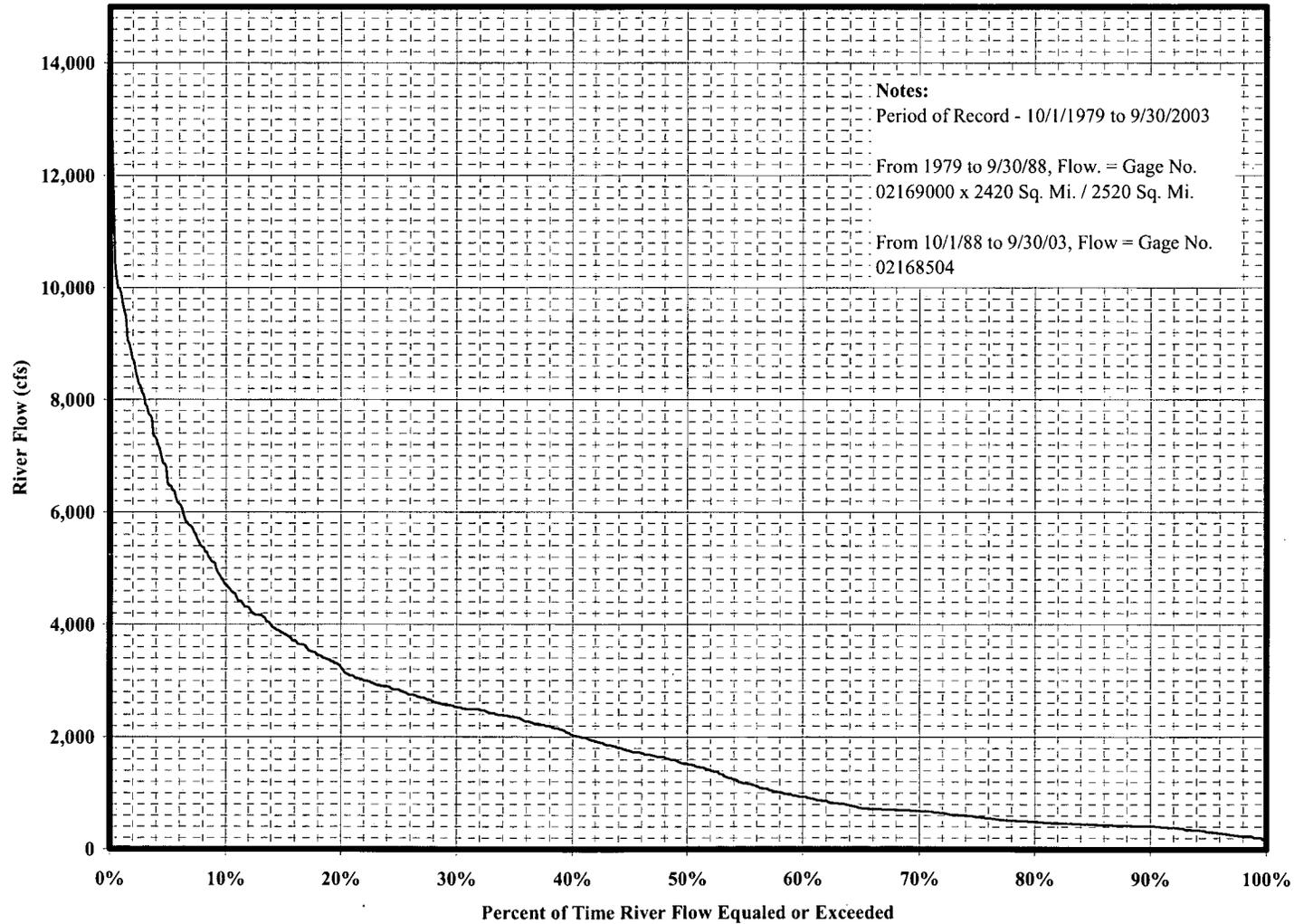


Figure B-12 Saluda Project FERC No. 516, South Carolina Electric & Gas Co., December Flow Duration Curve

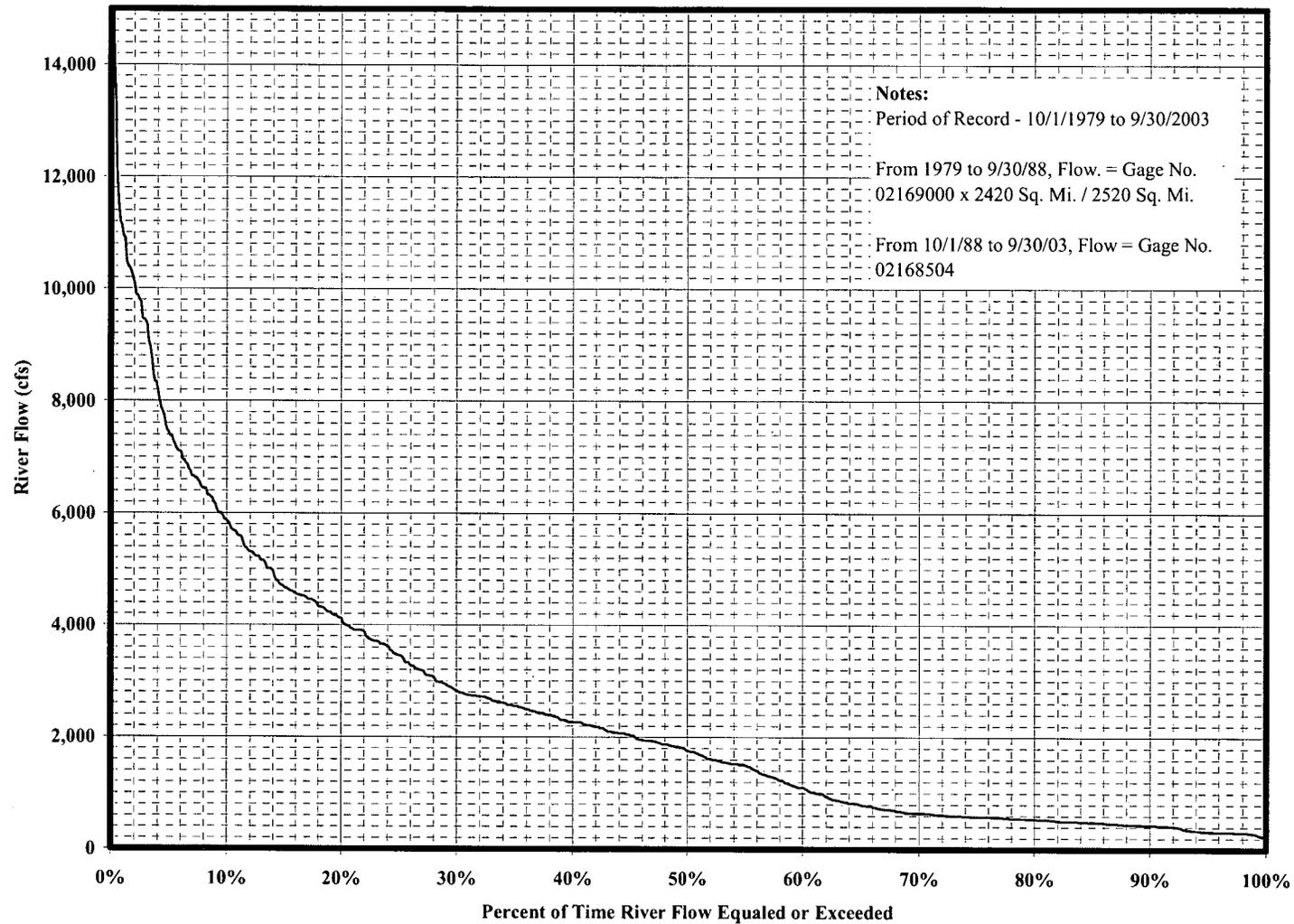
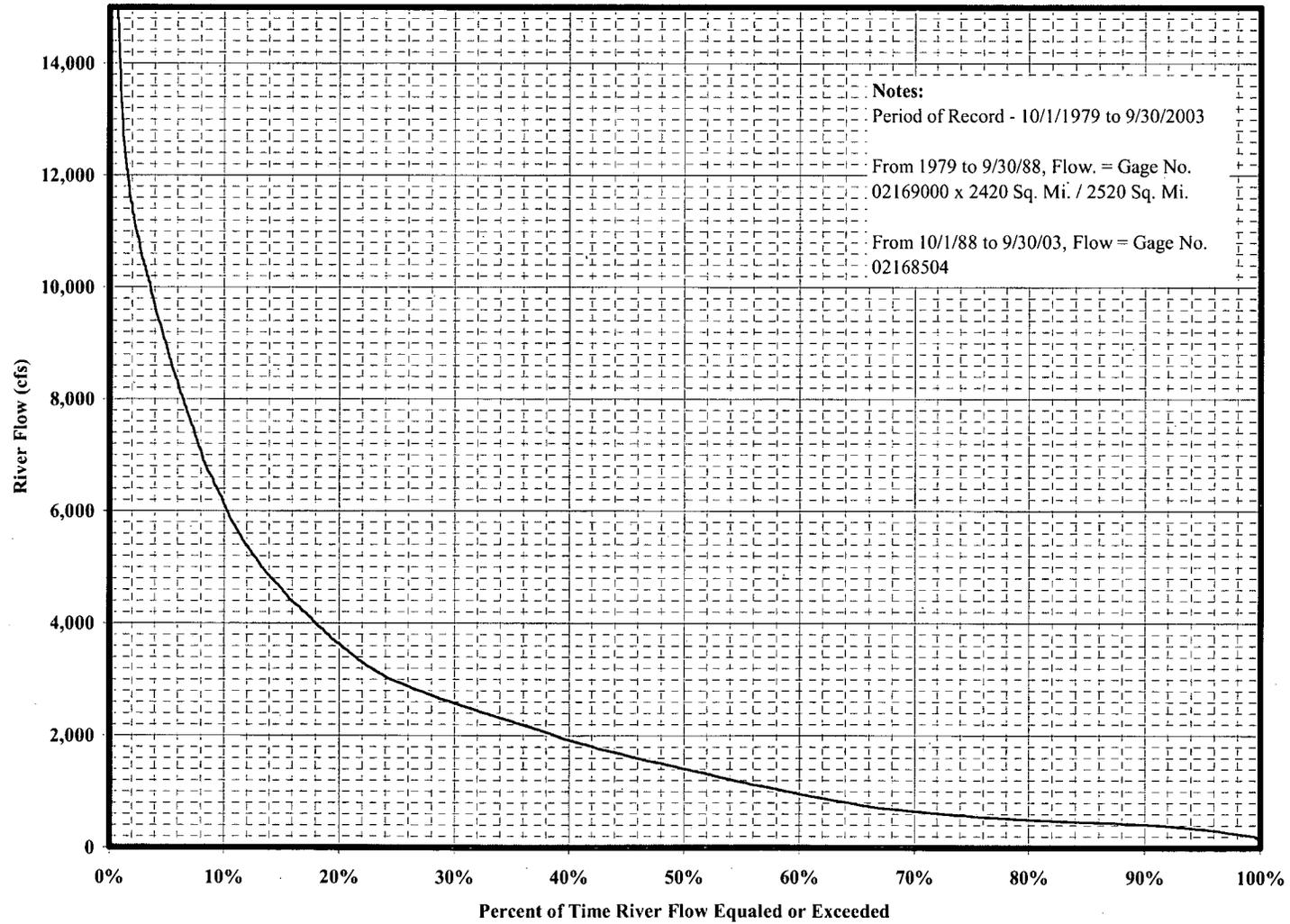


Figure B-13 Saluda Project FERC No. 516, South Carolina Electric & Gas Co., Annual Flow Duration Curve



C: THE SALUDA HYDROELECTRIC PROJECT HISTORY

The Saluda Hydroelectric Project was constructed in 1927 - 1930 by the Lexington Water Power Company, which merged in 1943 with SCE&G.

G. A. Guignard of Columbia incorporated Lexington Water Power Company in 1903. Guignard acquired the flowage rights on the Saluda River at Dreher Shoals, the present site of the Saluda Hydroelectric Project, and 20 miles upstream. He planned to build two dams - one at Dreher Shoals and another at Bear Creek five miles up the Saluda River.

Guignard sold the Dreher Shoals portion of the property in 1907. In 1925 the land became the property of General Gas & Electric Corporation, parent of Broad River Power Company and a unit of W. S. Barstow & Company, Inc. Guignard retained control of the Bear Creek site until May 1926 when the common stock of Lexington Water Power Company was purchased by the New York engineering firm of Murray & Flood.

Murray & Flood entered into an agreement with W. S. Barstow & Company for a mutual development of the Saluda Hydroelectric Project. On July 8, 1927 the *Federal Power Commission* (FPC) granted a license to Lexington Water Power Company for construction of a dam and powerhouse at Dreher Shoals. At this point control of the company passed principally from Murray & Flood to General Gas & Electric Corporation.

Construction of the Project began in April 1927 with the Arundel Corporation in charge of construction of the Dam. W. S. Barstow & Company, general contractor, was in charge of clearing work, spillway, power plant structures, machinery installations, substations, temporary and permanent housing, and the cableway connecting the Dam and intake towers. Hydraulic works design was by J. G. White Engineering Corporation.

Lake Murray reached an elevation of 300 feet PD in July of 1930. In 1931 Lake Murray reached an elevation of 350 feet PD, and in 1933 it reached 360 feet PD. In December of 1930 the first electric power was delivered to Duke Power Company. Lexington Water Company was a production company only, and as such did not own any *transmission lines*. The Saluda Project

was financed primarily through sales contracts with Carolina Power & Light Company, Duke Power Company and Broad River Power Company, all of which built their own transmission lines to the Saluda Hydro Plant.

When the hydro plant was completed it had four turbines, each capable of producing 32,500 Kilowatts (KW). When the Dam was built, plans were formulated to later add fifth and sixth turbines. The intake tower and the associated tunnels to carry lake water under the Dam to the future unit were constructed when the Dam was originally built.

In 1936 heavy rains and insufficient spillway capacity caused the lake to reach its maximum elevation of record – 361.38 feet PD. As a safety measure the FPC directed that the lake be lowered to an elevation of 350 feet PD. After further study the FPC then allowed the maximum lake elevation to be increased to 355 feet PD. This maximum elevation was maintained until the spillway capacity could be increased and better drainage achieved on the downstream face of the Dam.

Between 1943 and 1946 two additional spillway gates were added, the spillway discharge channel was enlarged and partially rerouted, and the Dam was strengthened by raising the crest elevation by 3 feet and adding rock excavated from the spillway channel to the downstream face of the Dam. When these measures were complete, the FPC permitted the increase of the lake elevation to its current maximum operating level of 360 feet PD.

In 1943, Lexington Water Power Company merged with SCE&G, in whose service area the Project was located. The FPC approved the Consolidation in an order issued in July 1943 [3 FPC 1046 (1943)].

Since the late 1950s, Lake Murray has also been used as a source of cooling water for the McMeekin steam electric generating plant. The FPC issued a finding and order on June 15, 1956 [15 FPC 1544 (1956)] approving the use of the Project reservoir (Lake Murray) for supplying circulating cooling water to McMeekin Station. McMeekin Station, which is located near the Saluda Hydro Plant, was completed and began commercial operation in 1958.

Engineering studies for adding a fifth generating unit at Saluda Hydro began in 1966. The FPC issued an amendment to the Project License, to include Unit No. 5, in December 1967 and construction began in 1968. The fifth unit, which is larger than the original four and can produce 70,000 KW, was put into commercial operation during the summer of 1971, making the total capacity of the Saluda Hydro Plant 216,000 KW. Computers from the dispatching office in Columbia control all five generating units.

In 1984, the FERC (formerly Federal Power Commission) issued a new license for the continued operation of the Saluda Hydroelectric Project (retroactive to the date of the original license expiration, August 1977).

As the Saluda Hydroelectric Project neared its 60th year of operation, a number of modifications were undertaken to insure its continued safe operation. Among these were removal of the surge tanks and improvements to the intake towers and spillway.

In 1988, studies began to determine whether the badly deteriorated surge tanks on Saluda Unit Nos. 1 and 3 could be safely removed. Over the years since the original construction of Saluda Hydro, the electric system in which it operates had changed, alleviating the need for the quick (about 6-second) on-and-off response time which the two surge tanks provided. Following analysis and testing that showed they could be safely removed; the tanks were demolished in late 1991.

In early 1990 man-doors were installed in the five intake towers to prepare them for epoxy grouting of cracks in the concrete walls between elevations 345 and 360 feet PD. The crack grouting was accomplished in the fall of 1990 with Lake Murray at elevation 345 feet PD. Also in the fall of 1990, Spillway Gate Nos. 5 and 6 were painted, gate seals were replaced, and damaged structural members of Gate No. 6 were replaced.

Installation of post-tensioned anchors in the south abutment wall of the spillway was begun in late 1991 and completed in February 1992. This work was done to stop rotation of the wall.

The four original riveted steel spillway gates (Gate Nos. 1 - 4), which were badly deteriorated, were replaced in 1994 with new welded steel gates of similar design. Installation was complete and all four gates tested in December 1994.

As a result of two of the articles in the license issued in 1984, two major modifications of the Dam have been required. In 1989, a sheet pile wall was added to the crest of the Dam at the upstream side of SC Highway 6, to protect the Dam from overtopping in the event of a new, larger PMF.

In 2002, construction activities began on a new dam immediately downstream of the existing Dam, which had been determined to be subject to possible failure during an occurrence of a seismic event of the magnitude of the 1886 Charleston earthquake. The new dam will consist of rock fill sections on the north and south ends, with a roller-compacted concrete section in the center. The existing Dam will remain in place, and during construction, additional material will be added to it to provide a base for two additional lanes of SC Highway 6. The new dam is scheduled to be complete in the spring of 2005.

The Project is subject to the Applicant's lien of the Indenture dated as of January 1, 1945 of South Carolina Power Company (SCE&G, as successor corporation) to Central Hanover Bank and Trust Company (J P Morgan Chase Bank, successor trustee), as Trustee, as amended and supplemented.

E: ENVIRONMENTAL RESOURCES

8.0 GEOLOGY AND SOILS

8.1 Geological Setting of the Saluda Dam

Saluda Dam is located along the Eastern Piedmont Fault zone (Hatcher, 1977) in west central South Carolina. This Fault Zone extends from Western Georgia through Virginia and can be seen as a strong lineament on the Aeromagnetic Map on Figure E-1. The magnetic anomaly illustrated indicates presence of a deep basement structure. At the surface near Saluda Dam, this structure is mapped as the Modoc Shear Zone (MZ), as shown on Figure E-2. The foundation bedrock at Saluda Dam is composed of metamorphosed mid to upper-level amphibolite grade facies rocks. The foundation lies along the Modoc Shear Zone, a 4-5 km wide fault zone characterized by a steep metamorphic gradient, indication of intense plastic strain, and presence of lenticular granitic bodies (Snoke and Frost, 1990). Generally, the Zone extends from the Shull Island Peninsula of Lake Murray to Clark Hill Reservoir on the Savannah River (Secor and Snoke, 1978) and continues to the south until overlapped by Coastal Plain sediments. The fault zone occurs between the southern flank of the Carolina Slate Belt, a zone of greenschist facies metasedimentary and metavolcanic rocks deposited during late Precambrian to Cambrian (630ma), and the northwestern flank of the Kiokee Belt, also known as the Dreher Shoals Terrane (Hibbard et al., 2002). The latter has amphibolite facies metasedimentary and metavolcanic rocks with stratiform masses of plutonic orthogneiss (Secor and Snoke, 1978). The Carolina Slate Belt borders the northeastern terminus of the Dreher Shoals/Kiokee belt outcrop to the east of Lake Murray. The location of the Modoc Zone in relation to the two belts is shown on Figure E-3. Rocks of the Modoc Shear Zone are dominantly a metamorphic assemblage of schist and gneiss in an antiform structure with schist mantling the gneiss on the north, east and south. Many interpret that the protolith of the gneiss was granite and the source material for the schist was sedimentary (Carr, 1978).

Unlike the Carolina Slate Belt, the Modoc Zone experienced late Paleozoic high-grade metamorphism (Secor and Snoke, 1978), and overprinted evidence of earlier Taconic and/or Alleghanian greenschist events.

8.2 Late Paleozoic Orogeny Deformation Patterns

At least two episodes of the late Paleozoic Orogeny affecting the eastern Piedmont are considered to be associated with movement along the Modoc Shear Zone. The deformational events relevant to the area are known as D1 (Delmar Deformation), D2 (Lake Murray Deformation), D3 (Clarks Hill Deformation), and D4 (Irmo Deformation) (Clendenin and Niewendorp, 1997).

Evidence for D1 deformation in the Kiokee Belt has been largely destroyed by later Paleozoic events. D1 in the Slate Belt is synchronous with regional greenschist facies metamorphism and resulted in slaty cleavage and foliation. This deformational event occurred approximately 520-300 (Pre-Alleghanian) million years ago (ma) as described in Secor and Snoke, 1978.

D2 took place during the late Carboniferous to Early Permian, 290-250ma, (Clendenin and Niewendorp, 1997), 315-292ma, (Snoke and Frost, 1990) and is characterized in the Modoc Zone by high-grade amphibolite facies metamorphism with regional folding. D2 is seen only locally in the Carolina Slate Belt. It is thought that rapid cooling after the Lake Murray deformation caused crustal omission across the Modoc Zone boundary, allowing for juxtaposition of the high-grade rocks of the Modoc Zone with the mid-grade rocks of the Carolina Slate Belt.

D3 resulted in vertically dipping dextral shear bands and mostly dextral folds. Shear bands strike approximately N10E-N40E. D3 deformation occurred approximately 255ma (Secor and Snoke, 1978). It was during this time that formation of the steeply plunging (NE) Irmo Antiform was initiated (Secor et al., 1986). The nose of the fold near Irmo marks the eastern terminus of the Modoc Zone/Kiokee Belt. The boundary between this fold and the Carolina Slate Belt is narrow and marked by intense mylonitization, similar to what was mapped in areas within the Dam foundation, and an almandine garnet

isograd (Secor and Snoke, 1978). The outcrop mapped in the excavation for the RCC Berm may contain a near complete exposure of the northern limb (NE-dipping) of the Irmo antiform (Hare, et al., 2004). Howard (2004) describes D-3 structures in rocks located less than three miles north of Saluda Dam; however, no D-3 structures were observed in the Berm excavation.

The late Paleozoic D4 deformational event produced early ductile structures (asymmetric dextral folds) and transitioned to late brittle fold-fault features. D4 occurred predominantly under retrograde metamorphic conditions (Clendenin and Niewendorp, 1997). The steeply plunging (NE) Irmo Antiform, while initiated during D3, is predominantly a result of D4 deformation (Secor, et al., 1986). Major lithologies mapped in the foundation of the Saluda Dam are:

- mylonitized quartzo-feldspathic microcline gneiss, or the Lake Murray Gneiss (MGN);
- mylonitized quartz biotite plagioclase schist (QMS);
- hornblende schist (HBS);
- kyanite schist (KS);
- leucocratic schist (LS);
- biotite schist (BS);
- garnetiferous schist (GT);
- quartz biotite plagioclase schist-gneissic phase (GP);
- alkali feldspar granite intrusive (AFG);
- deformed amphibolite (AMP);
- potassium and two-feldspar pegmatites (P);
- mafic (MD) and felsic dikes (FD) (previously mapped as lamprophyre or camptonite dikes by others);
- aplite (A); and
- anatectic granite/plagio-granitic sheets (GS).

The geologic map of these rocks is presented in RIZZO, 2005.

Common ductile deformation structures seen in the bedrock include sheath folds, boudinage, shear bands, tight to isoclinal (D2) folds, riedel shears, and mesoscopic kinematic indicators such as rotated porphyroblasts and sigmoidal fabric. Evidence of late brittle deformation is seen in numerous fractures and faults (striking NNW to NNE) and zones of brecciated material (Hare et al., 2004). Temperatures of 645 to 695°C degrees with pressures between 7.2 to 8.2 kb (30 km depth) are estimated for the garnetiferous pelitic schist in the spillway to the south of the Saluda Dam (Snoke and Frost, 1990).

As described in Hare et al., (2004), exposed rock in the foundation excavation consists of metamorphosed middle to upper amphibolite facies schist and gneiss that record multiple deformational events consistent with those exposed in the Lake Murray spillway. The geology of the spillway, approximately 1000 feet to the south of the Dam, has been studied by a number of researchers over the past 40+ years, most notably by D. T. Secor (Hare, et al., 2004) and is consistent with the geology seen in the Dam foundation.

8.3 Tectonic History of the Saluda Dam Area

During the Devonian through Carboniferous Periods, Africa and Europe were colliding with North America to begin the formation of the Appalachian Mountains. This mountain building event culminated with the Alleghanian Orogeny. Throughout this time, small micro-continents slid past and accreted onto North America. The Modoc Zone records at least part of this movement. Pervasive right lateral deformation is the most common structural feature displayed in the rocks of the Modoc Zone. This deformation is the result of at least tens of kilometers, but more likely several hundreds of kilometers of movement, and is direct evidence that two landmasses were sliding past each other. Modoc Zone rocks exposed at the Dam site were deformed at depths of 28 to 32 kilometers. This depth is far below the depth of possible seismic activity as rock is too ductile for brittle failure to occur.

In the past, rocks beneath the Rockfill and RCC Berms were generally called either schist or gneiss with some younger intrusives; however, detailed mapping has resulted in a more complex description. The ductile deformation of these rocks is tightly constrained by radiometric dating and may have occurred within a 50 million year period during late Pennsylvania and Permian time (Dallmeyer et al., 1986). Rock at numerous locations demonstrates a range of anatectic processes from differential melting, resulting in migmatization of the schistose units, to complete recrystallization. This range of processes produces tabular masses of differential melt derived "plagio-granites".

The rocks in the Dam foundation retain strong evidence of D-2 and D-4 (Lake Murray and Irmo) deformations. D-2 deformation includes migmatization and mylonitization. D-4 deformation is characterized by dextral shear, folding and faulting. These ductile structures are consistent with those reported by Dennis, et. al., and others (1987) for late-Alleghanian deformation in the area.

The mylonitized gneiss, schist and amphibolite units exhibit similar evidence of ductile deformation, which indicates that these rocks were deformed under comparable pressure and temperatures. Specifically, the dominant lithologies (Lake Murray gneiss and quartz biotite plagioclase schist) are S-C mylonites and have similar duplexes, boudinage, and disrupted fold sets. They also exhibit the same kinematic features – generally right lateral shearing. Contacts between the plagio-granites and surrounding gneiss or schist are sharp and exhibit little melting of the surrounding rock; however, the grain size is commonly coarser near the margin and finer in the interior of the plagio-granites.

All of the ductile deformation described in the preceding paragraphs occurred between 315 and 270 to 250 million years ago. From approximately 260 million years to 100 million years ago, the region was subjected to erosion and approximately 20 to 30 kilometers of material was stripped off. The east coast of North America evolved from being an active plate boundary to a passive continental margin. This is an important constraint upon the timing of seismic activity. Plate convergence ceased in this region at approximately 260 million years ago. After this time, seismic activity was predominantly related to basement readjustment. As material is eroded and transported across the land

surface, the stress state within the crust changed. These processes do not apply to one particular fault or fracture as much as they apply to all of the faults and fractures in the region.

During the Triassic Period, Africa and Europe decoupled from North America. Intrusives filled some fractures created during this extensional event, forming dikes. Triassic extension and subsequent infilling with igneous materials are processes that continue today at the Mid-Atlantic ridge. Dikes within the rock in the Berm foundation have various compositions ranging from diabasic to felsic and mafic. These dikes have not been age dated, but based on cross cutting relationships and a lack of strong ductile deformation, it is concluded that they are younger than the gneiss and schist rocks that they intrude. Other similar dikes within the Atlantic Coastal plain have been dated at 210 million years to 168 million years (upper Triassic to Jurassic age). Some dikes are offset and are associated with later seismic activity. However, as discussed in the preceding paragraph, the region was no longer a convergent plate boundary and most seismic activity was caused by extension as Africa pulled away from North America.

Following initial rifting, the predominant source of seismic activity was basement readjustment as 20 kilometers of crust was eroded. Large-scale erosion and deposition occurred contemporaneously, which contributed to differential loading and unloading and fracturing of the rock below.

During the Upper Cretaceous period, sediments of the Middendorf Formation were deposited on top of the erosional surface. Outcrops of the Middendorf can be found within a mile southeast of the Dam site. Middendorf and younger sediments are terrestrial (and deltaic) sands and gravels. They are the product of an eroding mountain range to the west. These sediments probably overlaid the area of the Dam site until relatively recently and would have protected the underlying rock from physical erosion. It is unlikely that the Coastal Plain sediments were more than a few hundred meters thick. This is due to the fact that sediments were continually migrating seaward and being deposited off of the continental margin. Lithification and/or diagenesis typically occur below 200°C and 3 kb (300 Mpa), so we can assume that burial conditions did not exceed these values if no cementation or crystal growth has been observed in the Coastal Plain

Sediments. Where exposed, these sediments are comprised of unconsolidated sands and often have a basal gravel layer.

Concretions are common within the Middendorf Formation due to ground water flow; however, grain-to-grain cementation has not been documented. Lack of cementation is evidence of shallow burial of the Coastal Plain Sediments. It also provides an explanation for the deep weathering profile observed in the Berm excavations.

Physical erosion of rocks halted 100 million years ago and chemical weathering processes dominated. This halting of physical erosion prior to 100 million years constrains the time of faulting prior to 100 million years as the faults include mineralization that only forms at depth. We note that seismic activity due to basement readjustment is always possible. We found no evidence of faulted Coastal Plain Sediments, however there is evidence that basement readjustment continued after deposition of Coastal Plain sediments within the Cretaceous.

8.4 Soils

The soils of the Project Area are predominantly Ultisols of the Carolina Slate Belt. These soils are described as the highly weathered soils of humid regions, with very low fertility, and a great deal of leeching. Their low fertility makes Ultisols well-suited for pasture or forest use (Mead and Hunt, 2000). Due to a subsurface accumulation of illuvial clay, these soils are often reddish or yellowish in nature. The Ultisols of this region generally have an *argillic horizon*. Due in part to weathering and climatological influences, ultisols have a low base saturation, usually less than 35 percent in the lower part of the soil profile.

The predominant soil association of the Project area is the Georgeville-Herndon-Almance association. These soils were mainly developed in residuum, from the fine-grained slate rock of the Carolina Slate Belt (USDA, 1962). They generally have moderate permeability with medium to high available water capacity and medium

amounts of runoff (USDA, 1976). The predominant texture class is a silt-loam surface soil, with a clayey subsoil (USDA, 1962). These gently sloping upland soils are highly dissected with drainage ways (Mead and Hunt, 2000; USDA, 1962). Wave action on the exposed shorelines of Lake Murray creates soil erosion problems in some areas, and in areas where bedrock is located close to the surface, soil slumping may occur. However, over the past 20 years, shoreline stabilization projects have been put in place to reduce the effects of such erosion on Project Areas (Mead and Hunt, 2000).

The thickness of the soils is dependent upon the rock type with the soils overlying the Gneiss unit being very thick (30 to 90 feet) and the soil over the schist unit being thinner (10 to 30 feet). The thinnest soil zones are on the tops of hills and very thin soils can be found at the abutments of the Saluda Dam.

8.5 Climate

The Project Area experiences a moderate climate year-round with long hot summers and short mild winters. July and August are typically the hottest months, with temperatures reaching above 90 degrees on an average of 49 days per year. Temperatures may reach 100 degrees or more on about two or three days. Summer is typically the wettest season, with 1/3 of the total annual rainfall occurring during this time. This is due to the frequent occurrence of showers and thunderstorms throughout the season. Masses of warm, fairly unstable, maritime tropical air typically persist in the atmosphere during the summer. However, the daily weather during the winter, fall, and spring is greatly influenced by the west to east motion of fronts and air masses (USDA, 1976).

Fall is characteristically the driest season, with warm, comfortable weather. Typically only 19 percent of the total annual rainfall occurs during this time. However, occasionally, tropical storms and hurricanes travel through the area during this season. The earliest killing frost may occur in late October, but occurs more frequently in early November. On about 60 percent of winter days, temperatures reach 32 degrees, and usually fall to 20 degrees or less on about 6 days out of the year (USDA, 1976). Soils occasionally freeze to a depth of 3-5" (USDA, 1962). Significant amounts of snowfall in

the Project Area occur infrequently. When they do occur the snow seldom remains longer than 1 day. Winter rainfall accounts for about 22 percent of the annual total (USDA, 1976).

March brings about heavy rains that gradually fade into a dry period that lasts from late April to June. Thunderstorms occur frequently during the spring, adding greatly to a yearly average rainfall of 46 to 48". The average date of the last freezing temperature in the spring is March 22 (USDA, 1976).

9.0 *WATER QUALITY*

This section includes a review of the data that has been collected over the last 30 years for the tributaries, Lake Murray, and the tailwaters associated with the Saluda Hydroelectric Project. The tailwaters refer to the section of the Saluda River immediately downstream of the Dam. First, a brief summary of the water quality standards applicable to each water body associated with the Project is necessary, and is given below.

9.1 Applicable Water Quality Standards

All waters entering and within Lake Murray are classified as “freshwaters (FW).” FW waters are considered suitable for primary and secondary contact, recreation, and as a drinking water supply using conventional treatment (based on requirements set forth by SCDHEC). FW waters are also suitable for industrial and agricultural uses, fishing, and the survival and propagation of a balanced indigenous aquatic community of flora and fauna.

SCDHEC water quality standards for FW waters (all waters entering and within Lake Murray) include (SCDHEC - Chapter 61, 2001):

DO	Daily average not less than 5.0 mg/L with a low of 4.0 mg/L
Fecal Coliform	Not to exceed a geometric mean of 200/100mL, based on five consecutive samples during any 30-day period; nor shall more than 10% of the total samples during any 30-day period exceed 400/100mL
pH	Between 6.0 and 8.5
Temperature	Not to vary from levels existing under natural conditions, unless determined that some other temperature shall protect the classified uses
<i>Turbidity</i>	Not to exceed 50 Nephelometric Turbidity Units (NTUs) (25 NTUs for lakes) or 10% above natural conditions, provided existing uses are maintained

In addition to the above standards, numeric nutrient criteria exists for lakes of 40 acres or larger, and are based on an ecoregional approach that takes into account the geographic location of the lake within the state. Lake Murray is situated in the Piedmont and Southeastern Plains ecoregion of the state. Nutrient criteria for this ecoregion include the following:

Total Phosphorous	Shall not exceed 0.06 mg/L
Chlorophyll <i>a</i>	Shall not exceed 40 µg/L
Total Nitrogen	Shall not exceed 1.50 mg/L

The section of the Saluda River downstream of the Saluda Dam was classified as “trout put, grow, and take” (TPGT) in 1990. TPGT waters are considered suitable for supporting the growth of stocked trout populations and a balanced indigenous aquatic community of flora and fauna.

SCDHEC water quality standards for TPGT waters (section of Saluda River downstream of the Saluda Dam) include (SCDHEC - Chapter 61, 2001):

DO	Daily average of not less than 6.0 mg/L
Fecal Coliform	Not to exceed a geometric mean of 200/100mL, based on five consecutive samples during any 30-day period; nor shall more than 10% of the total samples during any 30-day period exceed 400/100mL
pH	Between 6.0 and 8.0
Temperature	Not to vary from levels existing under natural conditions, unless determined that some other temperature shall protect the classified uses
Turbidity	Not to exceed 10 Nethelometric Turbidity Units (NTUs) or 10% above natural conditions, provided existing uses are maintained

Up until 2002, a site specific DO standard for the lower Saluda River (LSR) existed which was a daily average of 5.0 mg/l with no instantaneous minima. In that same year, the SCDHEC proposed changes to the existing DO site-specific standard for the LSR downstream of the Saluda Dam/Lake Murray. SCE&G working cooperatively with the SCDHEC, South Carolina Department of Natural Resources (SCDNR) and the Environmental Protection Agency (EPA) developed a study plan that would:

1. Describe the methodology to be used to identify a scientifically-based alternate DO standard for the LSR, and;
2. Develop and present a proposed numerical site-specific standard to the SCDHEC and SCDNR.

The study plan proposed distinct elements that are all integrated and critical in determining a site specific DO standard for the LSR. The studies in the plan address the designated use which is trout put, grow, and take. Those elements include:

1. In-situ trout growth study.
2. Turbine venting modeling.
3. Tailwater modeling.
4. Bio-energetics modeling.

Upon completion of the identified studies, a detailed report was prepared which documents results of scientific investigations necessary to formulate that proposed site-specific standard. These investigations included a trout growth study conducted during 2002-2003 and extensive modeling related to tailwater water quality, fish growth, and turbine venting effectiveness.

The fish growth study on the LSR indicated that an excellent trout fishery exists on the river. This fishery exists even though DO concentrations on occasion fall below 2 mg/L. The fish growth model showed that the good trout growth is due in part to the relatively high average DO concentrations that have occurred in the river due to the aeration system (implemented by SCE&G in 1999), in conjunction with the reduced incidence of high flows due to recent drought years, and a favorable temperature regime. It is estimated that the fishery would do nearly as well during normal hydrologic years using the current aeration system; however, in wet years or in years when the *pool* level of Lake Murray is drawn down for special purposes in September or October, the difference in fish growth might be measurable (i.e., a difference greater than 1/2 ounce or 1/16 inch was considered measurable for fish weighing over 2 pounds and having a length of about 18 inches).

In order to estimate the range of DO conditions the fishery might be exposed to in the future, a turbine aeration model was developed to predict the effects of using various aeration alternatives. This model was then used to predict DO conditions in the river for the years 1990 (wet), 1992 (normal), 1996 (normal with a special drawdown of Lake Murray), and 1999 (dry). The results of the turbine aeration model were summarized as DO metrics (e.g., minimum daily DO, average daily DO, 30-day average DO, etc) that represented potential measures of DO that could be considered for setting DO standards.

A tailwater hydrodynamic water quality model was calibrated using actual onsite water quality data. A fish bioenergetics model was calibrated using tailwater model results and results of the growth study. The fish bioenergetics model was then used to estimate trout growth for various aeration scenarios for each of the years. The results showed that growth was best correlated to the moving 30-day average DO. This finding is consistent with the recommendations in the EPA criteria document for DO.

A central concern was found to be the minimum DO level that occurs with the current aeration system. A minimum DO of 3 mg/L is considered to be protective for trout survival, and this same level likely would be sufficient for other aquatic life that serves as food supply for the fishery. However, a minimum of 4 mg/L has been set by SCDHEC for application to all waters of the State, and SCDHEC made it clear that nothing less than that standard would be accepted by them. SCE&G had little choice but to propose 4 mg/L as the minimum DO for the site-specific standard.

The results of the scientific studies, in addition to SCDHEC's admonition regarding an acceptable minimum, supported the following site-specific standard for the lower Saluda River:

- Instantaneous DO 4 mg/L minimum
- Daily average DO 5 mg/L minimum
- 30 day average DO 5.5 mg/L minimum

These levels of DO were shown to be protective of the fishery and would achieve trout growth objectives equivalent to those that would result from application of the DO standard previously proposed by SCDHEC.

After going through extensive state and federal regulatory review and legislative processes the above site specific DO standard was adopted for the LSR in 2004.

9.2 Lake Murray Water Quality Conditions

9.2.1 Tributaries to Lake Murray

When considering which water quality parameters are important for Lake Murray, it is essential to consider those that may impact the designated uses, such as recreation, fishing, and drinking water supply. The most important parameters to consider include pathogens (*i.e.* fecal and total coliform), temperature, DO, nutrients (*e.g.*, phosphorous), chlorophyll *a*, and water clarity. Major factors that may affect these water quality parameters are significant point source discharges

(e.g., wastewater treatment plant effluents), septic systems around the lake, and other miscellaneous activities within the watershed. Therefore, it is important to consider water quality not only in the lake/reservoir, but also in the tributaries or inflows to the lake, and in the tailwaters or section of Saluda River downstream of the Saluda Dam.

Lake Murray has several tributaries that contribute to the large volume of water that is stored in the reservoir. Some of the major tributaries are the Saluda River, Little Saluda River, Bush River, Little River, Clouds Creek, Rocky Creek, and Ninety-Six Creek. The Saluda River is the primary source of water to the lake, contributing approximately 68% of the mean *streamflow* into Lake Murray. The other six tributaries make up the remaining 32% of the inflow. While the lake itself covers approximately 75 square miles, the drainage area for Lake Murray encompasses 2420 square miles.

As stated above, Saluda River is the main flow entering Lake Murray. Nearly 55 miles upstream of the Saluda Dam on the Saluda River is the Buzzard's Roost Dam. Water from behind this dam (Lake Greenwood) is the primary source of water that enters Lake Murray. In the late 1980's, the level of nutrients and organic matter released from the Buzzards Roost Dam (Buzzards Roost) was reduced.

With the exception of the Dreher Island State Park, wastewater discharge, there are no direct point source discharges into Lake Murray. Table E-1 lists the major wastewater discharges and the number of minor discharges in each of the tributary watersheds of Lake Murray, downstream of Buzzards Roost on the upper Saluda River. Run-off and other non-point sources are considered significant in such a large watershed, with residential and commercial development at such high levels. SCDHEC has monitored water quality in both Lake Murray and its tributaries on a monthly basis since 1973. The primary water quality parameters of concern in the tributaries include nutrients, with respect to their loading into Lake Murray, specifically total phosphorous, 5-day biochemical oxygen demand (BOD₅), a measure of the organic pollution in a surface water, total kjeldahl

nitrogen (TKN), a measure of the organic nitrogen and ammonia nitrogen, nitrate+nitrite, chlorophyll *a* (popular measure of biological productivity in water bodies), and fecal coliform. Phosphorous is normally the limiting nutrient in freshwater systems. Sources of phosphorous include both point (*e.g.*, wastewater treatment plants) and non-point sources (*e.g.*, agricultural run-off and septic system leachate).

According to a 1998 report from SCDHEC, the SCDNR led an intensive watershed study on the Bush River and Camping Creek to address non-point sources. This is primarily an agricultural watershed that drains into Lake Murray. The study began in 1990 and continued through August of 1998. The study funded the implementation of Best Management Practices (BMPs) for farmers in the watershed, related to row-cropping and confined animal operations. BMPs involved manure nutrient testing, portable animal waste lagoon pump-out and spray irrigation equipment available for rent, as well as effective pesticide management.

Phosphorous

Four of the tributaries to Lake Murray, including Ninety-Six Creek, Bush River, Little Saluda River, and Clouds Creek, contribute approximately 73 percent of the total phosphorous to Lake Murray; while their stream flows contribute only 20 percent of the flow into the lake (see Table E-3). The total phosphorous concentrations in these smaller tributaries are likely caused by point sources (*e.g.*, wastewater treatment plants) and development in the watershed. If the total phosphorous concentrations were reduced in these streams, the upper lake area would have less algal growth and improved water clarity. Because of the reduced algae levels, the DO levels in Lake Murray and the releases from the Saluda Project would increase. In order to reduce nutrient loading into the lake, specifically phosphorous, the SCDHEC recommended implementing watershed management practices with an emphasis on the Rocky Creek and Bush River sections of Lake Murray.

Data from just downstream of Buzzard's Roost Dam on the Saluda River indicate that total phosphorous levels have steadily decreased since 1985, due to the implementation of tertiary treatment at the Greenville wastewater treatment facility (point source discharge to the Saluda River). The current mean concentration of total phosphorous at this station is roughly 0.02 mg/L. Total phosphorous concentrations seem to increase drastically from the station just below Greenwood Dam, to the station on Saluda River located at SC 39 near Chappells. Approximately 3.5 miles downstream of the Greenwood Dam at the Chappells station, concentrations were averaging 0.06 mg/L. This may promote a significant amount of organic loading to Lake Murray due to the relationship between total phosphorous and algal growth. Ninety-Six Creek, which empties into the Saluda River downstream of Buzzards Roost, has a mean total phosphorous concentration of approximately 0.7 to 1.0 mg/L and this water body is most likely responsible for the increase in total phosphorous levels on the Saluda River from the station downstream of Buzzards Roost to the station near Chappells.

Bush River, near its inflow point to Lake Murray, contains high concentrations of total phosphorous, about 0.8 mg/L. The Bush River had the highest total phosphorous concentration in 9 of the 12 months sampled during the comprehensive assessment conducted in 1974 to 1975. The Little Saluda River near the inflow to Lake Murray has been monitored by SCDHEC since 1974. The SCDHEC data show a significant decreasing trend of total phosphorous concentrations since 1974, with a major decline in 1989. These major declines observed in 1989 correspond to improvements of the Western Carolina Regional Authorities treatment plant serving the city of Greenville, SC. The current total phosphorous levels in the Little Saluda River, near the mouth, are 0.2 mg/L. Clouds Creek, which feeds into the Little Saluda River, shows the exact opposite trend of the Little Saluda, with increasing concentrations since 1979. Near the Clouds Creek mouth, average total phosphorous concentrations are about 0.3 mg/L.

*BOD₅, TKN, Nitrate+Nitrite, Chlorophyll *a*, and Fecal Coliform*

With respect to the other water quality parameters, information is provided for the Saluda River, specifically from the monitoring station located just downstream of Buzzard's Roost and is considered representative of the primary input of each to Lake Murray. The BOD₅ levels in the Saluda River have decreased from a mean of 2.5 mg/L from 1969 to 1986, to a mean of 1.3 mg/L from 1987 to 1998. TKN levels followed a similar pattern to total phosphorous, due to the TKN associated with algal growths. Nitrate+Nitrite concentrations appear to have decreased since 1985. It is also important to note that each year the nitrate+nitrite concentrations decrease to near zero during the summer and fall months, which may limit the type of algal growth that may occur in the upper end of the lake to the troublesome blue-green algae species. The upper lake tributaries were found to have the highest chlorophyll *a* concentrations, such as the Saluda River, Little Saluda River, Bush River, and Clouds Creek.

9.2.2 Lake Murray

Lake Murray covers approximately 78 square miles and is approximately 41 miles long, with a maximum width of 14 miles, and a maximum depth of 180 feet (mean depth = 46 feet). Because of its size and the hydrology of the system, Lake Murray has a long retention time of approximately 417 days. It is this characteristic that causes the lake to thermally stratify each year, resulting in water quality conditions that have been extensively studied and monitored.

9.2.2.1 Past Studies

A significant effort has been placed on collecting water quality data in Lake Murray for the past 60 years. Different agencies, including the South Carolina Pollution Control Authority (SCPCA), SCDHEC and U.S. Geological Survey (USGS), have made various water quality measurements for the reservoir during the 1950s, 1960s, and early 1970s. SCDHEC has continued to monitor water quality in both the lake and its

tributaries on a monthly basis since 1973. In 1974, the EPA included Lake Murray in the National *Eutrophication* Survey, which collected data from specific lakes and reservoirs all over the U.S. Most recently, SCE&G coordinated with USGS to collect data on Lake Murray from 1990 to 1996, using 13 water quality monitoring stations (12 are located on Lake Murray and one is downstream from the Saluda Dam). SCE&G has continued the water quality monitoring effort since 1996, collecting monthly field samples at all 13 locations and chemical samples twice a year at seven of the stations.

Comprehensive Assessment of Lake Murray (1974 – 1975)

In preparation of relicensing for the current FERC license, a comprehensive assessment of Lake Murray was conducted from September 1974 through August 1975. Using a total of 33 different stations in and around the lake, 24 different physical and chemical parameters were sampled and tested during the one-year period. The comprehensive study determined that:

1. Total alkalinity levels in Lake Murray were low;
2. pH levels were rarely outside of the Class A limits for waters of 6.0 to 8.0 (SCPCA), with pH levels ranging from 5.3 to 9.1 during the 12-month study period;
3. The highest chlorophyll *a* levels were found in the upper lake tributary stations;
4. Total phosphorous concentrations were highest in the upper lake, near the inflows/tributaries, and lowest near the Dam, with a mean concentration for the lake of 0.10 mg/L;
5. Fecal and total coliform levels were occasionally high in the Lake, exceeding the standards at some of the upper lake stations on occasion, specifically after periods of heavy run-off in the watershed (storm

events);

6. 12 of the 24 trophic status determinations classified the lake to be mesotrophic and 11 of the 24 determinations classified the lake as eutrophic. The comprehensive assessment report stated that because of the potential for increased shoreline development and additional nutrient inputs from the watershed and septic systems, Lake Murray will show signs of greater eutrophication.

Comprehensive Water Quality Report (1974-1998)

SCE&G has worked with SCDHEC and USGS for a number of years monitoring the water quality in Lake Murray. These water quality monitoring efforts serve as a continuation of work that was first begun by the SCPCA, SCDHEC and the USGS in the mid 1940's. The data collected from 1974 to 1998 was recently compiled into a database that was prepared to evaluate historical trends in water quality of Lake Murray and its drainage area up to Lake Greenwood. Water quality information was compiled using a specialized computer software program and then put together into a comprehensive water quality report. This report and respective database serve as a pertinent source of information about present and past water quality trends. Since Lake Murray serves as an important economic and recreational resource, the water quality parameters that have the highest effect on these economic and recreational activities are considered the most important. Various plots and charts were generated in order to aid in the assessment of the results from these studies. Summaries of various components of this report are presented below with the report presented as Appendix E.

SCDHEC Saluda River Basin Water Quality Reports

The SCDHEC has published two reports related to the water quality in the Saluda River basin, including:

1. Watershed Water Quality Management Strategy - Saluda-Edisto Basin, Technical Report No. 003-95, June 1995, Bureau of Water Pollution Control
2. Watershed Water Quality Assessment - Saluda River Basin, Technical Report No. 005-98, December 1998, Bureau of Water

In these reports, seasonal trends and changes in water quality over the entire length of Lake Murray were evaluated. Generally, differences were seen between upper and lower stations in the lake. Concentrations of nitrates, phosphates, fecal coliforms, and biochemical oxygen demand (BOD) were typically higher at the upstream lake stations compared to the lower stations (closer to the Dam). This condition could be attributed to the faster flowing waters in the upper lake (convergence of several of the main tributaries into the *headwaters* of the lake) in contrast to the slower moving waters in the lower part of the lake. In addition, sedimentation was most prominent in the upper part of the lake, specifically between Rocky Creek and Blacks Bridge, which are located 19 to 25 miles upstream of the Saluda Dam. This seven-mile stretch of the lake primarily contained a high percentage of small particle sediments compared to other sections of the lake, with the exception of the lower part of the Little Saluda embayment (near the Highway 391 bridge).

Both SCDHEC reports are similar; however, the 1998 report indicated that a greater number of locations in Lake Murray are 'not supporting' and 'partially supporting' for their designated uses, specifically aquatic life and recreation. Table E-2 lists the number of locations in the lake, embayments, inflows, and tailwater and how water uses were

supported based on the SCDHEC reports. Within the Lake Murray watershed, 18 locations were labeled as fully supporting their designated uses in 1995 compared to only 9 locations in 1998. Based on the 1998 report, SCDHEC found 7 of the 12 stations on Lake Murray to be either 'not supporting' or 'partially-supporting' their respective water uses. Metals were listed as the cause for 6 of the 7 stations not meeting their designated uses, while nutrients were listed as the cause for 2 of the 7 stations (one station had both metals and nutrients listed as the cause).

9.2.2.2 Metals

Copper concentrations were found to exceed the acute water quality criteria for aquatic life at 5 stations on the lake. Two stations listed copper as the cause for the 'partially supporting' status for aquatic life. However, SCDHEC noted that copper concentrations are high in many locations throughout the state, but do not seem to cause toxic conditions in those waters. Increased metals concentrations in the lake seem to be related to the elevated concentrations in the inflows, which may be originating from the natural geology of the watershed.

9.2.2.3 Pathogens

Fecal coliform was identified as the cause for impacting recreation at 6 locations in 1995 and 8 locations in 1998 in the inflows/tributaries to the lake and in the tailwater of Saluda Dam. These conditions were all attributed to point and/or non-point sources in the watershed. However, all locations in Lake Murray were found to fully support the recreational use designation based on fecal coliform data.

Fecal coliform is listed as the cause for Total Maximum Daily Loads (TMDL) at three sites in the Lake Murray watershed, including two sites on the Bush River and one site on Rawls Creek, which discharges into the Saluda River downstream of the Dam. Another eight sites are

designated as potential TMDL sites, with six of the site designations caused by fecal coliform. There are a total of 51 TMDL-designated sites in the watershed listed on the state 303(d) list. Fecal coliform is the most significant water quality indicator and is responsible for TMDL designation for 21 of the sites. Most of these 21 sites indicate a significant potential concern to recreation where the streams enter Lake Murray (i.e. the headwaters) or the Saluda River. Lake recreational uses may potentially be impacted at the inflow areas from these sites following significant rainfall/runoff events.

9.2.2.4 Phosphorous

Elevated phosphorous levels are the cause for listing two sites on the state 303(d) list, including the Bush River arm and the Rocky Creek area of Lake Murray. However, neither site is listed as a potential TMDL site despite the high priority listing. Total phosphorous concentrations in Lake Murray tend to be highest in the upstream section of the lake, near the main tributaries/inflows. The downstream part of the lake, near the Dam (*forebay*) has historically had the lowest concentrations of total phosphorous. Most of the phosphorous is either utilized by the plants and algae in the lake or settles out onto the bottom of the lake. In general though, total phosphorous concentrations have shown a decreasing trend in the lake, since the mid-1980s. By way of example, Figure E-5 shows total phosphorous concentrations in the area of the lake by the Dam (forebay) from 1972 to 1998.

9.2.2.5 Trophic Status

Eutrophication refers to the level of nutrients in a lake and the resulting level of productivity by the organisms (*e.g.*, plants and *phytoplankton*) that utilize the nutrients, such as phosphorous and nitrogen. A lake that has low concentrations of nutrients and low levels of productivity (*i.e.* limited algal blooms and plant growth) is referred to as

oligotrophic. On the other hand, a lake that is high in nutrients and has levels of productivity (significant algal blooms and plant growth, resulting in poor water clarity) is classified as eutrophic. The mesotrophic classification falls in the middle of oligotrophic and eutrophic, characterizing a lake containing moderate levels of nutrients and moderate productivity.

In the SCDHEC 1995 and 1998 reports, a multiple parameter index was used to assess eutrophication in Lake Murray. The multiple parameter index is based on measurements of water clarity, total phosphorous, total inorganic nitrogen, chlorophyll *a*, and DO. Based on a baseline assessment in 1980-1981, conditions in the upper lake had improved, with the exception of Rocky Creek and the Bush River section of the lake, which were stated as some of the most eutrophic sites on large lakes in South Carolina. The 1998 report indicated that two upstream locations on the Saluda River arm and the Little Saluda River arm had improved to intermediate trophic status (*i.e.* mesotrophic). The 1998 report also indicated that all locations between Rocky Creek and the Saluda Dam were some of the least eutrophic sites in the state, with decreased levels of total phosphorous and decreasing trends of nitrogen and BOD.

9.2.2.6 DO and Temperature – Lake Murray

Water quality profiles, including DO and temperature have been performed in Lake Murray throughout the 1990s. As an example, Figures E-6 through E-11 illustrate longitudinal contour plots of DO in Lake Murray during the months from May to October of 1998. The plots use DO profiles from seven different locations in the lake, which are plotted at their location relative to the Dam (x-axis) versus elevation or meters above sea-level.

Lake Murray thermally stratifies each year, forming three different layers in the water column during the months of May through October. The water column stratifies because of the change in temperature and density of each layer. The epilimnion is the upper layer of the lake, which is the only one to remain in contact with the surface and is characterized by high DO and temperature levels. The hypolimnion is the bottom layer of the lake that remains isolated from the atmosphere during the stratification period. The hypolimnion contains the coolest waters (down to 11°C in 1996) and some of the lowest DO waters, even having anoxic conditions (no DO) during September and October. The metalimnion is the middle layer of the water column, which contains the controlling region known as the thermocline. The thermocline is referred to as the waters having the greatest temperature change over depth. This layer is basically the transition layer between the epilimnion and hypolimnion. In Lake Murray, this layer can have the lowest DO levels, depending on flows entering the lake.

The magnitude of flows or hydrology for each year controls the level of nutrients, algae, and other organic matter that enter the lake. The nutrients, algae, and other organic matter contribute significantly to DO demand, which relates to the amount of oxygen required to decompose the organic matter that is ultimately produced by the nutrients and algae. In addition, sediment oxygen demand can contribute to the DO demand in the lake bottom waters. Sediment oxygen demand can result from several things, one of which is from the deposition of organic matter on the lake bottom.

The water column in the lake becomes thermally stratified during the summer months and the bottom waters do not come into contact with the surface to replenish DO levels, thus eventually becoming void of oxygen or anoxic, depending on annual flows. In a low flow year, for example, the magnitude of nutrient input to the lake would be lower, resulting in a limited DO demand and higher DO levels in the bottom

waters of the lake, particularly downstream towards the Dam. Higher flow years would result in an increased loading of nutrients, algae, and organic matter to the lake that would create a high DO demand and lower DO conditions in the bottom of the lake, specifically during the summer months. These effects were most recently noticed in 2003. DO levels at the upstream portion of the lake, where most of the inflows enter, are less dependent on flow conditions. Flow conditions in the watershed primarily control the distribution of the water quality at the upstream portion throughout the lake.

Referencing Figures E-6 through E-11, it is readily apparent that DO levels start to decrease in the upper part of the lake in May and June of each year. DO levels are less than 2.0 mg/L in the metalimnion and near the bottom in the upper part of the lake by June of each year. However, DO levels are often lower at different points in the water column compared to near the bottom, which indicates a high DO demand in the water (*e.g.*, nutrients, algae). As previously mentioned, the low DO conditions in the upper lake are caused by the decomposition of algae and other organic matter entering the lake as well as the effects of sediment oxygen demand in the lake bottom. Depending on flow conditions, this poor water quality may cause the same low DO conditions in the metalimnion and hypolimnion throughout the lake, down to the Dam.

In July, DO levels become much more dependent on the annual hydrology, particularly in the area of the lake by the Dam, referred to as the Dam forebay. In low flow years, the DO was typically greater than 5.0 mg/L at all depths in the Dam forebay, while normal flow years are marked by reduced DO levels, normally less than 5.0 mg/L at most depths in the forebay. The pattern for DO levels in the Dam forebay during the month of August is similar to July. In low flow years, the DO is normally greater than 3.0 mg/L at all depths, while normal flow years have DO levels less than 3.0 mg/L at nearly all depths of the Dam forebay. This pattern of DO behavior, based on flow conditions, for the months of July

and August, indicates that water displacement within the reservoir affects the DO distribution in the reservoir.

In September, the DO in the forebay area is typically 0.5 mg/L or less at most depths during normal flow years. In low flow years, the DO is usually greater than 1.5 mg/L at all depths in the forebay. Finally, in October, the DO in the hypolimnion of the lake is normally less than 0.5 mg/L at all locations.

9.2.2.7 Current Studies

As previously stated, in 2002 SCDHEC issued a formal notice that the DO standard for the LSR would be revised. Upon review of the comprehensive water quality report for the Saluda Hydroelectric Project relicensing, it was shown that phosphorous trend data indicates potential problems with nutrient loading into Lake Murray. In order to comply with a new DO standard, SCE&G sought to evaluate the potential effects of what a nutrient reduction would have on the DO levels in Lake Murray and the discharges from Saluda Hydro. SCE&G proposed a battery of industry accepted models and studies, including a two-dimensional water quality model, CE-QUAL-W2. The CE-QUAL-W2 model has been shown to be quite accurate in predicting water quality conditions. It is an extremely useful tool when analyzing the effects that inflow water quality has on the receiving lake water quality, as well as the discharges from the lake. After an extensive review of the water quality data gathered for Lake Murray and its inflows by SCDHEC, USGS and SCE&G, a CE-QUAL-W2 model was developed for Lake Murray (Ruane, 2004).

Data was combined and used in the calibration of the model for the year 1996. This calibration year was chosen based upon available data and hydrologic conditions. Moreover, this year does not reflect the effects of the aeration system implemented by SCE&G in 1998, which would hinder the comparison of Lake Murray inflow and outflow data.

Temperature, DO, algal levels, and phosphorus were the primary water quality constituents studied using this modeling technique. The model was tested using statistical and graphical analysis, which subsequently showed that it was well calibrated for this year and conditions. The model was then tested for the years 1992 and 1997. Even though the model was not calibrated for these years, the results were still good. Phosphorus data achieved from conducting the CE-QUAL-W2 model provided more precise and detailed results than did the data from the previous phosphorus studies (Ruane, 2004).

When predicting water quality conditions in Lake Murray using the CE-QUAL-W2 model, results were achieved assuming that the phosphorus concentrations occurring in the inflows to Lake Murray contained the maximum allowable concentrations that were still in compliance with SCDHEC standards. When reducing the phosphorus loads to these maximum allowable levels, the model showed substantial improvements in water quality conditions on Lake Murray. The DO levels in the turbine discharges from Saluda Hydro were also shown to increase to such an extent that alternative aeration of the water may not be needed for the DO in the turbine discharges consistently to meet state standards for the lower Saluda River. Furthermore, it is inferred that as a result of phosphorus reductions, striped bass habitat would be greatly improved, as well as the pH levels on the LSR (Ruane, 2004).

Results from the Lake Murray study were compared to results achieved by modeling projects similar to Saluda Hydro. Data derived from the CE-QUAL-W2 model predicted that the most likely cause for water quality problems in Lake Murray stem from the point source discharges of phosphorus into Ninety-Six Creek and the Bush River; the discharge of phosphorus at these locations is very high. The Saluda River is responsible for 68% of the mean *streamflow* into Lake Murray; however, it only contributes 15% of the total phosphorus load. Moreover, the other smaller tributaries together only make up 32% of the mean

streamflow into Lake Murray, however, they contribute 85% of the total phosphorus load (Table E-3). Another indication that point source pollution is a major contributor to water quality issues in Lake Murray is that phosphorus discharges from Lake Greenwood are relatively low due to tertiary waste treatment upstream. In turn, model results estimated that 60% of the phosphorus input into Lake Murray occurs as a result of discharge from point sources. Additionally, if sources of point pollution into Lake Murray were in compliance with SCDHEC standards, the phosphorus discharges into Lake Murray would be reduced by about 66% (Ruane, 2004).

Reducing phosphorus levels in point source discharges into Lake Murray may be a cost effective and practical way of improving the overall water quality of the lake. A review of projects similar to Saluda Hydro indicates that a reduction in lake phosphorus levels contributed to an increase in the DO levels. The CE-QUAL-W2 model accurately indicates that most of the water quality problems could be solved by implementing point source phosphorus controls. The final report on the CE-QUAL-W2 model is currently being finalized and should be concluded in the upcoming months (Ruane, 2004).

9.2.3 Saluda Dam Tailwater

SCE&G began monitoring DO and temperature in the Saluda Project turbine releases in 1989 and continues the effort to the present day. These monitoring efforts have determined that nutrient loading from the tributaries and the thermal stratification of Lake Murray from May to November of each year result in the depletion of DO levels in the metalimnion and hypolimnion layers of the lake. These anoxic conditions during the summer months in the lake can translate into low DO concentrations in the water released through the Project turbines. The anoxic conditions and low alkalinity levels in the bottom waters of the lake can also result in moderately low pH conditions ($\text{pH} < 7.0$), because of

the lack of oxygen and the production of carbon dioxide from the various decomposition processes.

9.2.3.1 Past Studies – SCDHEC Reports

The 1995 and 1998 SCDHEC reports indicated that in the Saluda Dam tailwater, the section of the Saluda River immediately below the Project, ratings were 'not supporting' and 'partially supporting' for aquatic life uses at the first station downstream of the Dam. The listed cause for this impairment was the low DO levels measured in the Project releases from the turbines. Conditions at the downstream station were reported to have improved (1998 report) based on a lower percentage of the DO data that was less than the standards. Lower pH levels were also reported as a cause for the 'not supporting' conditions for aquatic life use in the tailwater.

Another water quality concern indicated by SCDHEC is the pH levels in the Saluda Project releases. The low pH associated with the reservoir releases is caused by the decomposition of organic matter in the lake, which commonly occurs in lake waters with low alkalinity conditions, such as Lake Murray. The pH excursions outside of the state standards (6.0 to 8.0) appear limited in magnitude and duration.

9.2.3.2 DO Enhancement of the Project Turbine Releases

In an effort to increase the DO levels in the releases from the Project turbines, SCE&G installed turbine vents and modified operations starting in 1999. Figure E-12 illustrates how turbine venting in conjunction with modified operational patterns has improved the project release DO levels since 1999. Turbine venting, in conjunction with modified operational patterns, has improved the Project release DO levels since 1999. The median DO concentration of the Project release has increased from 2.7 mg/L (before implementing turbine venting) to 7.2 mg/L (with turbine venting - 1999 to present). Ultimately, this has

resulted in less frequent occurrences of DO levels in the release below 5.0 mg/L, from 88% to about 12% of the time. The percentage of time the DO levels from the Project releases were below 3.0 mg/L has decreased from 55% to 3% since turbine venting and modified operations were implemented in 1999.

Daily average DO levels in the Project releases from 1999-2000 were periodically below 4.0 mg/L, particularly on days when flows through the turbines were high. The amount of water that passes through the turbines controls the amount of air drawn into the turbine system. A lower flow or gate setting will allow more air to be aspirated into the turbine system resulting in a greater degree of DO increase in the Project release. Once the planned hub baffles are installed on units 1 - 4, it is believed the daily average DO levels will improve, even under high turbine flows.

In 2004 SCE&G implemented operational protocols that further assist in maintaining enhanced DO levels in the LSR. These protocols were based on a detailed turbine venting model. To ensure continuing enhancement of DO levels, this model is reviewed on an annual basis.

9.2.3.3 Water Uses

Lake Murray and the LSR provide an exceptional source of high quality waters that can be used for both consumptive and non-consumptive uses. The reservoir serves as a source of drinking water and water for industrial uses for the cities of Columbia, West Columbia, Newberry and Lexington, and the surrounding areas. The Saluda Hydroelectric Project functions as a reserve capacity plant, meaning it runs on an "as needed basis." The McMeekin Station consumptively uses an insignificant amount of water, normally only about 35gpm and the event of a spillway discharge is very infrequent. There is water loss due to the natural occurrences of evaporation and ground water uptake. The agricultural

developments around Lake Murray generally meet their water demands through the uses of farm ponds. However, there is a small amount of water that is taken up by these operations. There are also small amounts of water that are taken up from Lake Murray by individual landowners for domestic uses. These water withdrawals are permitted by SCE&G's land management department. Honeywell is the sole industrial user of water from the LSR for non-consumptive purposes.

The reservoir and the LSR are used extensively by the public for recreational activities. Fishing alone accounts for much of the recreational water use of the area. These uses are discussed in further detail in the recreation section of this document.

Table E-1: Major Wastewater Dischargers and Number of Minor Dischargers in the Watersheds of Lake Murray (downstream from Greenwood Dam)

	MILLION GALLONS/DAY	NUMBER OF MINOR DISCHARGES
Ninety-Six Creek Watershed		12
City of Greenwood/Wilson Creek Plant	12.0	
Bush River Watershed		2
City of Newberry/Bush River Plant	3.22	
Laurens County WRC/Clinton	2.75	
Little River Watershed		10
City of Laurens	4.5	
Little Saluda River Watershed		3
Lake Murray Watershed		3

Table E-2: Number of Locations and How Water Uses Were Supported Based on the 1995 and 1998 SCDHEC Reports

	1995		1998	
	Aquatic Life	Recreation	Aquatic Life	Recreation
LAKE MURRAY				
Fully supporting	5	6	1	6
partially supporting	1, M*		2, M*	
Not supporting			3, M*	
EMBAYMENTS				
Fully supporting	6	6	4	6
partially supporting				
Not supporting			2, M*, N**	
SELECTED INFLOWS				
Fully supporting	6	3	4	3
partially supporting	3, DO	2, FC***	2, M*, DO	2, FC***
Not supporting		4, FC***	3, M*	4, FC***
TAILWATER				
Fully supporting	1	2		1
partially supporting		1, FC***	1, DO	2, FC***
Not supporting	2, DO		2, DO, pH, M*	
SUMMARY OF USES & CAUSES				
Fully supporting	18	17	9	16
partially supporting	4	3	5	4
Not supporting	2	4	10	4
Metals	1		11	
Fecal Coliform		7		8
DO	5		3	
Nutrients			1	

* M indicates metals are the cause;

** N indicates nutrients are the cause;

*** FC indicates fecal coliform were the cause

Table E-3: Percent Contributions to the Upper Regions of Lake Murray of Total Phosphorus Loadings and Mean Stream Flows Found Conducting CE-QUAL-W2 Model (Ruane, 2004)

<u>Lake Murray Tributary</u>	<u>Mean Streamflow,</u> <u>(percent)</u>	<u>Phosphorus Load,</u> <u>(percent)</u>	<u>Ratio of Phosphorus</u> <u>Load to Flow</u> <u>(percent)</u>
Bush River	4	18	4.5
Little Saluda River	7	12	1.7
Clouds and West Creeks	4	9	2.2
Ninety-Six Creek	5	34	6.8
Little River	7	6	0.9
Saluda River	68	15	0.2
All Other Flows	5	6	1.2

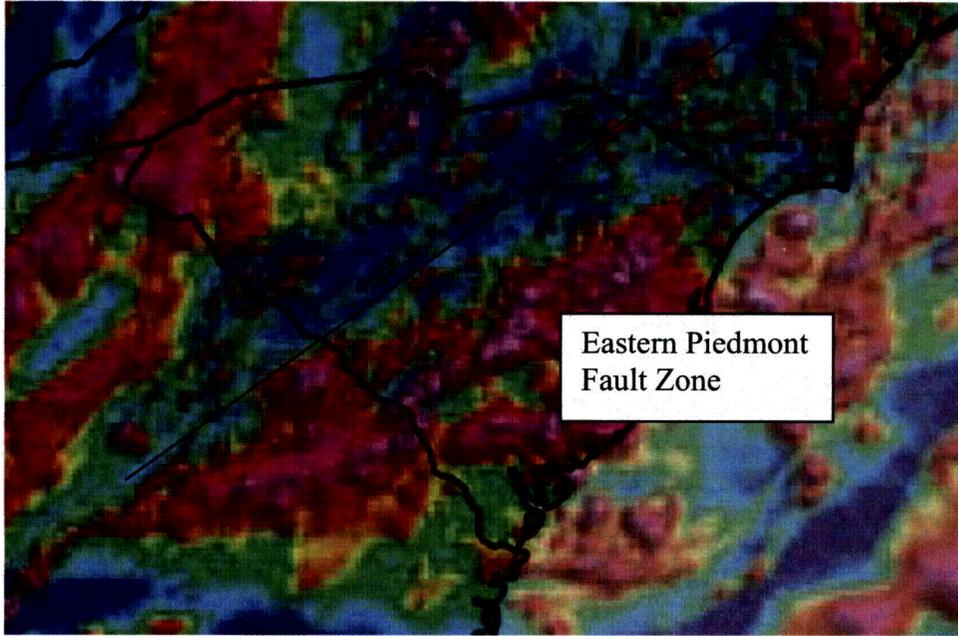


Figure E-1: Aeromagnetic Map of South Carolina

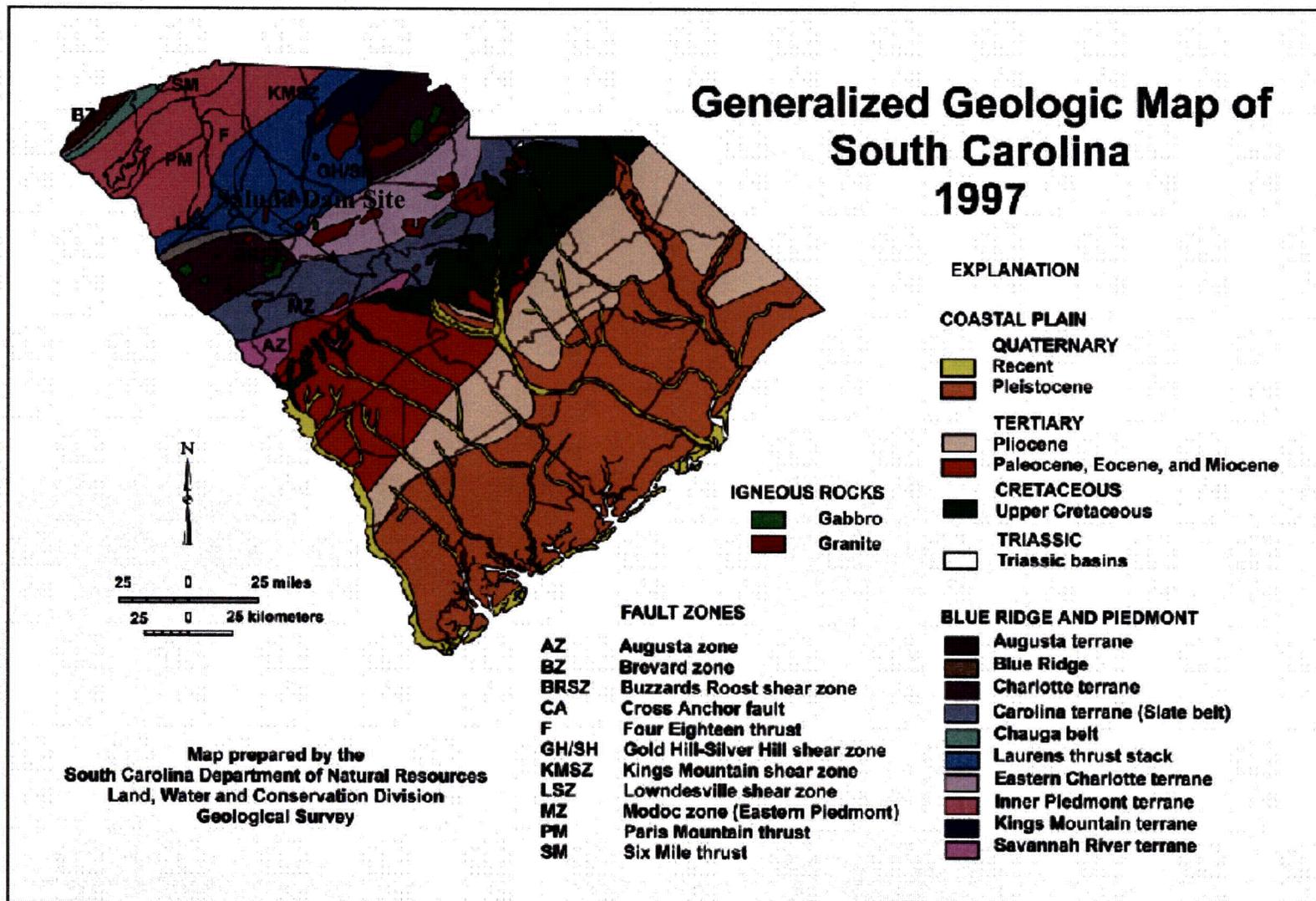


Figure E-2: Generalized Geologic Map of South Carolina

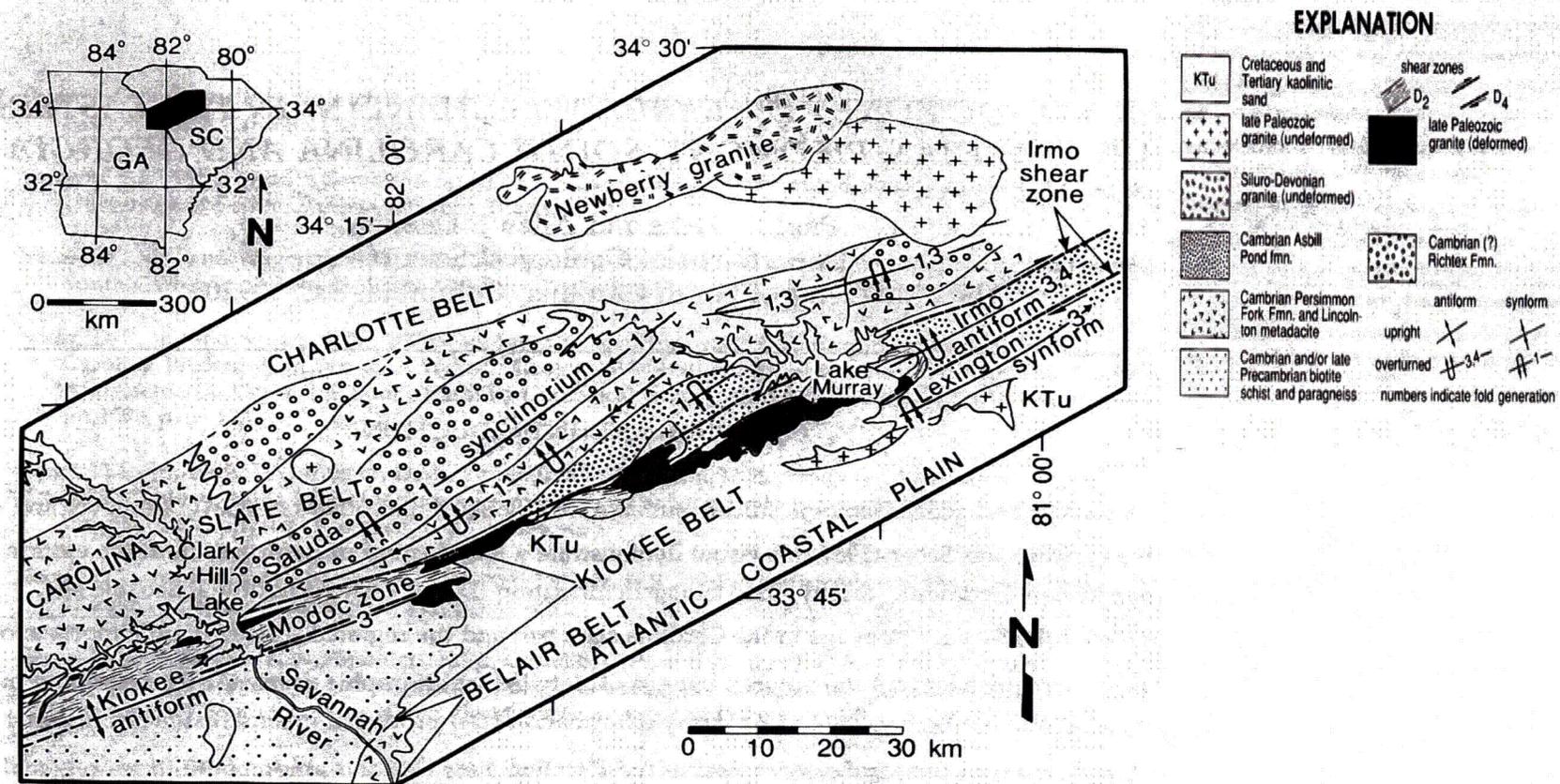


Figure E-3: Map of Eastern Piedmont Fault Zones and TERRANES (Reference: Sacks and Dennis, 1989)

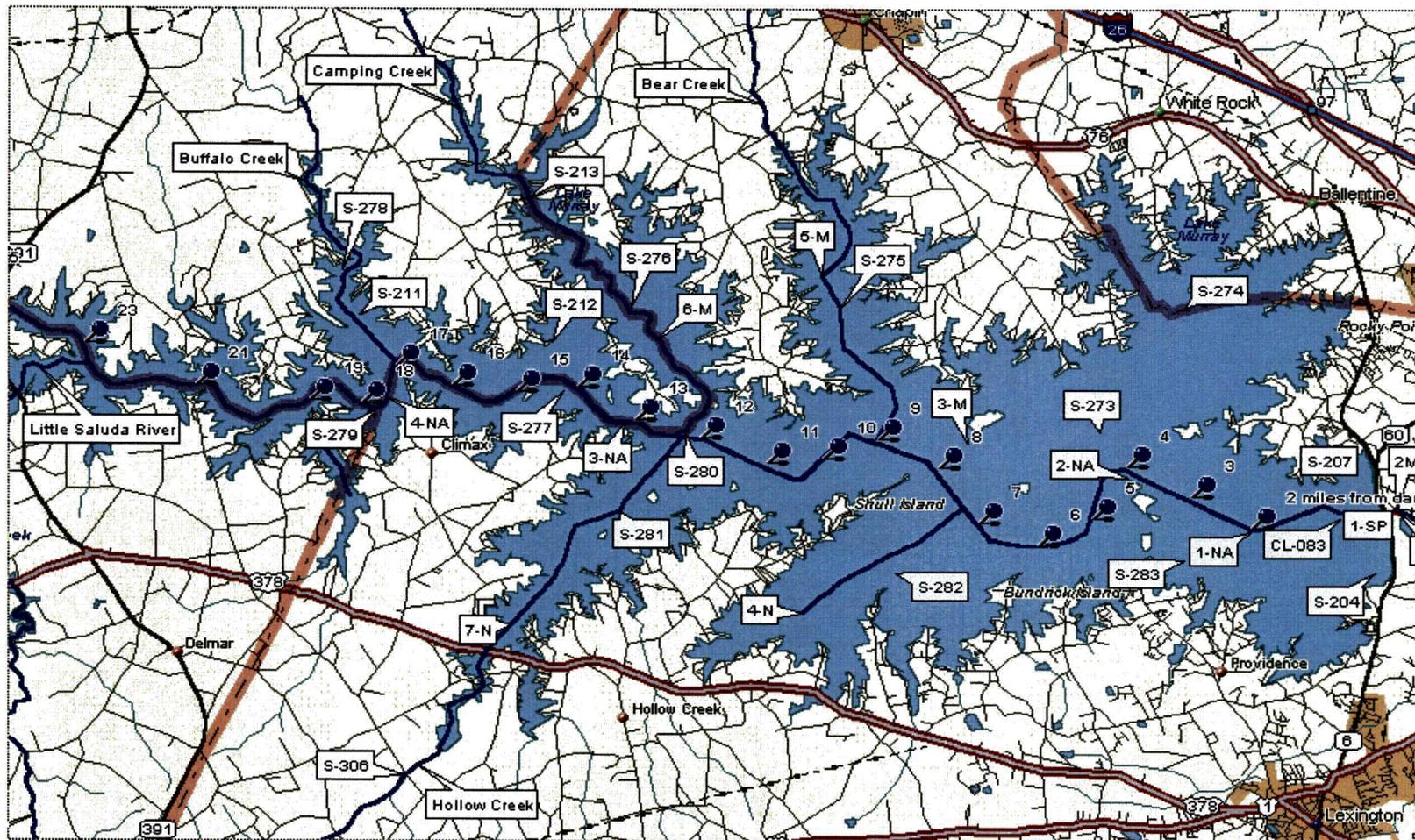


Figure E-4: Saluda River From Its Confluence with the Little Saluda River to the Saluda Hydroelectric Project Dam, Including Lake Murray and Mile Markers Showing Distance Upstream from Dam

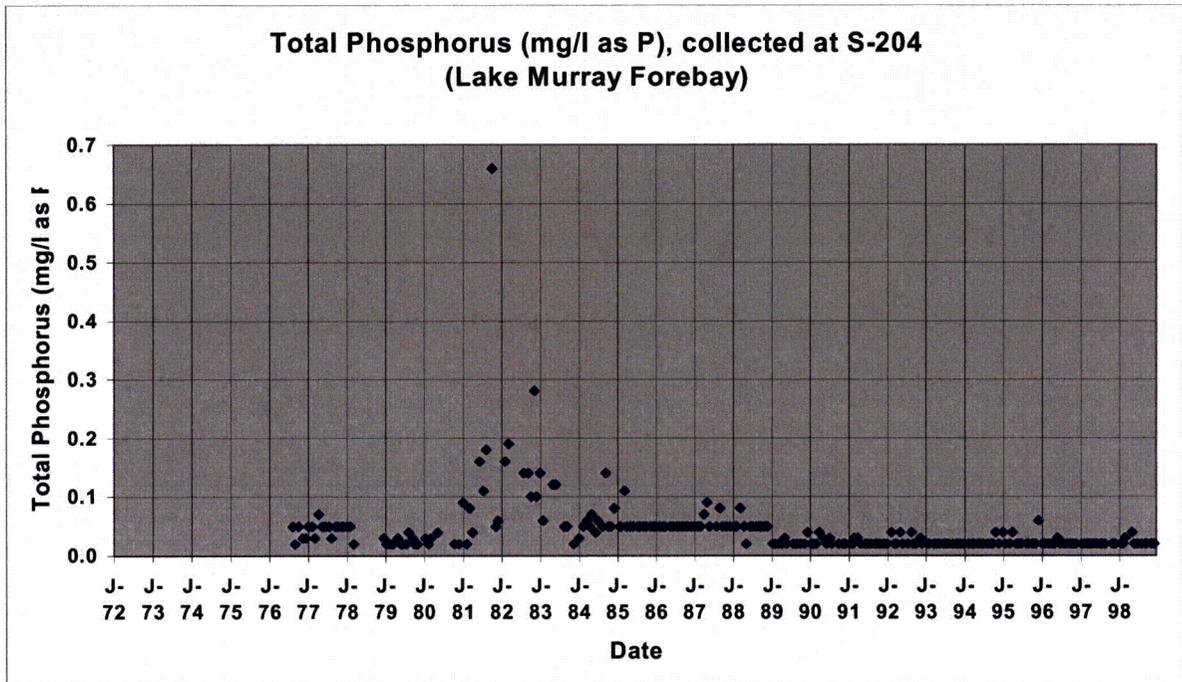


Figure E-5: Total Phosphorous Concentrations at the Dam Forebay of Lake Murray - 1972 to 1998

Lake Murray May 19-20, 1998-SCE&G stations

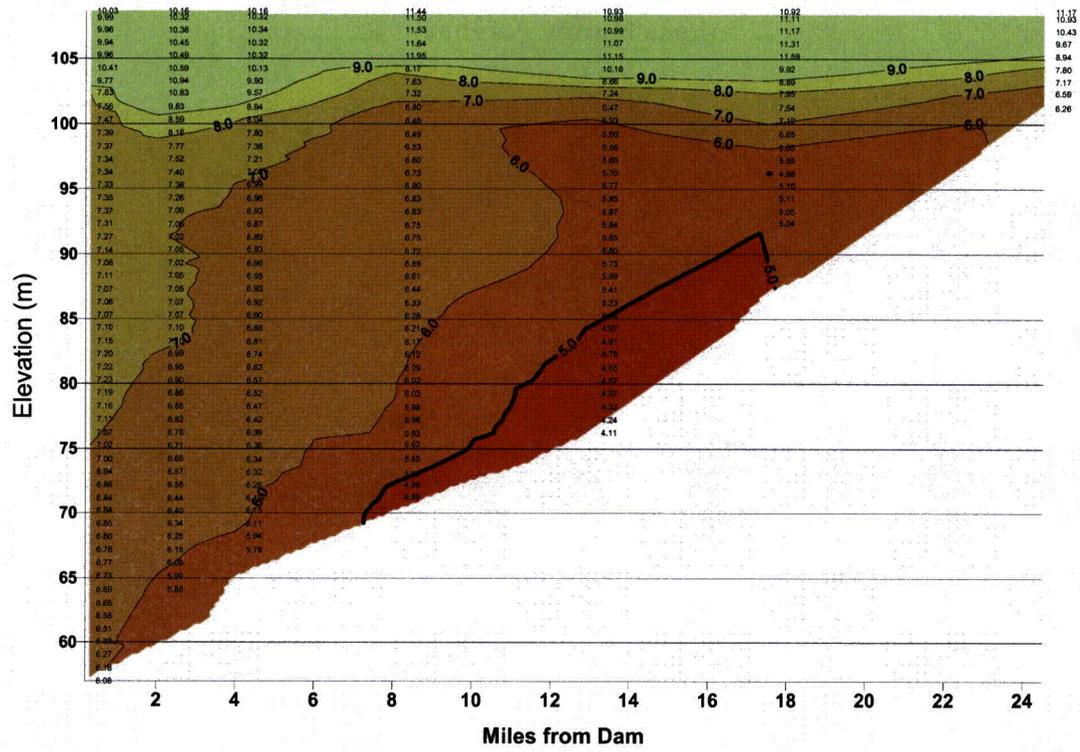


Figure E-6: Longitudinal Contour Plot of DO in Lake Murray for May 1998

Lake Murray June 23, 1998-SCE&G stations

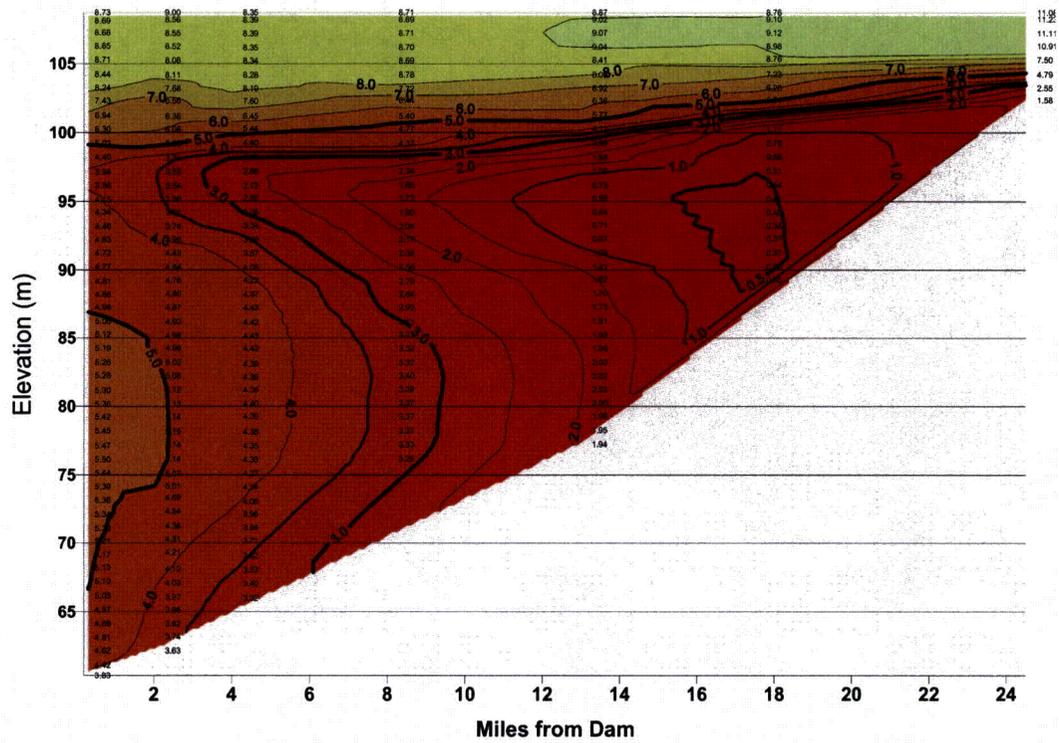


Figure E-7: Longitudinal Contour Plot of DO in Lake Murray for June 1998

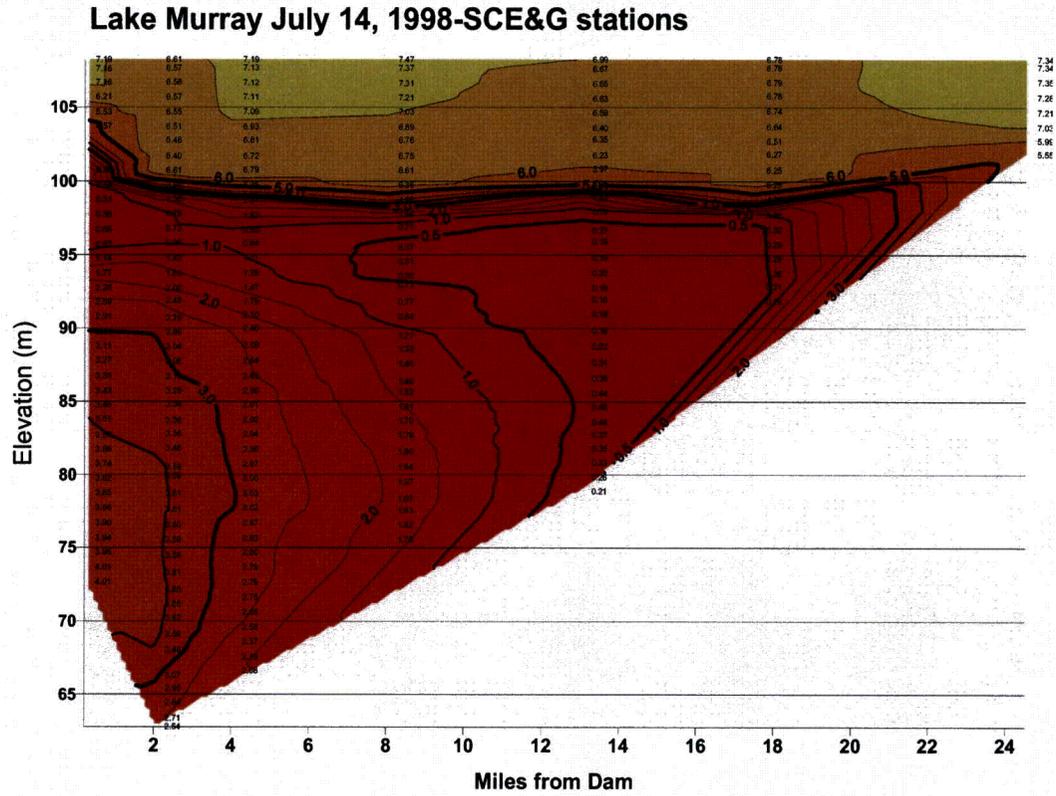


Figure E-8: Longitudinal Contour Plot of DO in Lake Murray for July 1998

Lake Murray August 11, 1998-SCE&G stations

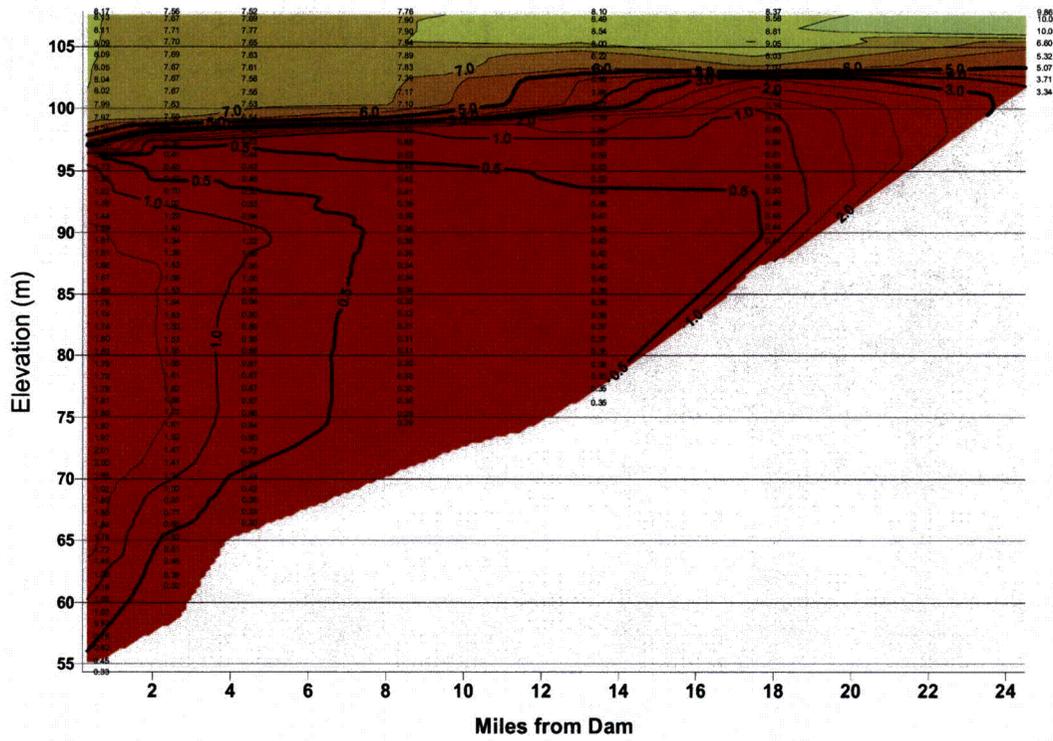


Figure E-9: Longitudinal Contour Plot of DO in Lake Murray for August 1998

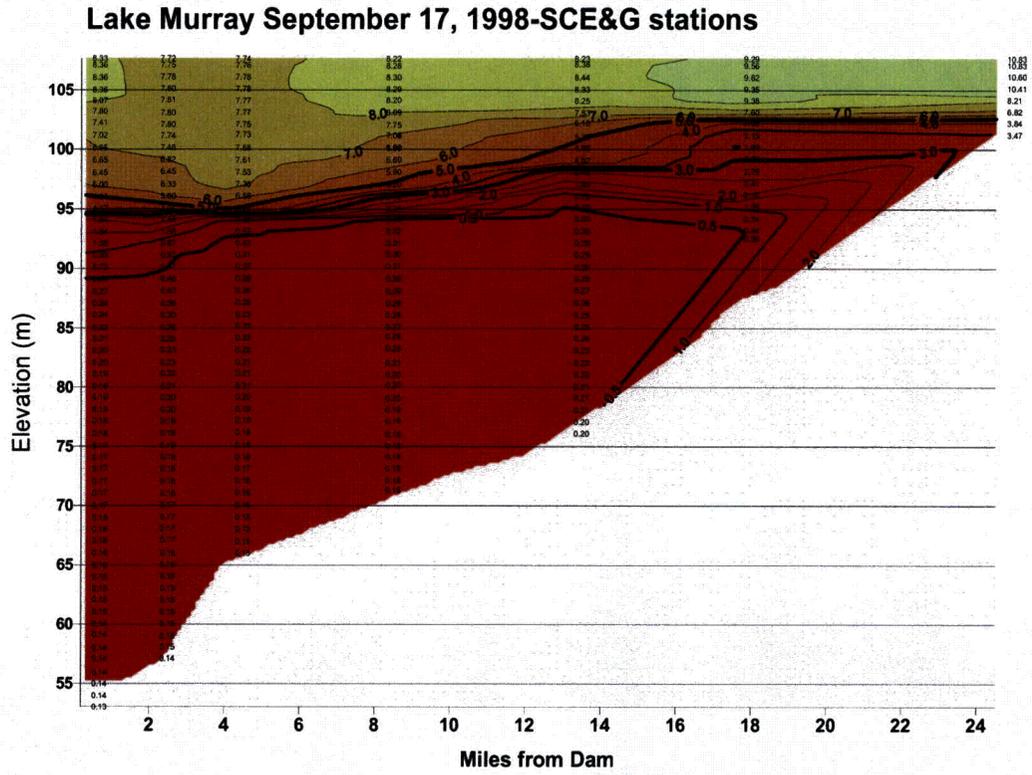


Figure E-10: Longitudinal Contour Plot of DO in Lake Murray for September 1998

Lake Murray October 14-15, 1998 - SCE&G stations

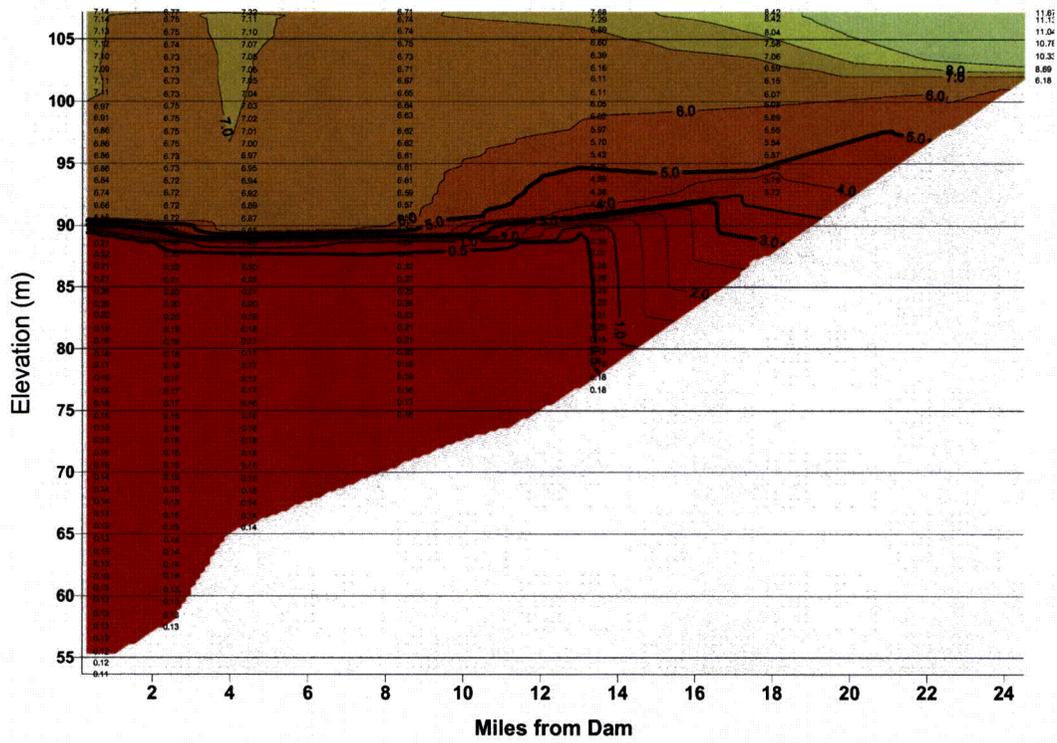


Figure E-11: Longitudinal Contour Plot of DO in Lake Murray for October 1998

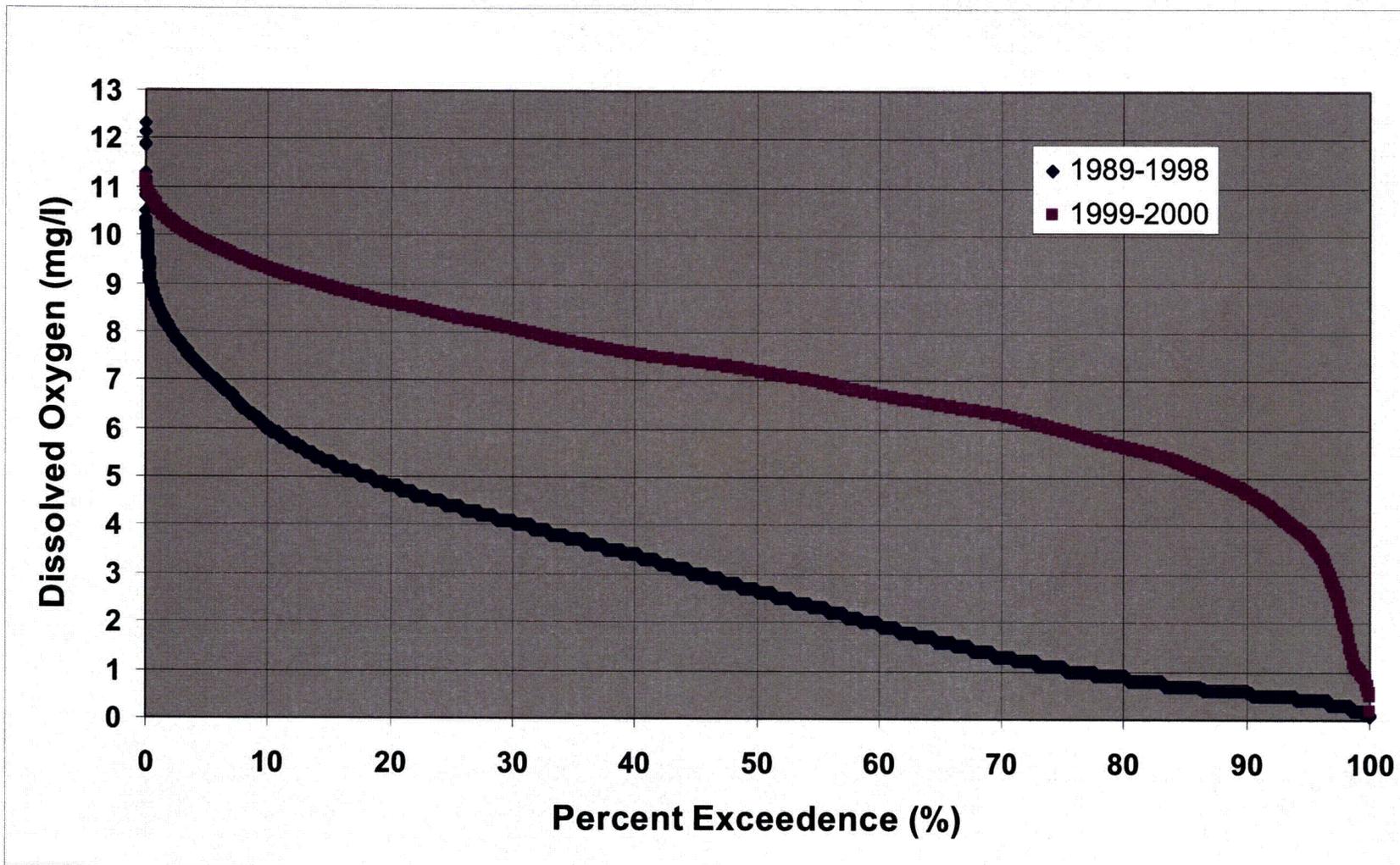


Figure E-12: Percent Exceedence for DO in the Saluda Dam Tailwater - All Hourly Data from the Low DO Period (approximately July 1 to November 15 of each year)

10.0 *AQUATIC RESOURCES*

With the exception of wildlife resources, we have divided the following discussions of the Project area into two distinct sections, Lake Murray and the lower Saluda River (LSR) (from the Saluda Dam downstream to the confluence with the Broad River). These areas, while containing some similarities in aquatic and terrestrial flora and fauna are frequently quite different - this is especially the case with aquatic resources. These two areas are briefly described below.

10.1 Lake Murray

Lake Murray is an approximately 48,000-acre multipurpose reservoir formed in 1930 primarily for power production purposes; additional uses such as municipal water consumption and recreation have been developed during the more recent life of the Project. It is the largest of a series of seven impounded water bodies in the Saluda River Sub-basin and drains nearly 1,447,420 acres. Lake Murray covers approximately 78 square miles with a total shoreline length of 650 miles. Bordered by Newberry, Saluda, Lexington, and Richland Counties in the midlands of South Carolina, Lake Murray's proximity to the capital city of Columbia places it in one of the most rapidly growing areas of the state (Hayes, 1994). The lake is situated in two geographic provinces: the lower Piedmont and Sand Hills physiographic regions.

10.2 Saluda River

The LSR originates at the base of Saluda Dam and consists of a 10 mile stretch of free flowing river before merging with the Broad River and forming the Congaree River in downtown Columbia. This river segment was designated as a State Scenic River Segment in 1991. Water depths in the LSR are highly variable and dependent upon water releases from the Saluda Project, but typically range from 3 to 15 feet. As with depth, stream flow is highly influenced by releases from the Saluda powerhouse.

10.3 Fisheries Resources

An enormous database of information exists on the fishery resources of Lake Murray. Survey and inventory information has been collected on nearly all major sport and prey fish species in the lake (Hayes, 1994). Through the efforts of the SCDNR, scientific data gathered in Lake Murray include standing crop estimates, survival, reproductive potential, food habits, age and growth, length/weight relationships, proportional *stock* densities, relative condition, population size, and structure.

By the mid 1950's the South Caroling Wildlife and Marine Resources Department, now SC Department of Natural Resources (SCDNR) was established to formulate sound management practices for the lakes of South Carolina (Campbell and Dean, 1976). The agency began conducting studies and producing annual progress reports since the 1980's that are useful for characterizing the Lake Murray ecosystem and fish population assemblages. These early management efforts coincided with the SCDNR's intense involvement in establishing striped bass (*scientific names are listed in Table E-4*) populations in Lake Murray. Through the efforts of the SCDNR, Lake Murray continues to be one of the most monitored and studied Lakes within the State of South Carolina.

10.3.1 Lake Murray

Lake Murray varies substantially in habitat from shallow coves and *wetlands* to vast open water with an abundance of diverse structure. The lake has a maximum depth of around 200 feet, but also has an extensive, shallow *littoral* fringe. This varied habitat within the Project boundary supports a diverse fish population and a valuable sport fishery. Approximately forty species representing 12 families have been documented in Lake Murray over the years (Hayes and Penny, 1993; Campbell and Dean, 1976). Of these, seven are considered game fish. At least 16 resident species of forage fish occur in the Project waters, with 10 of these species belonging to either the minnow or perch families. Fish growth in these waters is generally considered to be excellent and has produced several current state record fish (Mead and Hunt, 2002a).

As early as 1976, a number of important fish species were identified as having both ecological and economic importance to the sport fishery in Lake Murray. Campbell and Dean (1976) identified approximately 10 species including but not limited to spotted gar, common carp, largemouth bass and striped bass.

In 1994, the SCDNR prepared a comprehensive fishery management plan (discussed below) for Lake Murray identifying a number of fish species as having importance to the sport fishery in Lake Murray. Due to the relative importance of these fish to Lake Murray, a brief narrative on each species is included below.

Threadfin Shad

Threadfin shad are the primary prey species and dominate the clupeid prey base in Lake Murray (Hayes, 1994). The importance of these species as a food source for striped bass has been documented by the SCDNR in food habit studies (Hayes and Penny, 1991). Since threadfin shad are relatively small (rarely exceeding 3 inches), and very prolific, they provide a stable and readily available food source for most predatory species in Lake Murray. Ichthyoplankton studies conducted in the 1990's suggest that threadfin shad make up approximately 80 % of the lake's larval fish densities (Hayes, 1994).

Evidence suggests that in southeastern reservoirs threadfin shad typically become thermally stressed at water temperatures around 45 ° F. The SCDNR reports that, while possible, none of these die-offs have occurred in Lake Murray. Predation of moribund individuals by migrating gulls as well as fish species is known to occur. The late fall and early winter period is typically when temperatures reach a critical point for threadfin shad and this coincides with periods of significant surface schooling of striped bass. Local anglers have begun to "follow the gulls" to areas where the birds and the striped bass are heavily feeding on the thermally stressed shad (Hayes, 1994).

Gizzard Shad

The gizzard shad is the second most abundant clupeid found in Lake Murray and has historically comprised a significant portion of total biomass of fishes in cove rotenone studies conducted by the SCDNR (Hayes and Penny, 1992). Due to the rapid growth rates of the gizzard shad, only the larger predatory species can use this species as prey. During the late 1980's, the SCDNR reported that negligible spawning of this species occurred and overall abundance was low (Hayes, 1994).

Historically, the gizzard shad had been used as a source of live and cut bait for striped bass fisherman, but within recent years due to the introduction of blueback herring, usage appears to have been drastically reduced. Gizzard shad however are still used to a degree when blueback herring are unavailable or too costly (Hayes, 1994).

Blueback Herring

Blueback herring occurrence was initially documented in 1985 during winter gill net surveys on Lake Murray (Hayes, 1986). By 1989, Hayes and Penny reported that this species had totally adapted to a freshwater water environment. It is unclear how this species was introduced into Lake Murray, although the SCDNR postulated that the bait fishery, which provided herring for striped bass fishermen, is the likely source of introduction.

A commercial bait fishery for blueback herring exists on Lake Murray. However, the SCDNR reports that this fishery is seasonal and does not meet the demand of the market (Hayes, 1990). The SCDNR has indicated that Lakes Russell and Thurmond contribute significantly more to the statewide blueback fishery than currently occurring on Lake Murray (personal comm. Gene Hayes, SCDNR, 2002).

Blueback herring tend to congregate near the Saluda (Lake Murray) Dam in the late summer months searching out cool water habitats. In September 1990, a significant entrainment event of blueback herring occurred at Saluda Hydro Plant (Hayes, 1994). This entrainment event was attributed to blueback herring water quality habitat preferences which placed them in the vicinity of the intake tower for Unit 5. Although reported as "significant", an exact number of fish entrained or resulting mortality was never documented.

As a result of this reported entrainment event, SCE&G instituted measures to eliminate the potential for blueback herring entrainment at the Saluda (Lake Murray) Dam. In July 1992 SCE&G installed hydroacoustic transducers near intake tower number 5 to monitor late season movements of blueback herring. When acoustics show that blueback herring are congregated near the Unit 5 intake, SCE&G ceases operation of the unit. Since its installation, no significant blueback herring entrainment events have been reported by the SCDNR.

Largemouth Bass

The largemouth bass is one of the single most sought after game fish species in Lake Murray. Studies conducted in the early 1990's showed a healthy population with high recruitment and a stock size distribution well represented by large fish, > 14 inches (Hayes, and Penny 1990; Hayes and Penny 1991). Forty-six percent of the total fish pressure was directed at this species based on a 1991 creel census. Creel data collected in 2000 and 2001 suggest similar trends with forty percent of anglers targeting largemouth bass in Lake Murray (Hayes and Penny, 2001).

Recent trends suggest that while largemouth bass continues to be one of the most sought after fish species, angler efforts directed at this species are on the decline. The SCDNR noted in their 2001 – 2002 creel census that anglers targeting this species had dropped to approximately 29 % of total angling efforts. The SCDNR noted in their report that overall angling effort was down compared to previous years, and they speculated that downward economic conditions may

have contributed to the differences in angler effort and target species than those historically observed on Lake Murray (Hayes et al, 2002).

Lake Murray is ranked by Bass Anger Sportsman Society as one of the top bass fishing lakes in the United States (BASS, 2003). Historically, growth rates observed in Lake Murray were greater than those observed in other reservoirs in South Carolina (Hayes et al, 1995). However, since 1991, trends in fish condition factors for largemouth bass have steadily declined (Hayes *et al*, 1995). Data collected from a 1999 study suggested a decrease in fish condition with increasing length, a trend that was opposite to that observed in the 1991 studies (Hayes, 1995). SCDNR has speculated that the reason for declining condition factors in recent years could be due to lake drawdowns undertaken in 1990/91 for Project structure maintenance and in 1996/97 to control hydrilla. It is surmised by SCDNR that the prey fish community may have been restructured by reducing hydrilla in the littoral zones of the reservoir. An additional factor that may be adversely influencing largemouth bass populations in Lake Murray could be competition with a continuously growing striped bass population (Hayes, 1999).

Studies conducted in 2000 however noted a reversal of those declining largemouth bass condition factors observed in 1999. While there was still a trend of decreasing condition factors at increasing length, which has almost always been the pattern for Lake Murray bass, all size groups except one had condition values above 1.0 (SCDNR, 2001). The SCDNR speculates that these improved conditions may be attributable to an increased Lepomid population resulting from a resurgence of the aquatic plant community since 1999.

Due to early exploitation of this species, the SCDNR has a daily limit on largemouth bass that can be fished from Project waters. The limit imposed by the SCDNR allows for a total of 10 fish per day with no minimum length required. The SCDNR continues to monitor largemouth bass populations within Lake Murray on an annual basis.

Redear Sunfish

The SCDNR contends that Lake Murray has developed into a premier redear sunfish fishery, unlike any other reservoir in the state (Hayes, 1994). Within Lake Murray, the redear sunfish or "shellcracker" is the second most targeted species. A *creel census* conducted in 1990 indicated 5.88 angler-hrs/acre of fishing pressure was directed at this species, with catch rates of one fish per/hour resulting in a total harvest of 79,811 lbs (Hayes and Penny, 1992).

Information gathered by the SCDNR suggests that the redear sunfish populations have experienced a major expansion since the late 1950's. Surveys conducted in 1982 and 1992 revealed continued increases in the numbers and total weight of redear sunfish (Hayes, 1994). The SCDNR speculates that the increase in redear populations maybe the result of the introduction of an exotic/invasive species, the Asiatic clam (*Corbicula fluminea*). Campbell and Dean reported in 1976 that stomach analyses revealed the Asiatic clam to be the only food source used by the redear sunfish. This information was confirmed in studies conducted in 1996 by the SCDNR, which demonstrated that mollusks predominantly comprise the stomach contents, especially in fish greater than five years old (Beard, 1996). The 1996 studies indicated full development of the pharyngeal teeth and an overall increase in fish size which may have allowed the fish to expand their diet to include the larger more difficult to digest Asiatic clam. Today, the redear sunfish remains one of the most sought after game fish in Lake Murray (Hayes et al, 2002).

Bluegill Sunfish

The bluegill sunfish was reported to be the third most sought after fish species in Lake Murray. Creel data collected in 1990 suggest that anglers directed approximately 250,000 hours of effort at this game fish, resulting in a harvest of 61,232 lbs (Hayes and Penny, 1992). Recent information suggests that the bluegill sunfish continues to be one of the most sought after game fish species in Lake Murray (Hayes et al, 2002).

Striped Bass

Since its original stocking in 1960, Lake Murray has come to support a significant striped bass fishery. Lake Murray was one of the first upstate reservoirs stocked with striped bass. When originally stocked by the SCDNR, two main objectives were defined 1) introduce a predator base that could feed on the large gizzard shad population and 2) provide anglers with a highly prized game fish with large growth potential (Hayes, 1994).

Early stockings in the 1960's to produce a viable striped bass fishery met with unsuccessful results. By the early 1970's, innovations in hatchery production made it possible to produce sufficient numbers of fingerling striped bass for stocking into Lake Murray. Since 1971 over 30 million striped bass have been stocked in Lake Murray. These fish have been stocked into Lake Murray to a varying degree ranging from a low of 8,800 in 1986 to a high of 1,771,761 in 1983.

Due to a perception in the angler community in the late 1980's that the quality and size of striped bass had diminished, the SCDNR conducted investigations into the size structure of striped bass population in Lake Murray. Studies showed a downward trend in the length distribution of the population and mean weight of fish (Hayes and Penny, 1989). As a result of these downward trends the SCDNR imposed a 21-inch minimum length limit and the creel limit was reduced from 10 to 5 fish per day.

After posting these regulations, the SCDNR initiated studies to determine how the regulations were affecting the size distribution of striped bass in Lake Murray. Prior to the 5 fish - 21 inch restriction, striped bass in Lake Murray were predominately 16- 19 inches. Studies conducted in 1993 indicated a shift in size distributions of striped bass to the 20-22 inch range (Hayes et al, 1999).

The striped bass fishery in Lake Murray is a non-self sustaining fishery and must be maintained through stocking efforts. Until recently, Lake Murray

was considered to have no natural reproduction of striped bass. May (1963) identified egg transport time as the single most limiting factor in striped bass reproduction.

As a result of their 1999 sampling efforts, the SCDNR postulated that the recent increase in striped bass densities, despite the decrease in stocking rates, may be due to an increase in minimum flows from the Buzzards Roost Hydroelectric Project located upstream creating favorable conditions for natural reproduction (Hayes et al, 2000). Additionally, Duke Power has implemented DO enhancements in the tailwaters of the Buzzards Roost, which contribute favorably to fishery habitat.

In 2000, the SCDNR initiated studies to document the occurrence of natural striped bass reproduction within Lake Murray. In the first year of the study, a total of 108 beach seine collections were made, resulting in the capture of 4 juvenile striped bass (CPUE = 0.04 striped bass/seine). In 2001 a total of 10 young-of-year striped bass were collected. This equated to a CPUE of 0.05 striped bass/seine haul, which was similar to the catch rate for 2000-01 (Hayes et al, 2002).

All stocked striped bass stocked into Lake Murray are treated with oxytetracycline (OTC). OTC causes identifiable marks on treated fishes' otoliths (*i.e.* earbones). The SCDNR processed otoliths from 8 of the 14 juvenile fish collected to determine whether the fish were of hatchery origin or naturally reproduced in Lake Murray. Although the sample size was relatively small, all 8 juvenile striped bass possessed OTC markings indicating they were *spawned* in the hatchery and stocked into Lake Murray (pers. Comm. Jenni Chrislip, SCDNR 2003). The SCDNR plans to continue evaluating the potential for natural reproduction of striped bass in Lake Murray. However, due to the drawdown of the lake for remedial repairs to the Dam and the resulting lack of suitable seining areas, the program has been suspended until Lake Murray is refilled (pers Comm. Jenni Chrislip, SCDNR, 2003).

Striped bass stockings in Lake Murray have not been without some controversy. Panfish anglers in the early 1990's raised concerns that striped bass predation was having an adverse effect on the crappie populations in Lake Murray. The SCDNR initiated a two year food habit assessment in 1990 to alleviate the concerns of the panfish anglers. The studies revealed that the predominate food item of striped bass in Lake Murray was threadfin shad. Of the 107 striped bass stomachs analyzed, only 4 contained fish species other than threadfin shad, and those contained leptomids and yellow perch (Hayes and Penny, 1992).

Lake Murray has been historically plagued with annual striped bass mortalities from the early 1970's up to around 1994 in the areas of Spence Islands and the Saluda (Lake Murray) Dam. During the late summer and early fall, natural thermal gradients establish a strong stratification in Lake Murray which results in the production of a warm water epilimnion on the surface of the lake and a cool water hypolimnion in the deeper portions of the lake. Since striped bass prefer cooler water temperatures they become restricted to the thermal refuges in the hypolimnion zone. During the summer and early fall, DO levels slowly decline in the hypolimnion thus reducing the amount of preferred habitat for striped bass. The decreasing DO stresses associated with these thermal refuge areas of adult fish appears to be the primary cause for striped bass mortalities (Hayes, 1994). The magnitude of fish kills related to temperature and DO stress has been variable and was not extensively assessed until 1990. The biggest die-off of striped bass was observed in 1991, when 3,139 striped bass were estimated to have died.

The SCDNR had speculated that operation of the Saluda Unit 5 might have been a contributing factor in the mortality events. Since the Unit 5 intake is located at approximately the same depth as striped bass thermal refuge areas, it was postulated that operation of Unit 5 might actually reduce the size of thermal refuge areas and increase stress levels on striped bass. In the mid 1990's, SCDNR and SCE&G agreed to an operational scenario for reduction in the use of Unit 5

during the late summer and early fall to help prevent blue-back herring entrainment events, which may have helped reduced die-offs in recent years.

10.3.2 Lower Saluda River Fishery

Several studies have been conducted in recent years to assess the fish community structure of the LSR. The LSR prior to 1996 had experienced short periods (July – October) of low DO levels resulting from *hypolimnetic* releases from Lake Murray Dam. Much emphasis has been placed in recent years on maintaining and improving water quality conditions in the LSR. Resource agencies and citizen groups have expressed concerns over the possible negative impacts that degraded water quality may have on the river's fish community and associated habitats (Beard, 2000).

In 1996 SCE&G implemented a fish sampling program to characterize the fishery resource and to assess the potential impacts of low DO levels in the LSR. In addition to the SCE&G data, the SCDNR continues to conduct fish sampling on the LSR as part of their statewide monitoring program.

10.3.2.1 Fisheries Community

Currently, the LSR supports a diversity of species and has a reputation for providing a variety of fishing opportunities (Beard, 1997). The LSR is unique in that it has the ability to support both coldwater and warm water species of fish. Through the trout stocking efforts of the SCDNR, this two-story fishery has been established to enhance recreational fishing opportunities on the LSR. In 1995, the SCDNR investigated the potential to establish a smallmouth bass fishery in the LSR. The SCDNR evaluated the river's ability to meet this species' requirements for food, cover, water quality and reproduction as well as growth, survival, and abundance, based on the habitat suitability criteria for smallmouth bass as described in the literature (Beard, 1996). The SCDNR's findings suggested that while many of the criteria to support a

smallmouth bass fishery were present, it was not feasible to implement this strategy as a fishery management goal in the LSR because suitable habitat was found to be inadequate to support species needs.

10.3.2.2 Resident Fish

The *resident fishery* resource of the LSR is typical of many southern tailwater systems. The fishery resources of the LSR include an assortment of resident game and non-game species (Table E-4). Studies conducted as early as 1991 found approximately 50 species of fish, 48 of which are considered endemic to the region (Jobsis, 1991). Redbreast sunfish, a species typically found in healthy riverine environments, were the most abundant game fish species found in the LSR 1991 study. Bluegill sunfish were typically found in relatively high abundance as well but were highly variable in numbers based on specific habitat types (Jobsis, 1991).

Based on work performed in the late 1980's and early 1990's, catch per unit of effort (CPUE) and number of species collected were generally lower in the upper portion of the LSR (Crane 1987; Jobsis, 1991). However in the 1991 study, when total CPUE's were compared from the upper and the middle section, CPUE's (number/ 100 meters electrofished) were lowest in the middle sections (38.1 fish/hour) of the LSR as compared to lower (66.8 fish/hour) and upper (50.9 fish/hour) sections. In terms of relative abundance, redbreast sunfish were dominant in the upper sections as compared to the lower and middle sections.

It is not uncommon to experience lower CPUE or relative abundance values immediately below hydropower Projects. In tailrace areas subject to hydropower releases, scouring *peaking* flows often limit habitat diversity and colonization of macroinvertebrate species, produce periods of lower DO concentrations, and result in lower abundance of fish species (Bednairak, 2002).

Growth studies conducted on redbreast sunfish in the LSR during 1991 indicated that these species of fish grow more slowly when compared to other rivers in the southeast (Jobsis, 1991). However, this is not surprising since coldwater temperatures have been shown to limit growth of *warmwater fish* in similar watersheds (Ruane, *et al.*, 1986).

Fish sampling data gathered by SCE&G suggests some unique trends in terms of the fish community structure. Total catch in 1995 and 1996 was dominated by gizzard shad. Gizzard shad comprised approximately 25% of the catch. After 1997, which corresponds to the onset of SCE&G's turbine venting program, a marked decline was observed in the harvest of gizzard shad in the LSR, while increases in sportfish species were noted.

Recent sampling conducted in 2001 -2002 by the SCDNR support similar trends as those observed in the SCE&G data. Of special note, the SCDNR data suggests a significant increase in the chain pickerel populations. The SCDNR theorized that these increases are due to a significant increase in the aquatic macrophyte community in the LSR over the last few years (personal communication. H. Beard, 2003).

10.3.2.3 Trout Stocking

The LSR trout fishery has been in existence since the early 1950's and the river continues to support a put, grow, and take rainbow trout and brown trout fishery. Trout stockings vary in number depending primarily on availability of fish from the Walhalla Fish Hatchery. Stocking records suggest that typically the SCDNR stock approximately 28,000 to 30,000 trout annually in the LSR, with a 3:1 ratio of brown trout to rainbow trout, respectively. The length of the fish at the time of stocking is typically 7-8" for brown trout and 9-10" for rainbow trout.

Trout are typically stocked from November – March throughout the LSR. The initial stocking event is typically done by the use of helicopter to facilitate distribution of both species along the LSR. Subsequent stockings are conducted by truck with stocking locations limited to 3 locations along the LSR. Access to the river appears to be the most limiting factor affecting stocking of trout.

Intense fishing pressure, predation by striped bass, and late-summer low DO concentrations require that these trout populations continue to be restocked annually to maintain this fishery. However the local Saluda River Chapter of Trout Unlimited and SCDNR knew prior to 1985 from angler reports that some rainbow trout survive up to several years to become trophy fish of 4 to 8 pounds (Study Plan, 1985). This information was confirmed very recently when the SCDNR captured several large rainbow trout in electrofishing efforts in 2002 (personal communication, H. Beard SCDNR, 2002).

10.3.2.4 Trout Growth Studies on the Lower Saluda River

The LSR is known for its productive striped bass and trout fisheries. In order to maintain healthy and robust fish there are certain criteria that need to be met in regards to available DO, food, and water temperatures. To determine the extent to which the needs of fish, trout in particular, were being met on the Lower Saluda River, In 2003 LSR, SCE&G performed a trout growth study in association with a study to propose a site-specific standard for DO for the LSR downstream of Saluda Hydro. The fish growth study on the LSR indicated that an excellent trout fishery exists on the river.

A FISH model was used to compare annual trout growth under a range of DO patterns in the LSR. Among other comparisons, the growth predictions can be compared with growth achievable at the EPA dissolved oxygen criteria concentration of 6.5 mg/L. Model predictions also allow

comparison of trout growth under any other patterns of DO dynamics. Making such comparisons was the goal of the EPA-TVA model development (Kleinschmidt, 2003).

To predict trout growth in the LSR, the model requires information on the effects of both temperature and DO on appetite and an estimation of the amount of food available to trout in their natural environment. The effects of temperature on appetite are well documented for use in growth models, and the data from the EPA criteria document were used for determining the effects of DO on appetite. Food availability in the LSR can be estimated by measuring the growth of trout in the river and knowing the temperature and DO during the period that growth is measured. Site-specific data on trout growth were gathered through a study of trout planted into the LSR in 2002-2003 (Kleinschmidt, 2003).

Approximately 11,000 rainbow trout were released into the LSR between December 2002 and March 2003.

The growth data collected, along with temperature and DO data from the USGS gages and the tailwater model for the LSR, were used to calculate the amount of food available to the fish. As is common to such studies, the results indicated that the amount of food available was less than the appetite of the fish. In this case, about 68% of maximum appetite was available, based on model calibration. After determining food availability, the model was used to predict trout growth under a range of temperature and DO conditions for various hydropower, meteorological, and regulatory conditions (Kleinschmidt, 2003).

The measured average trout growth rate (0.7 percent weight gain per day, 0.67 inches per month) is higher than that found in most other tailwater trout growth studies (see Table E-7). Analysis of the growth data indicated that data from all 111 fish could be pooled and used in the model, as there was no significant difference in growth as a result of fish

size or condition at release, site of release, date of release, date of capture, direction and distance of movement in the stream, or site of capture (Kleinschmidt, 2003).

Additional information collected during the growth study revealed significant numbers of rainbow and brown trout that appear to be carryovers from previous stockings. A total of 441 tagged and untagged trout were collected from the LSR, with 253 rainbow and 188 brown trout comprising the total catch (Kleinschmidt, 2003).

Of the 441 rainbow and brown trout collected, 74 exceeded 16 inches in length. The largest rainbow and brown trout collected during these surveys were 22 and 24 inches, respectively, with all fish appearing robust and healthy. This may be attributable to higher DO levels since the inception of SCE&G's turbine venting program than those DO levels historically observed in the LSR (Kleinschmidt, 2003).

10.3.2.5 Fish Consumption Advisories

Currently, there are no fish consumption advisories issued by SCDHEC for the Project area, which includes both Lake Murray and the LSR. Further information regarding water quality of Lake Murray can be found in Section 9.2.

10.3.2.6 Fisheries Management Goals

Lake Murray

The SCDNR's current Lake Murray management plan was prepared based on the database of information for the Lake Murray fishery with a focus on major sport and prey species inhabiting the lake. The management plan cited that the longest running management activity on

Lake Murray has been the construction and annual maintenance of fish concentration areas (artificial reefs). In 1975, the fish concentration program began with the installation of 20 fish attractors constructed of brush and trees (May 1976). By 1994, the program expanded to include 22 fish concentration areas that had been established on the lake. Today, the program currently comprises over 29 fish concentration areas managed by the SCDNR (personal Communication, Jenni Chrislip, SCDNR, 2003).

The management plan also identified approximately 11 future activities and management objectives that the SCDNR would like to see implemented:

1. Develop or use existing techniques to determine the extent of blueback herring spawning in Lake Murray. Determine the contribution that blueback herring make to the total prey base of the Lake.
2. Work with the Department's environmental staff and regulatory agencies to protect the important littoral habitat of Lake Murray from further destruction by developmental interests.
3. Gather information on redear sunfish including life history.
4. Continue long-term monitoring of crappie populations.
5. Conduct a significant fall and winter drawdown on Lake Murray every fifth year.
6. If Duke Power Company is forced by FERC to generate minimum flows at Buzzards Roost Hydro to attain relicensing of the facility, efforts should be made to assess if transport time is sufficient for the development and hatching of striped bass eggs.
7. Establish additional fisherman mooring device areas at suitable bridge crossings in Newberry and Lexington counties.

8. Continue to document and enumerate the loss of the striped bass in the downlake region each summer to develop a database of these mortality events. This information can be used to evaluate and encourage operational changes at the Saluda Project that may be impacting the thermal refuges of striped bass.
9. Improve and increase recreational and access facilities on Lake Murray.
10. Continue a rotational schedule of cove rotenone sampling, spring electrofishing and creel census.
11. Continue to stock only Phase 1 striped bass fingerlings to maintain the current level of the fishery.

To date, many of these objectives have been implemented. The SCDNR is continuing to develop and consider additional changes to the plan but to date no final recommendations have been made.

Lower Saluda River

A fishery management plan for the LSR is currently being revised by the SCDNR. However, the LSR fishery has been identified as important to the local economy. A creel census conducted by the SCDNR indicated that the fishery generates approximately 1.8 million dollars annually, with the trout fishery being responsible for the majority of the revenues (Beard, 2000).

10.3.2.7 Anadromous Fish

Anadromous fish are species that live in the ocean but migrate into freshwater environments to spawn. Reports as early as the mid 1800's have suggested that historical migrations of such species as American shad, blueback herring, shortnose and Atlantic sturgeon have ascended

rivers included in the Santee River basin with many species reaching the upper terminus into the Piedmont regions of North and South Carolina. By the late 19th and early 20th centuries, many rivers in the Santee Basin began to see a marked decline in the numbers of anadromous fish species due to the construction of dams and intense exploitation of the fisheries (USFWS, 2001).

Historical evidence suggests that many of these species heavily used the Broad and Congaree Rivers and to lesser degrees the smaller rivers including the Saluda River for these spawning runs. The Santee Cooper dams, constructed in 1942, have become a major impediment in historical runs of diadromous fish up the Santee River basin (USFWS, 2001). Fish passage facilities installed at Santee Cooper have allowed for successful passage of certain anadromous fish species upstream of the Dam.

American shad, striped bass, Atlantic and shortnose sturgeon have historically used Project waters. Mills reported as early as 1826 that American shad and sturgeon ascended rivers above the fall-line, more specifically the Saluda River (USFWS, 2001). Noticeably absent from the list of anadromous fish historically documented from the Saluda River is the blueback herring. While historical data regarding distribution is sparse, Mills reported herring in waterways of the Charleston District. There are reports of blueback herring moving as far up as Santee-Cooper Dam and successfully passing upstream to Lakes Marion and Moultrie. Fisheries surveys conducted in support of the Columbia Project have found no occurrence of blueback herring in the Broad River (adjacent to the Saluda River) (SCE&G, 1999).

Striped bass are the only known anadromous fish to consistently use the LSR. Striped bass migrate up from the Santee Cooper lakes in the early spring and use areas of the LSR in late summer as thermal refuge areas. Anglers on the LSR have reported catching trophy size striped bass,

with many individuals reaching in excess of 50 pounds (personal Communication, Hal Beard, SCDNR, 2002).

Spring electrofishing sampling conducted by SCE&G from 1995 – 2003 revealed only sporadic catches of striped bass. As in previous sampling, the SCDNR has reported no presence of diadromous species such as blueback herring or American shad (Beard, 2002). However, sampling conducted by SCE&G in the spring of 2003 detected the presence of three American shad in the LSR.

10.3.2.8 Catadromous Fish

Catadromous fish are species that live most of their lives in freshwater environments and upon reaching sexual maturity, migrate to the ocean to spawn. The juvenile offspring of catadromous fish migrate through the ocean to the mouth of rivers and move upstream to various habitats to live until adulthood.

The American eel is the only known catadromous fish to inhabit Project waters (Beard, 2002). The presence of this fish species has been documented however, based on sampling information, their numbers in the LSR appear limited.

Current Diadromous and Catadromous Fish Studies

On November 10th 2004, SCE&G and Kleinschmidt Associates hosted a meeting with the SCDNR, USFWS, and NOAA fisheries concerning early diadromous fish studies requested by their agencies. Subsequently, a diadromous fish study plan was developed in conjunction with, and approved by, the above noted resource agencies. The purpose of this study plan is to document the relative abundance and distributions of historically present diadromous fish species on the LSR and the Upper Congaree, as well as the degree to which these species are spawning.

Target species will include the anadromous American shad, hickory shad and blueback herring, and the catadromous American eel. Sampling is scheduled to commence during the 2005 spring spawning season. The sampling strategies that are to be used include gillnetting, ichthyoplankton sampling, and American eel sampling using eel pots. A more precise description of the methodologies used in the sampling regimes is listed in the Final Saluda Diadromous Fish Study Plan (can be found at www.saludahydrorelicence.com). All of the information that is collected during these sampling efforts will be recorded and used as an informational resource during the relicensing process for resource agencies, *stakeholders*, and issue working groups during the relicensing process.

10.3.2.9 Fish Restoration

Anadromous fish restoration efforts for the Santee Basin appear geared more toward establishing historic runs of anadromous fish up the Congaree and Broad Rivers than the Saluda. The Anadromous Fish Restoration Plan (Plan) reports that the Broad River and its tributaries is the most promising sub-basin for diadromous fish restoration (USFWS, 2001). The restoration plan evaluated Project waters and suggests that the hydraulically altered Saluda River ranked low on the efforts for anadromous fish restoration. The Plan states that the cold hypolimnetic water significantly reduces the ambient temperature of the LSR water and migrating fish may choose to use the warmer waters of the Broad and not the Saluda River (USFWS, 2001). Furthermore, alteration of the existing thermal regime of the LSR would be an engineering challenge and likely adversely affect the coldwater trout fishery in the tailwater.

10.3.2.10 Macroinvertebrates

The *benthic macro-invertebrate* community was last sampled from the lower Saluda in the summer of 2004. Hester Dendy samplers (multi-

plate substrate sampler which mimic narrow substrates such as leaves or woody debris) were placed in six different locations on the LSR. They were then allowed to be colonized for seven weeks before they were removed and the benthic macroinvertebrate community was analyzed (Shealy, 2004).

This study was performed in order to determine if there are significant differences in the benthic macroinvertebrate community as the distance from the Dam increases. However, it is not possible to determine if the Saluda Dam has actually *caused* a change in the levels of macroinvertebrates due to the lack of reference or control stations (Shealy, 2004).

The sampling stations were located in various increments along the Saluda River. The uppermost station being located directly downstream of the Dam and the furthestmost station being 10.5 kilometers from the Dam. At each station three Hester Dendy samplers were placed. There were several stations at which samplers were not recovered. The available habitat in these locations varies from submerged logs and snags to vegetated banks (Shealy, 2004).

Studies during 2004 showed that as the distance from the Dam increased the relative numbers and richness of taxa increases. However this is to be expected due to the general characteristics of dams. The water level fluctuations and flow regimes of dams in general tend to cause a decrease in suitable macroinvertebrate habitat. Statistical analysis showed only small differences between the stations. They all had a NCBI rating of fair except only one replicate at station TR (located near the Dam) that had a rating of poor. Table E-8 shows the relative richness and abundance of Macroinvertebrate species on the LSR (Shealy, 2004).

10.3.2.11 Mussels

SCDNR is still in the process of compiling data on mussel distribution throughout South Carolina. However, through discussions with Jennifer Price of SCDNR, there were two survey points sampled on the LSR. Neither of these sites yielded any signs of mussels during sampling (Per. Corr. with Jennifer Price). This was further illustrated in the 2004 *Macroinvertebrate Assessment of the Lower Saluda River*. Six sites were surveyed along the LSR and no mussels in the order Unionoidia were found (Shealy, 2004). Furthermore, extensive surveys have shown that the Carolina Heelsplitter (*Lasmigona decorata*), which was designated as endangered throughout North and South Carolina in 1993, has no cited populations in the Saluda River (USFWS, 2003).

10.3.2.12 Threatened and Endangered Species

As indicated, shortnose sturgeon historically have inhabited the Congaree River basin. Recent information suggests that the shortnose sturgeon may migrate up the Congaree River. Shortnose sturgeon movements have been tracked as far as the Rosewood Boat Ramp on the Congaree River approximately 3 miles downstream from the confluence of the Broad and Saluda Rivers (pers Comm. Doug Cooke, SCDNR 2003). This is the farthest upstream movement of this species within recent years. To date no data supports the theory that shortnose sturgeon currently use the LSR. SCE&G is cooperating with current SCDNR studies to determine movements of shortnose sturgeon in the Congaree, Broad, and Saluda Rivers (pers. Comm. Steve Summer, SCE&G, 2003). Based on tracking information provided by the SCDNR, no sturgeon have been monitored moving into the Saluda River (pers. comm., Steve Summer SCANA Services, 2003).

Table E-4: Fish Species Typical of Lake Murray and the Lower Saluda River

Common Name	Scientific Name	Lake Murray	Lower Saluda River
Amiidae			
bowfin	<i>Amia calva</i>	X	X
Anguillidae			
American eel	<i>Anguilla rostrata</i>		X
Aphredoderidae			
pirate perch	<i>Aphredoderus sayanus</i>		X
Atherinidae			
brook silverside	<i>Labidesthes sicculus</i>	X	
Catastomidae			
Northern hog sucker	<i>Hypentelium nigricans</i>		X
creek chubsucker	<i>Erimyzon oblongus</i>		X
spotted sucker	<i>Minytrema melanops</i>	X	X
striped jumprock	<i>Moxostoma rupiscartes</i>		X
silver redhorse	<i>Moxostoma anisurum</i>		X
smallfin redhorse	<i>Moxostoma robustum</i>		X
shorthead redhorse	<i>Moxostoma macrolepidotum</i>	X	X
v-lip redhorse	<i>Moxostoma pappillosum</i>		X
river carpsucker	<i>Carpionodes carpio</i>	X	
Centrarchidae			
black crappie	<i>Pomoxis nigromaculatus</i>	X	X
white crappie	<i>Pomoxis annularis</i>	X	X
bluegill	<i>Lepomis macrochirus</i>	X	X
dollar sunfish	<i>Lepomis marginatus</i>	X	
pumpkinseed	<i>Lepomis gibbosus</i>	X	X
green sunfish	<i>Lepomis cyanellus</i>	X	
<i>Lepomis</i> hybrid	<i>Lepomis sp.</i>	X	
redbreast sunfish	<i>Lepomis auritus</i>	X	X
redear sunfish	<i>Lepomis microlophus</i>	X	X
warmouth	<i>Lepomis gulosus</i>	X	X
largemouth bass	<i>Micropterus salmoides</i>	X	X
smallmouth bass	<i>Micropterus dolomeiu</i>		X
Clupeidae			
gizzard shad	<i>Dorosoma cepedianum</i>	X	X
threadfin shad	<i>Dorosoma petenense</i>	X	X
blueback herring	<i>Alosa aestivalis</i>	X	X

Common Name	Scientific Name	Lake Murray	Lower Saluda River
Cyprinidae			
dusky shiner	<i>Noropis cummingsae</i>		X
spottail shiner	<i>Notropis hudsonius</i>	X	X
rosyface chub	<i>Notropis rubescens</i>		X
sandbar shiner	<i>Notropis scepticus</i>		X
swallowtail shiner	<i>Notropis procne</i>	X	X
yellowfin shiner	<i>Notropis lutipinnis</i>		X
coastal shiner	<i>Notropis petersoni</i>	X	
highfin shiner	<i>Notropis altipinnis</i>		X
ironcolor shiner	<i>Notropis chalybaeus</i>		X
Eastern silvery minnow	<i>Hybognathus regius</i>	X	X
whitefin shiner	<i>Cyprinella nivea</i>		X
thicklip chub	<i>Cyprinella labrosa</i>		X
golden shiner	<i>Notemigonus crysoleucas</i>	X	X
bluehead chub	<i>Nocomis leptcephalus</i>		X
carp	<i>Cyprinus carpio</i>	X	X
Esocidae			
chain pickerel	<i>Esox niger</i>	X	X
Cyprinodontidae			
lined topminnow	<i>Fundulus lineolatus</i>		X
Ictaluridae			
snail bullhead	<i>Ameiurus brunneus</i>	X	X
flat bullhead	<i>Ameiurus platycephalus</i>	X	X
brown bullhead	<i>Ameiurus nebulosus</i>	X	X
yellow bullhead	<i>Ameiurus natalis</i>	X	X
white catfish	<i>Ameiurus catus</i>	X	X
channel catfish	<i>Ictalurus punctatus</i>	X	X
Lepisosteidae			
longnose gar	<i>Lepisosteus osseus</i>	X	X
Moronidae			
white bass	<i>Morone chrysops</i>	X	X
striped bass	<i>Morone saxatilis</i>	X	X
white perch	<i>Morone americana</i>	X	X
Percidae			
carolina darter	<i>Etheostoma collis</i>		X
piedmont darter	<i>Percina crassa</i>		X
tessellated darter	<i>Etheostoma olmstedi</i>	X	X
yellow perch	<i>Perca flavescens</i>	X	X
swamp darter	<i>Etheostoma fusiforme</i>	X	

Common Name	Scientific Name	Lake Murray	Lower Saluda River
Poeciliidae eastern mosquitofish	<i>Gambusia holbrooki</i>	X	X
Salmonidae brown trout rainbow trout	<i>Salmo trutta</i> <i>Oncorhynchus mykiss</i>		X X

SPECIES	1995	PERCENT COMPOSITION	1996	PERCENT COMPOSITION	1997	PERCENT COMPOSITION	1998	PERCENT COMPOSITION	1999	PERCENT COMPOSITION	2000	PERCENT COMPOSITION
pumpkinseed												
quillback												
quillback carpsucker												
rainbow trout												
redbreast sunfish	10	3.9	13	5.2	34	9.6	23	8.5	47	18.1	18	6.4
redcar sunfish	18	7.0	16	6.4	24	6.8	31	11.5	16	6.1	28	10.0
sandbar shiner			4	1.6	24	6.8					6	2.1
satinfin shiner	1	0.3									2	0.7
shorthcad redhorse	1	0.3	4	1.6	4	1.1			1	0.3	1	0.3
silver redhorse			1	0.4	1	0.2						
silvery minnow	1	0.3										
snail bullhead												
spottail shiner	1	0.3	11	4.4								
spotted sucker	24	9.4	29	11.7	34	9.6	33	12.3	13	5.0	40	14.3
striped bass	1	0.3			9	2.5			3	1.1	2	0.7
tesselated darter									2	0.7		
turquoise darter												
unid. Alosa			1	4.0								
unid. catostomid	14	5.4					10	3.7			3	1.1
unid. shiner												
v-lip sucker												
warmouth			3	1.2	1	0.2	1	0.3	3	1.1	3	1.1
white catfish					1	0.2	9	3.3				
white perch	3	1.1					7	2.6				
whitefin shiner												
white perch			2	0.8					49	18.9		
whitefin shiner	34	13.3	11	4.4	45	12.7			2	0.7	4	1.4
yellow perch												
yellowfin shiner					2	0.5	25	9.3	2	0.7		
TOTAL	255		247		352		268		259		278	

Table E-6: Fall Electrofishing Data Collected in the Lower Saluda River by SCE&G (1995-2000)

SPECIES	1995	PERCENT COMPOSITION	1996	PERCENT COMPOSITION	1997	PERCENT COMPOSITION	1998	PERCENT COMPOSITION	1999	PERCENT COMPOSITION	2000	PERCENT COMPOSITION
American ccl			1	0.4	3	0.8	1	0.3				
black bullhead												
black crappie			1	0.4			3	1.1	1	0.3		
bluegill	24	9.4	58	23.4	112	31.8	38	14.1	51	19.6	37	13.3
bluegill x redear sunfish												
bluhead chub											1	0.3
bowfin												
brook silversides											24	8.6
brown trout	1	0.3							1	0.3	1	0.3
Catasomidac unid.			1	0.4								
chain pickerel	6	2.3	5	2.0	9	2.5			21	8.1	13	4.6
channel catfish							1	0.3				
common carp	19	7.4	9	3.6	7	1.9	10	3.7	12	4.6	2	0.7
creek chubsucker	10	3.9	4	1.6	14	3.9	1	0.3	13	5.0	21	7.5
eastern silvery minnow					8	2.2						
flat bullhead												
gizzard shad	77	30.1	56	22.6	1	0.2	60	22.3	2	0.7	28	10.0
golden shiner									1	0.3		
grass carp									1	0.3		
greenfin shiner												
highback chub												
highfin shiner											4	1.4
ironcolor shiner											18	6.4
largemouth bass	9	3.5	16	6.4	12	3.4	13	4.8	12	4.6	16	5.7
longnose gar												
mosquitofish							2	0.7	2	0.7		
northern hogsucker	1	0.3	1	0.4	1	0.2					6	2.1
Notropis sp												
pirate perch					6	1.7			4	1.5		

SPECIES	1996	PERCENT COMPOSITION	1997	PERCENT COMPOSITION	1998	PERCENT COMPOSITION	1999	PERCENT COMPOSITION	2001	PERCENT COMPOSITION
Notropis sp			7	1.9						
pirate perch	5	1.6								
pumpkinseed					1	0.7				
quillback									2	1.6
quillback carpsucker	3	0.9								
rainbow trout	13	4.2	8	2.2	3	2.3			8	6.4
redbreast sunfish	9	2.9	13	3.5	8	6.3	1	11.1	3	2.4
redcar sunfish	40	12.9	60	16.5	29	23.0	1	11.1	10	8.0
sandbar shiner					1	0.7				
satinfin shiner										
shorthead redhorse	1	0.3								0.8
silver redhorse	1	0.3								
silvery minnow										
snail bullhead			2	0.5						
spottail shiner									1	0.8
spotted sucker	31	10.0	20	5.5	9	7.1			23	18.4
striped bass	2	0.6	12	3.3					10	8.0
tessclated darter										
turquoise darter	2	0.6								
unid. <i>Alosa</i>			1	2.0						
unidentified shiner									1	0.8
v-lip sucker										
warmouth										
white catfish	16	5.1	3	0.8	2	1.5				
white perch										
whitefin shiner									6	4.8
yellow perch	28	9.0	43	11.8	20	15.8	2	22.2	4	3.2
yellowfin shiner										
TOTAL	309		362		125		9		125	

Table E-5: Spring Electrofishing Data Collected in the Lower Saluda River by SCE&G (1996-2001)

SPECIES	1996	PERCENT COMPOSITION	1997	PERCENT COMPOSITION	1998	PERCENT COMPOSITION	1999	PERCENT COMPOSITION	2001	PERCENT COMPOSITION
American ccl			1	0.2						
black bullhead									1	0.8
black crappie	4	1.3								
Bluegill	46	14.8	54	14.9	17	13.4	3	33.3	4	3.2
Bluegill x										
redcar sunfish			1	0.2						
bluhead chub									1	0.8
Bowfin									1	0.8
brook silversides										
brown trout	28	9.0	21	5.8	4	3.1			7	5.6
catasomidac unid.										
chain pickerel	1	0.3	6	1.6					5	4.0
Channel catfish	1	0.3	6	1.6						
common carp	10	3.2	7	1.9					2	1.6
creek chubsucker	2	0.6	9	2.4	1	0.7			17	13.6
eastern										
silvery minnow	9	2.9								
flat bullhead	1	0.3							1	0.8
gizzard shad	32	10.3	72	19.8	26	20.6				
golden shiner	1	0.3	1	0.2	1	0.7			1	0.8
grass carp	8	2.5	2	0.5						
greenfin shiner									7	5.6
highback chub									1	0.8
highfin shiner										
ironcolor shiner										
largemouth bass	13	4.2	10	2.7	3	2.3	2	22.2	7	5.6
longnose gar			2	0.5					1	0.8
mosquitofish										
northern hogsucker	2	0.6	1	0.2					1	0.8

Table E-7: Comparison of Saluda Trout Growth Study Results Versus Other Southeastern Hydropower Tailwaters (Kleinschmidt, 2003)

Growth Rate Comparison – SE Tailwaters								
Dam	State	Length (mi)	Period	Start size (in)	T (deg C)	DO (mg/L)	Grow rate (in/mo)	Notes
Saluda	SC	10	Nov 1988-Apr 89	6 (40g)	10-18	0.5-12	0.25	Before aeration - RBT
			Dec 2002-Jun 2003	10 (150g)	8-15	4-12	0.67	Current aeration - RBT
various	KY	--	current				0.5	per KDFWR staff – BT, RBT
Wolf Creek	KY	50	Apr-Nov 1997	7.5	9-27	3-10	0.52	Dreves (2003) KDFWR - BT
			Apr-Nov 1998	8.2	9-27	3-10	0.48	
			Apr-Nov 1999	8.2	9-27	3-10	0.49	
			Apr-Nov 2000	7.0	9-27	3-10	0.71	
			Apr-Nov 2001	7.4	9-27	3-10	0.69	
			Apr-Nov 2002	7.7	9-27	3-10	0.54	
Center Hill	TN	26	Mar-Jul 1997	9.4		4-7	0.51	Devlin (1999) TTU - RBT
Norris	TN	30	Jan-May 1975	9.3	7-10	>8	0.62	1993 TVA data - RBT Shiao, et. al (1993) weights using CF=1.1; growth probably T limited
			Jan-May 1985 abv weir	7.5-8.0	5-9	>8	0.48	
			Jan-May 1985 bl weir	7.5-8.0	5-9	>8	0.30	
			Jan-May 1986 abv weir	7.0-7.5	6-10	8-10	0.38	
			Jan-May 1986 bl weir	7.0-7.5	6-10	8-10	0.43	
South Holston	TN	14	Mar-July 1992	4.72	6-8	8-12	0.58	1992 TVA - RBT data Shiao, et. al (1993) Yeager, et. al (1993) Bettoli (2003) TTU - RBT Bettoli (2003) TTU - RBT Bettoli (2003) TTU - BT
			July-Sep 1992	7.64	6-8	8-12	1.69	
			Mar-Sep 1992	4.72	6-8	8-12	0.90	
			1997 – Mar. stocking		<22	>6	0.35	
			1997 – Sep stocking		<22	>6	0.63	
			1997		<22	>6	0.43	
Wilbur	TN		1998 – Mar stocking				0.27	Bettoli (2003) TTU - RBT
			1998 – July stocking				0.19	
Growth Rate Comparison – Non-Tailwater Locations								
Sierra Nevada streams	CA		Avg 1987-1996 site #1 (fall-spring)	Age 0	Avg 7.2		0.44	Railsback and Rose (1999) - RBT
			Avg 1987-1996 site #2 (fall-spring)	Age 0	Avg 10.2		0.54	
			Avg 1987-1996 site #1 (summer)	Age 1	Avg 14.9		0.20	
			Avg 1987-1996 site #2 (summer)	Age 1	Avg 18.1		0.06	

Table E-8: Bioassessment Metrics for the 5 Saluda River Hester Dendy Stations Downstream from the Lake Murray Hydroelectric Dam, Operated by South Carolina Electric and Gas Company. Lexington County, SC. 01 July, 2004 (Shealy, 2004)

Metric	Station										
	TR1	TR2	TR3	SPW1	SPW2	SPW3	LR1	LR2	LR3	OPC2	OPC3
Taxa Richness	15	21	20	30	27	38	31	30	27	24	26
Number of Species	166	156	178	171	176	189	107	138	68	231	298
EPT Index	2	2	2	3	3	4	5	5	4	5	6
EPT Abundance	27	26	22	31	34	27	30	49	5	170	204
Chironomidae Taxa	5	9	8	14	13	17	11	14	10	12	11
Chironomidae Abundance	15	35	29	70	43	87	38	47	33	36	41
EPT/Chironomidae Abundance	1.80	0.74	0.76	0.44	0.79	0.31	0.79	1.04	0.15	4.72	4.98
North Carolina Biotic Index	7.93	7.31	7.62	7.02	7.47	6.97	7.50	7.38	7.53	7.17	6.91
Percent Collector-Filterers	6.02	10.26	8.43	22.22	11.93	16.40	32.10	31.33	36.48	24.30	38.22
Percent Collector-Gatherers	1.20	1.92	1.69	14.04	3.98	7.41	1.33	1.29	1.64	2.78	1.04
Percent Omnivores	7.23	8.97	3.37	7.60	13.64	7.41	6.37	18.45	7.38	2.53	2.37
Percent Predators	0.60	5.77	1.12	6.43	4.55	5.82	11.41	5.58	8.20	4.05	5.78
Percent Scrapers	78.92	57.69	74.72	38.01	57.95	38.62	48.28	41.20	44.26	65.82	52.30
Percent Shredders	6.02	15.38	10.67	11.70	7.95	24.34	0.53	2.15	2.05	0.51	0.30
Scraper/Scraper & Collector-Filterers	13.10	5.63	8.87	1.71	4.86	2.35	1.50	1.32	1.21	2.71	1.37
Percent Dominant Taxon	34.94	17.95	30.90	15.79	17.61	12.70	29.97	30.04	35.25	21.27	35.85
Number of Dominant Taxa	4	8	6	7	6	6	3	4	2	6	5

11.0 ***BOTANICAL RESOURCES***

11.1 Upland Habitat

The botanical and forestry resources of the Project area consist mainly of the dominant woody pioneer or climax species of the southern Piedmont hardwood forests. Forested areas of the Project function mostly in support of forestry, wildlife or game management, and recreational or aesthetic values. Various combinations of the tree and shrub species cover 4,513.5 acres of Project lands over a shoreline distance of 92.9 miles (Mead and Hunt, 2002a). One of the most common trees is loblolly pine (*see table E-9 for scientific names*), coming in early after disturbance of most well-drained sites and dominating for up to 40 years afterwards. This tree is also the species of choice for the regional forestry industry, growing rapidly and generating clear, straight wood for a number of uses.

SCE&G manages forest resources on total of 10,532 acres (within a quarter mile of Lake Murray) of its land according to an official Forest Management Plan. The plan provides for selective harvesting of pines and hardwoods, and maintenance of a 100-foot-wide shoreline buffer to protect water quality, wildlife, fishery, and aesthetic values. In certain areas such as cliffs, steep slopes, or atypical groups of trees, no logging is allowed. On private riparian lands sold by SCE&G since 1984, a 75-foot vegetated buffer zone above the 360-foot contour is maintained in accordance with current FERC license conditions. In this zone, brushing or clearing of vegetation is limited to trees or shrubs of 3 inches in diameter or less. Enforcement of buffer zone compliance is by written agreement, with penalties imposed by SCE&G through denial or revocation of dock permits for violators (SCE&G, 1994).

11.1.1 Lake Murray

Along the forested slopes in the upper region of the lake, mature oak-dominated forest can be found with a diverse canopy and sub-canopy layer (SCE&G, 1994). Species differ between the upper and lower slopes and because

of the dense canopy, the herbaceous layer is sparse. These forests are important mainly as wildlife habitat. They cover 20.6 acres of land and over a mile of shoreline (Mead and Hunt, 2002a).

Rocky Shores are located along the shoreline adjacent to rock outcroppings. They are usually devoid of vegetation but do provide a stable vertical structure to otherwise uniform bottom relief. They attract littoral fish species and, if located in open water, are equally attractive to pelagic fishes (SCE&G, 1994).

11.1.2 Lower Saluda River

Habitat diversity found in the LSR is more homogeneous than the highly diversified habitats of Lake Murray. In the areas below the Dam, vegetation consists of mesic (environments midway between extremes) hardwood forests, wetlands, pine plantations, and open, disturbed herbaceous plant communities on the berms surrounding the former ash ponds for McMeekin Station and areas impacted by the remediation work associated with the Dam. These areas are highly disturbed and contain little in the way of botanical resources. The mixed hardwood forest cover type dominates much of the available habitat along the LSR, especially near the rivers edge (pers. observation).

The forest edge habitat of the LSR, which is located in the transitional area between open and forested cover types, comprises approximately ten percent of the total habitat along the LSR. This cover type is the interface between the forested and field habitats and provides a great deal of vegetative diversity and height class complexity (Colinvaux, 1986).

Open field habitat makes up approximately fifteen percent of the available habitat along the LSR. Open field habitat is limited to those areas that are periodically mowed and maintained and are typically dominated by assorted grasses. These cover areas are confined to narrow strips in agricultural areas along the river corridor (pers observation A. Stuart Kleinschmidt, 2003).

Based on visual estimates made by Kleinschmidt Associates, river edge cover type makes up approximately sixty-five percent of the available habitat along the LSR. These areas are highly diverse in terms of botanical resources (pers. comm. David Haddon SCE&G 2003).

11.1.3 Islands

The 61 islands within the Project boundary support a variety of plant communities depending on elevation and land-use history. The riverine islands primarily support bottomland hardwood forests. The herbaceous layer on the islands consists of a mixture of forbs and graminoid plants and may be patchy depending on the canopy cover.

Loblolly pine-mixed hardwood islands are found on the middle and lower portions of the lake. However, most of these islands have been subjected to periodic burning and have a dense canopy composed of loblolly and shortleaf pine, water oak, and sweetgum, which does not allow for a significant herbaceous understory to develop. Open, disturbed islands support scattered trees and shrubs and, in the more open areas, dense herbaceous layers consisting of a diversity of grasses and forbs. The vegetation is dominated by successional species. Successional describes a species or community that is ephemeral in that it will be replaced by species that will form the climax community. An abandoned farm field for example contains successional species. These species will be replaced by a more stable long-term community unless regular disturbance such as annual mowing keeps it in a successional state.

Continued natural and anthropogenic disturbances in the form of wind and wave action, prescribed burning, past agricultural use and present recreational use serve to maintain the open aspect of these islands (Mead and Hunt, 2002a). The herbaceous layer on the open and disturbed islands is dominated by grasses and composites in the autumn, many of which are typical species of old field succession. Old field succession is typically when herbal communities of old

fields succeed each other and give way to pines, the organic layer of the soil deepens and the water retaining capacity of the soil increases (Colinvaux, 1986).

The most ecologically distinct island is Lunch Island, located approximately 4.5 miles upstream of the Dam, which has a dense stand of switch cane and abundant pokeberry. As mentioned in more detail in the Wildlife section, this island is home to one of the largest colonies of nesting purple martins in the world. Lunch Island is also covered by an open habitat of scattered trees and shrubs over a dense herbaceous layer of grasses and composite forbs very similar to a number of other small islands in the lake (SCE&G, 1994).

The islands provide important wildlife habitat for a number of species and are a major recreational and aesthetic asset for the lake. The islands total approximately 617.7 acres, with a combined shoreline length of 36.9 miles (Mead and Hunt, 2002a).

11.1.4 Wetlands

In March 2000, the SCE&G staff delineated wetlands in 31 different locations immediately downstream of the Project Dam comprising approximately 55 acres. The hydrology of these areas varies from an intermittent or seasonal inundation to perennial flow. The vegetation in the wetlands includes a wide variety of forested, shrub, vine, and herbaceous cover types. The different types of wetlands downstream of the Dam include small, seasonally flooded forests, abandoned borrow pits/quarries that have developed ponded and *palustrine* habitats, a narrow riverine forested wetland, seasonally flooded areas of scrub/shrub, seasonally flooded bottomland hardwoods, and emergent wetlands (Mead and Hunt, 2002a). These are the only wetlands downstream of the Project Dam to be delineated. However NWI maps for the Project Area depict wetlands within the Project boundary. Information on wetlands in the *project vicinity* is currently in the process of being developed digitally by the USFWS National Wetlands Inventory.

Wetlands upstream of the Project Dam, specifically those around the Lake Murray shoreline, consist primarily of *lacustrine* fringe communities and *submerged aquatic vegetation* (SAV). The predominant lacustrine fringe communities on the lake include emergent aquatic species at the lower elevations and emergent and shrub species at the higher elevations. Other emergent wetland species occupy a narrow band of the lacustrine fringe habitat along the reservoir and larger flat regions of the Saluda and Little Saluda Rivers. Approximately 363 acres of emergent wetland exist below the 360-foot contour around the lake, with nearly ninety percent of them occurring in the headwater region of the lake along the Saluda River (Mead and Hunt, 2002a).

Palustrine scrub-shrub wetlands occupy the lacustrine fringe, shallow coves, and the tributary banks. There are approximately 140 acres of this type of wetland below the 360-foot contour around Lake Murray. Pockets of the shrub habitat can be found in coves with the most extensive areas occurring along the Saluda River, just upstream of the Little River confluence. The predominant shrub community consists primarily of buttonbush and black willow, with the occasional presence of persimmon and water willow as well. The palustrine forested wetlands (PFO) occupy approximately 1,618 acres below the 360-foot contour around the lake. It is expected that most of the forested wetlands associated with the lake receive infrequent and irregular flooding, in addition to other inputs such as streamflow and runoff (Mead and Hunt, 2002a). Wetlands are delineated on the USFWS National Wetland Inventory (NWI) database. The USFWS is charged with maintaining the NWI wetland Mapping system. It should be recognized that both jurisdictional and non-jurisdictional wetlands are depicted on NWI maps. The NWI uses an identification and classification system developed specifically for the USFWS (Cowardin et al. 1979) that is similar to the US Army Corps of Engineers (COE) but it differs in several key aspects. Therefore, it is important to note that jurisdictional wetlands are those wetlands that are subject to regulation under Section 404 of the *Clean Water Act*, and that wetlands not subject to this permitting process are referred to as non-jurisdictional. In terms of resource management, only the COE system

determines whether or not a wetland is jurisdictional, while the NWI further classifies wetlands according to hydrology, vegetation and other characteristics.

Water Tupelo stands are located in the upper lake in low wet flats. They consist of a dense, monotypic stand of water tupelo. Since water tupelo stands occur only in areas that are consistently inundated, the shrub layer is absent. Swamp beggar-tick grows on the trunks of the trees at or just above the high water mark (SCE&G, 1994). In areas where the substrate is exposed, false pimpernel is found. These areas are relatively limited and comprise 0.6 acres over 0.1 miles of shoreline habitat (Mead and Hunt, 2002a). These stands are unique because they are the northern most occurrences of water tupelo known to exist in the Saluda River (SCE&G, 1994).

In addition to the forested areas and wetlands, islands, shallow coves, and other ecologically significant botanical resources occur within the *riparian areas* of the Project. These were most recently described and classified by SCE&G (1994) in response to a 1991 FERC *Order to Amend the Land Use and Shoreline Management Plan* (FERC, 1991). Studies undertaken by SCE&G to amend the plan resulted in the classification of 11 habitat types as Environmentally Sensitive Areas (ESAs) below the 360-foot contour, which included nine vegetated habitat types described briefly below, as well as unvegetated shallow shoals and rocky shores having littoral buffer or fishery values. The botanical species found in each of the habitat types are listed in Table E-9. The designation as ESA was not meant to imply an existing threat or need for preservation, but was intended as a reference tool in consideration of management alternatives and establishment of management objectives (SCE&G, 1994).

Shallow Coves are jurisdictional wetlands that include flats and gentle slopes above the 352-foot contour and extend down to about 6 feet below the annual mean high-water mark. They occur immediately below buttonbush and willow flats (described below). Depending on water level, they provide shallow water or exposed shoreline habitat and are usually inundated from late winter through spring. The higher, more exposed portion is more diverse because of its

longer exposure and supports distinctly-zoned assemblages of forbs, grasses, sedges, and rushes. The coves cover 32.7 acres of Project lands over a shoreline distance of 2.9 miles (Mead and Hunt, 2002a). These areas provide habitat for several wildlife species and are significant to the recreational fishery, representing most of the suitable spawning and nesting habitat for the resident centrarchids (*i.e.* bass and sunfish).

The draw-down zone is the area between the high water level and the actual water level and is usually inundated from late winter through spring. Graminoid plants (Grasses) dominate the draw down zone and the vegetation usually exhibits a strong pattern of zonation, especially in the lower lake (Mead and Hunt, 2002a). The upper portion of the draw-down zone is typically the most diverse because of the extended periods of exposure (not covered by water), supporting a mixture of forbs (broad leafed herbaceous plants) and graminoid plants. The intermediate and lower portions of the draw down zone are dominated by spikerushes. The draw down zone in the upper portion of Lake Murray consists of extensive flats rather than the sloping, exposed shoreline. The riverine flats are similar to exposed bars and are dominated by graminoid plants.

Shallow shoals areas located on Lake Murray generally consist of submerged ridges and hill tops located above the 352-foot contour. These shallow shoal areas are generally in unprotected areas and are subject to constant wave impact, which makes colonization by vegetation in these areas difficult. However, these areas are important transition zones between the shallow cove, buttonbush, and willow habitats and the deep water.

Buttonbush and willow flats usually occur at or just below the 360-foot elevation and are common along the upper margins of shallow coves and other shoreline areas (SCE&G, 1994). They also occasionally extend up feeder creeks at lower flood plain elevations and are considered jurisdictional wetlands. These flats typically support buttonbush on the lake side with black willow located behind the buttonbushes. Infrequently, only buttonbushes may be found in this zone, either in dense stands or as scattered individuals. This community, when

disturbed, is very susceptible to invasion by water primrose. The buttonbush and willow flats cover approximately 352.3 acres of the Project over a shoreline distance of 139.4 miles (Mead and Hunt, 2002a). Other species occurring in these areas are shown in Table E-9. The stability provided by the root systems of the plants growing in this habitat reduces the effects of erosion caused by wave action. Because of this stability, spawning centrarchids use these areas extensively. The structural complexity of these areas also provides a safe haven for larval and juvenile fishes (Mead and Hunt, 2002a).

Bottomland hardwood areas occur in the upper lake as a transition zone between wet flats and upland forest and on the lower lake between shallow coves or buttonbush and willows and upland forest. They are generally found where creeks enter the lake. These areas are important wetlands and help to filter out pollutants and sediments present in runoff. Bottomland hardwood provides important foraging and nesting habitat for several species of wildlife such as the white-tail deer, squirrels, raccoons and a number of neo-tropical bird species (Mead and Hunt, 2002a).

Exposed bar areas of Lake Murray occur in the upper lake and are typically associated with the riverine islands. They are remnants of the old river system and consist primarily of sand and heavier materials deposited during flood events along the river banks before the Saluda River was impounded. Exposed bars are still heavily influenced by river currents and the inflow of nutrients. These areas are inundated during most of the year and are usually exposed only during the winter months, which classify them as wetlands under the NWI mapping system. Graminoid plants typically tend to dominate the plant community structure of the exposed bars. The high velocity and nutrient loading in the upper portion of the reservoir determine habitat suitability of the exposed bars for reservoir fish. Upstream portions of the bars usually have limited fish habitat, while the more protected downstream areas of the bars offer more favorable spawning locations for nest-building bass, crappie, and sunfishes. Exposed bars include 52.2 acres of the Project area over a shoreline distance of 1 mile (Mead and Hunt, 2002a).

Wet flats exist in the upper lake between the bottomland hardwoods and shallow coves and have two distinct forest cover types depending on elevation (low wet flats vs. higher flats). Both types are jurisdictional wetlands. The wet flats provide important wildlife habitat for the lake ecosystem and, when submerged, are prime feeding areas for migratory waterfowl. During high-water periods, they are also an important source of coarse particulate organic matter for the lake, which forms an important supplement to fine and dissolved sources of nutrients supplied by tributary creeks and rivers. The total area of wet flats is 495.4 acres and covers over 15.8 miles of shoreline (Mead and Hunt, 2002a).

11.1.5 Threatened and Endangered Botanical Species

Seven species are listed as either rare, threatened, or endangered as indicated by federal and state agencies. An assessment of Threatened and Endangered species for the Saluda Dam Remediation Project was conducted in 2001. The following information on threatened and endangered species potentially found in the Project area was taken from the remediation Project environmental report prepared by Mead and Hunt in 2000.

The smooth coneflower (*scientific names for threatened and endangered species are listed in Table E-10*) is an herbaceous perennial that flowers from May to July. They are mainly found in basic soils that undergo periodic mowing, burning, or other disturbances that suppress competition and allow full sunlight to penetrate. These habitats include open woods, cedar barrens, roadsides, clear-cuts, right-of-ways, and dry limestone bluffs. A small population of this coneflower is known from Fort Jackson in Richland County, but there are no known populations in Lexington County. No specimens of smooth coneflower were located during fieldwork conducted in 2000; and with the lack of burning or similar disturbances on downstream Project lands, habitat potential for this species is limited.

Schwienitz's sunflower is a rhizomatous, perennial herb that flowers in late summer in clearings and along the edges of upland woods, roadways, and

utility easements. There are no known populations of this species in the Project area and no specimens of this species were located during fieldwork in the late summer of 2000.

Canby's dropwort is a perennial herb of the Coastal Plain wetlands occurs in pond cypress savannas, pond cypress/pond sloughs, and wet pine savannas. It also requires regular burning or mowing. All known populations are in Carolina bays of the Coastal Plain. No habitat exists for this species in the Project area and no specimens were found during field surveys of Project wetlands downstream of the Dam in 2000.

Rough-leaved loosestrife is a perennial herb is found in the Coastal Plain and Sandhill Regions of the Carolinas. It inhabits the grass-shrub transition zone between longleaf pine woods and pond pine pocosins on seasonally-wet sands or shallow organic soils over sand. It also occurs on deep peat soils of the Carolina bays. These habitats are also fire-maintained. The only known South Carolina population of this loosestrife is at Fort Jackson in Richland County. Since there is intensive development and fire suppression in the Project area, there is no habitat potential for this species (Mead and Hunt, 2002a).

In 1991 the USFWS found little amphianthus (pool sprite) in a pool in Saluda County. This plant is restricted to shallow, flat-bottomed depressions, rock-rimmed and normally less than one foot deep, on granitic outcrops, where water collects following a rain event. The depressions may be dry for most of the summer, except for occasional rainy periods (Georgia Natural Heritage Program, Mead and Hunt, 20012).

A harperella population was found by USFWS (1992) in Saluda County. The plants normally occur in rocky or gravel shoals, margins of clear, swift-flowing sections of stream, or at the edges of intermittent pineland ponds in the coastal plain. The status of this species as occurring in the Project boundary is unknown.

A known population of the rocky shoals spider lily exists approximately 10 miles downstream of the Saluda Dam at the confluence of the Saluda and Broad Rivers in Columbia (Clemson University Dept. of News Services, 1997). The plant is found in major streams and rivers among boulders in the rocky shoals, typically with riverweed and water willow. This lily has become rare because of habitat loss caused by the building of dams and canals along river systems, which have altered the flow patterns over the rocky shoals. SCDNR stated that the plant could tolerate high flows, which may reduce the occurrence of competitive plant species.

These species listed require specialized habitats to carry out their life cycles and these habitats are not likely found in the Project area, with the exception of the Rocky Shoals Spider lily (RSSL). ARM Environmental Consultants conducted an assessment of threatened and endangered species for the Saluda Dam remediation project and found that any federally listed species would not occur in the impacted area due primarily to lack of suitable habitat (ARM, 2001). The RSSL has been located in the downstream most reaches of the LSR. For a listing of all botanical Federal and State listed threatened and or endangered species in counties occupied by the Project, please refer to Table E-10.

11.1.6 Invasive Aquatic Plants

Invasive aquatic plants have been problematic in Lake Murray and the LSR for a number of years. In order to keep track of plant abundance and distributions, quantitative data on aquatic plants has been collected through aerial surveys and summarized in distribution maps. In the early 1990's, Brazilian elodea was the primary aquatic plant of concern on Lake Murray (Aulbach-Smith, 1997). Brittle waternymph presented problems as well, however a shift of concern occurred upon the discovery of hydrilla in 1993. Hydrilla is an exotic plant that was introduced into the United States in the 1960's through the aquarium trade. Presently millions of dollars are spent every year in order to control this noxious weed. One key to hydrilla's success is the multiple modes

through which it reproduces. Not only does hydrilla spread through seeds, it also reproduces through tubers, plant fragments, and turions (overwintering buds). Boat traffic and waterfowl also contribute to the spread of populations throughout bodies of water (Access Washington, 2004).

Lake Murray

There are several invasive aquatic plant species that are under observation on Lake Murray. These include hydrilla, Eurasian water milfoil, and several species of pondweed (*Potamogeton pusillus*, *P. crispus*, and *P. illinoensis*) (Aulbach-Smith, 1997). Hydrilla populations are beginning to decline in Lake Murray due to the introduction of triploid Chinese grass carp into Lake Murray in 2002. The diet of grass carp is almost exclusively aquatic plants and they can help tremendously in the reduction of invasive plant species. Eurasian milfoil is also a cause for concern on Lake Murray. However, through numerous pesticide applications the spread of Eurasian water milfoil has been confined to one cove of the lake. Several species of pondweed are present and are posing problems as well. The most notable of these is Illinois pondweed. It releases large amounts of seeds that are spread by waterfowl and wave action. Grass carp will readily consume Illinois pondweed, though it seems unaffected by the winter drawdowns that are used in the control of hydrilla (Aulbach, 2001b).

The Lower Saluda River

The majority of aquatic vascular plants on the lower Saluda River are introduced species. Seasonal changes and water fluctuations in the lower Saluda River tend to cause a reduction in the numbers of aquatic plants present in the river channel. However, Brazilian elodea is one *exotic species* that is continuing to expand, and is also becoming more common in the rocky shoals. There is concern that Brazilian elodea may crowd out riverweed, a native plant, that usually resides in the rocky shoals. Parrot's feather grows sporadically amongst Brazilian elodia (Aulbach, 2003). Aquatic plants such as Asian dayflower and

water primrose are present in the shallow backwaters downstream from the confluence with the emergency spillway (see Figure E-13) (Aulbach, 2001a):

12.0 WILDLIFE RESOURCES

Although the Lake Murray shoreline continues to undergo development, the project area contains extensive habitats that support diverse and abundant wildlife populations. Shoreline habitats are typical of the Piedmont area of South Carolina and include pine plantations, bottomland and upland hardwood forests, mixed pine/hardwood forests, open fields, and sandhills. The majority of wildlife habitats in shoreline areas are found in the 75 ft. setback, riparian buffer zones, Environmentally Sensitive Areas (ESAs), and undeveloped areas of the project. Details regarding the vegetative resources (*i.e.*, wildlife habitats) are presented in Section 9.3.4.

Forested and other terrestrial areas surrounding the project harbor typical woodland species such as wild turkey, white-tailed deer, raccoon, gray squirrel, opossum, and gray fox. Terrestrial areas also support a variety of resident and migratory birdlife including songbirds, woodpeckers, raptors, and upland game birds. Typical species include red-tailed and red-shoulder hawks, bobwhite quail, mourning dove, American robin, eastern bluebird, pileated woodpecker, and meadowlark. The project area also supports an abundance of terrestrial reptiles and amphibians such as eastern box turtle, green anole, broad-headed skink, gray rat snake, southern toad, green tree frog, and marbled salamander.

The abundant open- and shallow-water habitats within the project area support a variety of aquatic and semi-aquatic wildlife such as beaver, river otter, muskrat, and possibly mink. Shallow, often vegetated areas in creekmouths, backwaters, and along reservoir shorelines are used for foraging and cover by migratory and resident waterfowl such as wood ducks, Canada geese, American coots, and black ducks, as well as wading birds such as great blue herons, great egrets, and green herons. In addition to providing important breeding habitat for most amphibian species, these shallow waters also provide year-round habitat for aquatic reptile and amphibian species such as eastern newt, bullfrog, spring peepers, brown and red-bellied water snakes, and mud and musk turtles.

Open water areas are often utilized by such species as bald eagle, kingfisher, osprey, and various gulls for foraging.

Lunch Island on Lake Murray is one of the largest pre-migratory roosting sites for purple martins in the United States (Russell and Gathreaux, 1999). The purple martin is a neotropical migrant, meaning that it migrates annually from its normal range in South America, the West Indies and portions of Central America, northward to breeding grounds across North America (Brown, 1997). This species is unique in that it nests in large colonies and is almost entirely dependant upon man-made structures for nesting (Russell and Gathreaux, 1999). Following the fledging period, purple martins often congregate in large nocturnal roosts of 100,000 or more birds prior to returning southward (Brown, 1997). Beginning in late June and extending through August or early September these congregations engage in two mass movements daily as they exit the roost in the morning to feed and return in the evening (Russell and Gathreaux, 1999). It has been estimated that at least 700,000 birds utilize the Lunch Island roost (Russell and Gauthreaux, 1999), prompting SCE&G, SCDNR, and the Columbia Chapter of the National Audubon Society to designate the eastern end of the island as North America's first purple martin sanctuary.

Typical wildlife species for the project area are listed in Tables E-11 through E-13.

12.1 Threatened and Endangered Wildlife Species

Five species classified as threatened or endangered by state or federal agencies are known to occur within the four counties (Lexington, Richland, Saluda, and Newberry) that the Saluda Project is situated (see Table E-10). However, many of these are coastal plain species and the habitats necessary to support them are not present within the Project boundaries. Currently, only federally threatened bald eagles and federally endangered wood storks are known to occur within the Saluda Project Boundary, and as such, are described in greater detail below (SCDNR, 2002b).

Bald Eagle

The bald eagle was listed as federally-endangered on March 11, 1967, partially due to the significant population declines attributed to the use of DDT. Subsequent to the banning of DDT, populations began to increase and the eagle's status was lowered from endangered to threatened on July 12, 1995 (USFWS, 1995a). Populations continue to recover, with the number of nesting pairs in the lower 48 states increasing from an estimated 417 to 6571 since the 1960's (Bryan et al., 1996). In South Carolina, the number of estimated nesting pairs has increased from 13 in 1977 to 181 in 2003 (Wilde et al., 2003).

Bald eagles may be found throughout North America, typically around water bodies where they feed primarily on fish and scavenge carrion. Studies suggest reservoirs, especially those associated hydroelectric facilities, are particularly attractive to foraging bald eagles (Brown 1996). Eagles nest in large trees near water and typically use the same nest for several years, making repairs to it annually (Degraaf and Rudis, 1986). In South Carolina, the distribution of eagle nesting has shifted, from historically being located primarily along the coast, to encompass more inland areas; this expansion has been attributed to the construction of approximately 491,000 acres of large reservoirs in the state since the early 1900's (Wilde et al., 2003).

Bald eagles have likely used Lake Murray for foraging and nesting since its construction in 1930. Eagles utilizing the lake for foraging are thought to be a mix of native nesting adults and juveniles from South Carolina and adult and juveniles from outside the state (Wilde et al., 2003). Eagles forage on Lake Murray year round, with peak usage likely occurring during the winter months. Nesting of bald eagles on Lake Murray was first documented in 1996, and since that time, the nesting population has increased to six pairs (Wilde et al., 1996). Productivity (young produced) has also increased substantially around the lake from two chicks in 1996 to 10 chicks in the 2002/2003 nesting season (Wilde et al., 2003).

Lake Murray was one of four South Carolina reservoirs affected by an outbreak of Avian Vacuolar Myelinopathy (AVM), which was first documented at DeGray Lake, Arkansas in the winter of 1994-1995 (Jeffers, 2000). AVM has been confirmed in birds from 11 reservoirs in five southern states (SC, NC, GA, AR, TX) and has resulted in the death of at least 93 bald eagles, thousands of American coots, and smaller numbers of waterfowl and other species (Wilde et al., 2003; Birrenkott et al., 2004). AVM is thought to be linked to an unknown neurotoxin that causes lesions in the white matter of the brain and the spinal cord. Affected animals demonstrate difficulty flying, swimming and walking (Jeffers, 2000). Evidence suggests that bald eagles contract AVM by preying on afflicted coots and other waterfowl that are unable to evade predators (Wilde et al., 2003).

Researchers suspect that the neurotoxin thought to cause AVM may be the product of a cyanobacteria (blue-green algae) often found growing in association with aquatic vegetation (i.e., *Hydrilla*) (Wilde et al., 2003). Sampling conducted at AVM-affected reservoirs by SDCNR and the University of South Carolina (USC) during 2001 and 2002 found that one particular species of blue-green algae, which is known to produce toxic compounds, had the greatest incidence of colonization at the location with the highest eagle mortality from AVM (Strom Thurmond Lake on the South Carolina/Georgia border). In addition, a recently-published feeding study involving mallards found a cause-effect relationship between ingestion of *Hydrilla* from these sites and AVM infection (Birrenkott et al., 2004).

Since 2001, SCE&G has funded monthly surveys on Lake Murray to monitor for the presence of AVM-affected birds, as well as periodic collections of American coots to screen for the disease. To date, there have been no known occurrences of AVM in the Lake Murray bald eagle population; however, a low percentage of the coots collected during the winters of 1999 (2 out of 17 collected), 2000 (5 out of 27 collected), and 2003 (1 out of 30 collected) did test positive for the disease, as well as one Canada goose collected during December 2000 (Wilde et al., 2003). Despite the presence of some affected prey species, SCDNR and USC scientists have concluded that, to date, the presence of AVM at

Lake Murray does not appear to have resulted in extensive losses of breeding adult bald eagle as both the number and productivity of eagles nesting on Lake Murray have increased from 1996 level (Wilde et al., 2003). It should be noted that the presence of AVM in the lone coot from the 2003 collection was determined only through clinical testing, with no birds displaying obvious neurological impairment, suggesting that AVM was not severe at Lake Murray during the 2002/2003 season (Wilde et al., 2003).

Wood Stork

The wood stork was federally-listed as endangered on February 28, 1984 (USFWS, 1997). The only stork native to North America, wood storks occurred historically throughout the coastal plain of the southeastern U.S. and Texas. The current U.S. breeding population has declined from an estimated 20,000 pairs in the 1930's to between 5,500 to 9,500 in recent years, with declines attributed primarily to loss of suitable foraging and nesting habitat. Currently, nesting of the species in the U.S. is thought to be limited to the coastal plain of South Carolina, Georgia, and Florida (USFWS, 1997).

Wood storks are highly colonial and typically nest in large rookeries and feed in flocks (USFWS, 1997). Typical foraging habitats include narrow tidal creeks, flooded tidal pools, and freshwater marshes and wetlands. Like most other wading birds, storks feed primarily on small fish. However, because wood storks feed by tactilocation (using the sense of touch), depressions where fish become concentrated during periods of falling water levels are particularly attractive sites (USFWS, 1997). Storks typically use tall cypresses or other trees near water for colonial nest sites. Nests are usually located in the upper branches of large trees and several nests are typically located in each tree. Trees used for nesting and roosting typically provide easy access from the air and an abundance of lateral limbs (USFWS, 1997).

While wood storks are primarily birds of freshwater and brackish wetlands along the coastal plain, wood stork activity has been reported by local residents at

several locations within the Lake Murray area since approximately 1999 (Personal Communication, E. Eudaly, USFWS, August 2004). Aerial surveys conducted during the summer of 2004 documented approximately 60 storks feeding at various locations in the middle Saluda River area and the upper portion of Lake Murray (SCE&G and Kleinschmidt, 2004a). SCE&G, in coordination with the USFWS and SCDNR, subsequently developed a long-term study plan to document wood stork usage within the Saluda Project Boundary and in the Project vicinity (SCE&G and Kleinschmidt, 2004a). This study is ongoing and updates of the results will be provided throughout the relicensing process.

Table E-9: Listing of Botanical Species Found Within the Saluda Project Area

Species Common Name	Species Latin Name	Lake Murray	Shallow Coves	Shallow Shoals	Buttonbush and Willow Flats	Bottomland Hardwood	Exposed Bars	Islands	Matured Hardwood Forests	Water Tupelo Stands	Wet Flats	Rocky Shores	Lower Saluda River
American beech	<i>Fagus grandifolia.</i>	X							X				X
American elm	<i>Ulmus americana</i>	X				X		X			X		
American holly	<i>Ilex opaca</i>					X		X	X				
American hornbeam	<i>Carpinus caroliniana</i>					X							
Arrowwood	<i>Viburnum dentatum</i>												X
Asian dayflower*	<i>Murdannia keisak</i>												X
Asters	<i>Aster sp.</i>							X					
Barnyard grass	<i>Echinochloa crusgalli</i>		X	X			X	X					
Beggar-tick	<i>Bidens frondosa</i>		X	X	X								
Bermuda grass	<i>Cynodon dactylon</i>							X					
Black cherry	<i>Prunus serotina</i>	X						X					
Black highbush													
blueberry	<i>Vaccinium atrococcum</i>							X					
Black oak	<i>Q. velutina</i>	X						X					
Black walnut	<i>Juglans nigra</i>												X
Black willow	<i>Salix nigra</i>				X			X					
Blackberries	<i>Rubus sp.</i>							X					
Blueberry	<i>Vaccinium sp.</i>								X				
Bluc-flowered cryngium	<i>Eryngium prostratum</i>			X	X								
Blunt spikerush	<i>Eleocharis obtusa</i>			X									
Bosc's bluet	<i>Hedyotis boscii</i>		X	X	X								
Box elder	<i>Acer negundo</i>	X											X

Species Common Name	Species Latin Name	Lake Murray	Shallow Coves	Shallow Shoals	Buttonbush and Willow Flats	Bottomland Hardwood	Exposed Bars	Islands	Matured Hardwood Forests	Water Tupelo Stands	Wet Flats	Rocky Shores	Lower Saluda River
Brazilian elodea*	<i>Egeria densa</i>	X											X
Brittle water nymph*	<i>Najas minor</i>	X											
Butterweed	<i>Senecio glabellus</i> <i>Cephalanthus</i>										X		
Buttonbush	<i>occidentalis</i> <i>Heterotheca</i>				X			X			X		
Camphor weed	<i>subaxillaris</i>							X					
Catbriars	<i>Smilax bona-nox</i>							X					
Catbriars	<i>S. rotundifolia</i>							X					
Catbriars	<i>S. glauca</i>							X					
Cedar	<i>Juniperus silicicola</i>												X
Cherry	<i>Prunus sp.</i> <i>Quercus falcata var.</i>												X
Cherrybark oak	<i>pagodaefolia</i>					X							
Cherrybark oak	<i>Quercus pagoda</i>							X					
Chickweed	<i>Stellaria media</i>												X
chinkapin oak	<i>Q. muhlenbergii</i> <i>Polystichum</i>	X							X				
Christmas fern	<i>acrostichoides</i>								X				
Clearweed	<i>Pilea pumila</i>												X
Cockle-bur	<i>Xanthium strumarium</i>		X	X	X								
Kentucky Bluegrass	<i>Poa pratensis</i>												X
Bentgrass	<i>Gramineae sp.</i>												X
Fescue	<i>Festuca sp.</i>												X
Cottonwood	<i>Populus deltoides</i>							X					X

Species Common Name	Species Latin Name	Lake Murray	Shallow Coves	Shallow Shoals	Buttonbush and Willow Flats	Bottomland Hardwood	Exposed Bars	Islands	Matured Hardwood Forests	Water Tupelo Stands	Wet Flats	Rocky Shores	Lower Saluda River
Crab-apple	<i>Malus Angustifolia</i>							X					
Creeping burhead	<i>Echinodorus cordifolius</i>				X								
Creeping fimbry Creeping primrose	<i>Fimbristylis autumnalis Ludwigia palustris</i>		X	X			X				X		
Creeping rush	<i>Juncus repens</i>		X	X									
Daisy	<i>Erigeron sp.</i>												X
Dandelion	<i>Taraxacum officiniale</i>												X
Deciduous holly	<i>Ilex decidua</i>					X		X			X		
Ditch stoncrop	<i>Penthorum sedoides</i>										X		
Dogwood	<i>Cornus sp. Eupatorium</i>												X
Dog fennel	<i>capillifolium</i>							X					
Dwarf bulrush	<i>Hemicarpha micrantha</i>		X				X						
Dwarf crabgrass	<i>Digitaria serotina</i>		X	X									
Eastern false- willow	<i>Baccharis halimifolia</i>							X					
Ebony spleenwort	<i>Asplenium platyneuron</i>								X				
Eclipta	<i>Eclipta alba</i>		X	X	X								
Elder	<i>Sambucus canadensis</i>												X
Elm	<i>Ulmus sp.</i>												X
English ivy	<i>Hedera helix</i>							X					
Eryngium	<i>Eryngium prostratum</i>		X										
Eurasian Water Milfoil*	<i>Myriophyllum spicatum</i>	X											

Species Common Name	Species Latin Name	Lake Murray	Shallow Coves	Shallow Shoals	Buttonbush and Willow Flats	Bottomland Hardwood	Exposed Bars	Islands	Matured Hardwood Forests	Water Tupelo Stands	Wet Flats	Rocky Shores	Lower Sabuda River
	<i>Panicum</i>												
Fall panic	<i>dichotomiflorum</i>		X	X									
False pimpernel	<i>Linderina dubia</i>									X			
	<i>Leucothoe</i>												
Fetterwood	<i>fontanesiana</i>								X				
Fireweed	<i>Erechtites hieracifolia</i>				X						X		
Flatedge spp.	<i>Cyperus polystachyos</i>						X						
Flatedge spp.	<i>C. strigosus</i>						X	X					
Flatedge spp.	<i>C. erythrorhizos</i>			X			X	X					
Flatedge spp.	<i>C. flavescens</i>						X						
Flatsedges	<i>C. iria</i>			X									
Flatsedges	<i>C. compressus</i>			X									
Flatsedges	<i>C. haspan</i>			X									
Flatsedge	<i>Cyoerus sp.</i>		X								X		
Flcabane	<i>Erigeron annuus</i>												X
Flowering dogwood	<i>Cornus florida</i>	X							X				
Goldenrod	<i>Solidago odora</i>							X					
	<i>Fraxinus</i>												
Green ash	<i>pennsylvanica</i>	X						X			X		
Harbor sweet gum	<i>Liquidambar sp.</i>										X		
Honeysuckle	<i>Gaylussacia sp.</i>							X					X
Hop hornbeam	<i>Ostraya virginiana</i>	X							X				
Horse-nettle	<i>Solanum carolinense</i>												X
Japanese honeysuckle	<i>Lonicera japonica</i>							X					X
Hydrilla*	<i>Hydrilla verticillata</i>	X											

Species Common Name	Species Latin Name	Lake Murray	Shallow Coves	Shallow Shoals	Buttonbush and Willow Flats	Bottomland Hardwood	Exposed Bars	Islands	Matured Hardwood Forests	Water Tupelo Stands	Wet Flats	Rocky Shores	Lower Saluda River
Johnson grass	<i>Sorghum halepense</i>							X					
	<i>Polypremum</i>												
Juniper-leaf	<i>procumbens</i>		X	X	X								
Laurel oak	<i>Quercus laurifolia</i>					X							
Least spikerush	<i>E. acicularis</i>			X	X								
Lespedeza	<i>Lespedeza intermedia</i>							X					
Loblolly pine	<i>Pinus taeda</i>	X						X	X		X		X
Maple	<i>Acer sp.</i>												X
	<i>Phoradendron</i>												
Mistletoe	<i>serotinum</i>							X					
Mockernut													
hickory	<i>C. tomentosa</i>	X											
Mountain laurel	<i>Kalmia latifolia</i>								X				
Muscadine grape	<i>Vitis rotundifolia</i>							X					
Mustards	<i>Brassia sp.</i>												X
Oak various spp.	<i>quercus sp.</i>												X
Overcup oak	<i>Quercus lyrata</i>				X			X			X		
	<i>Panicum</i>												
Panic grasses	<i>dichotomiflorum</i>				X								
Panic grasses	<i>P. rigidulum</i>				X								
Panic grasses	<i>P. scoparium</i>				X								
Panic grasses	<i>Dichanthelium sp.</i>							X					
Panic grasses	<i>Panicum sp.</i>										X		
Parasitic	<i>Phoradendron</i>												
mistletoe	<i>serotinum</i>										X		
	<i>Myriophyllum</i>												
Parrot's feather*	<i>aquaticum</i>												X
Passion flower	<i>Passiflora incarnata</i>							X					

Species Common Name	Species Latin Name	Lake Murray	Shallow Coves	Shallow Shoals	Buttonbush and Willow Flats	Bottomland Hardwood	Exposed Bars	Islands	Matured Hardwood Forests	Water Tupelo Stands	Wet Flats	Rocky Shores	Lower Saluda River
Pepper	<i>Ampelopsis arborea</i>							X					
Persimmon	<i>Diospyros virginiana</i>				X			X					
Pignut hickory	<i>C. glabra</i>	X											
Plume grass	<i>Erianthus sp.</i> <i>Toxicodendron</i>							X					
Poison ivy	<i>radicans</i>												X
Pokeberry	<i>Phytolacca americana</i>							X					
Pokeweed	<i>Phytolacca americana</i>												X
Pondweed sp. *	<i>Potamogeton crispus</i> <i>Potamogeton</i>	X											
Pondweed sp. *	<i>illinoensis</i>	X											
Pondweed sp. *	<i>Potamogeton pusillus</i>	X											
Post oak	<i>Quercus stellata</i>							X					
Purple-top tridens	<i>Tridens favus</i> <i>Gnaphalium</i>							X					
Rabbit tobacco	<i>obtusifolium</i>							X					
Rattle bush	<i>Sesbania punicea</i>							X					
Red cedar	<i>Juniperus virginiana</i>							X	X				
Red maple	<i>Acer rubrum</i>	X				X		X	X		X		
Red oak	<i>Q. rubra</i>	X							X				X
Redbud	<i>Cercis canadensis</i>	X											
Red-top panic grass	<i>Panicum rigidulum</i>		X	X			X	X					
River birch	<i>Betula nigra</i>	X						X					
River seedbox	<i>Ludwigia leptocarpa</i>							X					
Rushes	<i>Juncus sp.</i>						X						
Sassafras	<i>Sassafras albidum</i>												X

Species Common Name	Species Latin Name	Lake Murray	Shallow Coves	Shallow Shoals	Buttonbush and Willow Flats	Bottomland Hardwood	Exposed Bars	Islands	Matured Hardwood Forests	Water Tupelo Stands	Wet Flats	Rocky Shores	Lower Saluda River
Sedges	<i>Carex sp.</i>					X							
Shagbark hickory	<i>Carya ovata</i>	X							X				
Shortleaf pine	<i>P. echinata</i>	X						X					X
Shortleaf pine	<i>Pinus taeda</i>							X					
Shumard oak	<i>Quercus shumardii</i>					X							
Slender fimbry	<i>Fimbristylis autumnalis</i>			X			X	X					
Slender St. John's-wort	<i>Hypericum mutilum</i>							X					
Smart weeds	<i>Polygonum sp.</i>										X		
	<i>Polygonum</i>												
Smartweed	<i>pennsylvanicum</i>		X	X	X								
Smooth sumac	<i>Rhus glabra</i>							X					
Sourwood	<i>Oxydendron arboreum</i>	X							X				
Southern red oak	<i>Quercus falcata</i>	X						X	X				
Spikerush	<i>Eleocharis sp.</i>		X	X									
Spikerush	<i>E. baldwinii</i>				X								
Spiny amaranth	<i>Amaranthus Spinousus</i>												X
Spotted wintergreen	<i>Chimaphila maculata</i>								X				
St. Andrew's- cross	<i>Ascyrum hypericoides</i>					X							
Stalkless yellowcress	<i>Rorippa sessiliflora</i>			X									
Sugarberry	<i>Celtis laevigata</i>							X			X		
Sunflower	<i>Helianthus annuus</i>												X
Swamp beggar- tick	<i>Bidens discoidea</i>									X			

Species Common Name	Species Latin Name	Lake Murray	Shallow Coves	Shallow Shoals	Buttonbush and Willow Flats	Bottomland Hardwood	Exposed Bars	Islands	Matured Hardwood Forests	Water Tupelo Stands	Wet Flats	Rocky Shores	Lower Saluda River
Swamp chestnut oak	<i>Quercus michauxii</i>					X			X				
Swamp dogwood	<i>Cornus foemina</i> <i>Liquidambar</i>					X							
Sweet gum	<i>styraciflua</i>	X			X	X		X	X		X		
Switch cane	<i>Arundinaria gigantea</i>					X		X	X		X		
Sycamore	<i>Platanus occidentalis</i>				X			X			X		X
Teal lovegrass	<i>Eragrostis hypnoides</i>			X			X	X			X		
Throughworts	<i>Eupatorium sp.</i>							X					
Toothcup	<i>Rotala ramosior</i>		X	X	X		X	X					
Tridens	<i>Tridens flavus</i>							X					
Triple-awn grass	<i>Aristida sp.</i>							X					
Trumpet creeper	<i>Campsis radicans</i>										X		
Trumpet vine	<i>Campsis radicans</i>							X					
Tulip poplar	<i>Liriodendron tulipifera</i>	X									X		
Vetch	<i>Vicia sp.</i>							X					X
Violets	<i>Viola sp.</i> <i>Parthenocissus</i>												X
Virginia creeper	<i>quinquefolia</i>												X
Walnut	<i>Juglans sp.</i>												X
Water hickory	<i>Carya aquatica</i>	X						X			X		
Water oak	<i>Quercus nigra</i>	X				X		X					
Water primrose*	<i>Ludwigia hexapetala</i>				X								X
Water tupelo	<i>Nyssa aquatica</i>									X	X		
Water willow	<i>Justicia americana</i>				X								
Wax myrtle	<i>Myrica cerifera</i>	X											X
White oak	<i>Quercus alba</i>	X							X				X

Species Common Name	Species Latin Name	Lake Murray	Shallow Coves	Shallow Shoals	Buttonbush and Willow Flats	Bottomland Hardwood	Exposed Bars	Islands	Matured Hardwood Forests	Water Tupelo Stands	Wet Flats	Rocky Shores	Lower Saluda River
	<i>Rhododendron</i>												
Wild azalca	<i>canescens</i>	X							X				
Wild ginger	<i>Hexastylis arifolia</i>								X				
Wild oat	<i>Avena sativa</i>												X
Willow	<i>Salix sp.</i>												X
Willow oak	<i>Quercus phellos</i>	X				X		X			X		
Winged sumac	<i>Rhus copallina</i>							X					
Wood sage	<i>Teucrium scorodonia</i>												X

*Indicates an invasive aquatic plant species

Table E-10: All State and Federally Listed Threatened and Endangered Species for the Counties Surrounding the Saluda Hydroelectric Project

Common Name	Scientific Name	Counties	Federal Status	State Status
<i>Birds</i>				
bald eagle	<i>Haliaeetus leucocephalus</i>	Lexington, Richland, Saluda, Newberry	Threatened	Threatened
red-cockaded woodpecker	<i>Picoides borealis</i>	Lexington, Richland, Saluda	Endangered	Endangered
<i>Mammals</i>				
Rafinesque's big-eared bat	<i>Corynorhinus rafinesquii</i>	Richland	None	Endangered
<i>Herpetofauna</i>				
Webster's salamander	<i>Plethodon websteri</i>	Saluda	None	Threatened
pine barrens treefrog	<i>Hyla andersonii</i>	Richland	None	Threatened
<i>Plants</i>				
smooth coneflower	<i>Echinacea laevigata</i>	Richland	Endangered	Endangered
shoals spider-lily*	<i>Hymenocallis coronaria</i>	Richland, Lexington	Of Concern, Nationally	Of Concern, Nationally
rough-leaved loosestrife	<i>Lysimachia asperulifolia</i>	Richland	Endangered	Endangered
canby's dropwort	<i>Oxypolis canbyi</i>	Richland	Endangered	Endangered
pool sprite	<i>Amphianthus pusillus</i>	Saluda	Threatened	Threatened
harperella	<i>Ptilimnium nodosum</i>	Saluda	Endangered	Endangered

*Even though this species is not threatened or endangered it has been included in this table because it is of concern nationally and is known to occur and is being studied within the project boundary.

Table E-11: Mammals Commonly Found In and Around Lake Murray

COMMON NAME	SCIENTIFIC NAME
<i>TERRESTRIAL MAMMALS</i>	
white-tailed deer	<i>Odocoileus virginianus</i>
raccoon	<i>Procyon lotor</i>
gray squirrel	<i>Sciurus carolinensis</i>
virginia opossum	<i>Didelphis virginiana</i>
fox	Family <i>Canidae</i>
coyote	<i>Canis latrans</i>
skunk	Family <i>Mustelidae</i>
bobcat	<i>Felis rufus</i>
voles	Family <i>Cricetidae</i>
shrews	Family <i>Soricidae</i>
<i>AQUATIC MAMMALS</i>	
beaver	<i>Castor canadensis</i>
river otter	<i>Lutra canadensis</i>
muskrat	<i>Ondatra zibethicus</i>
mink	<i>Mustela vison</i>

Table E-12: Reptiles (Terrestrial and Aquatic) and Amphibians Commonly Found In and Around Lake Murray

COMMON NAME	SCIENTIFIC NAME
<i>TERRESTRIAL AND AQUATIC REPTILES</i>	
eastern box turtle	<i>Terrapene carolina</i>
painted turtle	<i>Chrysemys sp.</i>
mud turtle	<i>Kinosternon sp.</i>
musk turtle	<i>Sternotherus sp.</i>
snapping turtle	<i>Chelydra serpentina</i>
green anole	<i>Anolis carolinus</i>
northern fence lizard	<i>Sceloporus undulates hyacinthinus</i>
broadhead skink	<i>Eumeces laticeps</i>
copperhead	<i>Agkistrodon contortrix</i>
gray rat snake	<i>Elaphe obsoleta spiloides</i>
black racer	<i>Coluber constrictor</i>
timber rattlesnake	<i>Crotalus horridus horridus</i>
cottonmouth	<i>Agkistrodon piscivorus</i>
brown water snake	<i>Nerodia taxispilota</i>
redbelly water snake	<i>Nerodia erythrogaster erythrogaster</i>
<i>AMPHIBIANS</i>	
southern toad	<i>Bufo terrestris</i>
bullfrog	<i>Rana catesbeiana</i>
green frog	<i>Rana clamitans</i>
green treefrog	<i>Hyla cinerea</i>
leopard frog	<i>Rana sp.</i>
marbled salamander	<i>Ambystoma opacum</i>
red salamander	<i>Pseudotriton ruber</i>

Table E-13: Bird Species Commonly Found at Lake Murray

COMMON NAME	SCIENTIFIC NAME OR FAMILY
<i>WATERFOWL</i>	
wood duck	<i>Aix sponsa</i>
Canada goose	<i>Branta canadensis</i>
American coot	<i>Fulica Americana</i>
mallard	<i>Anas platyrhynchos</i>
American black duck	<i>Anas rubripes</i>
ring-necked duck	<i>Aythya collaris</i>
American anhinga	<i>Anhinga anhinga</i>
double-crested cormorant	<i>Phalacrocorax auritus</i>
herons and egrets	Family <i>Ardeidae</i>
<i>RAPTORS</i>	
bald eagle	<i>Haliaeetus leucocephalus</i>
osprey	<i>Pandion haliaetus</i>
great horned owl	<i>Bubo virginianus</i>
red-tailed hawk	<i>Buteo jamaicensis</i>
red-shouldered hawk	<i>Buteo lineatus</i>
<i>UPLAND GAME BIRDS</i>	
wild turkey	<i>Meleagris gallopavo</i>
northern bobwhite	<i>Colinus virginianus</i>
mourning dove	<i>Zenaida macroura</i>
<i>SONGBIRDS</i>	
warblers	Family <i>Parulidae</i>
thrushes	Family <i>Turdidae</i>
American robin	<i>Turdus migratorius</i>
vireos	Family <i>Vireonidae</i>
finches	Family <i>Fringillidae</i>
<i>MISCELLANEOUS BIRDS</i>	
woodpeckers	Family <i>Picidae</i>
vultures	Family <i>Cathartidae</i>
gulls	Family <i>Laridae</i>
yellow-bellied sapsuckers	<i>Sphyrapicus varius</i>

Lower Saluda River Aquatic Macrophytes

November 2004

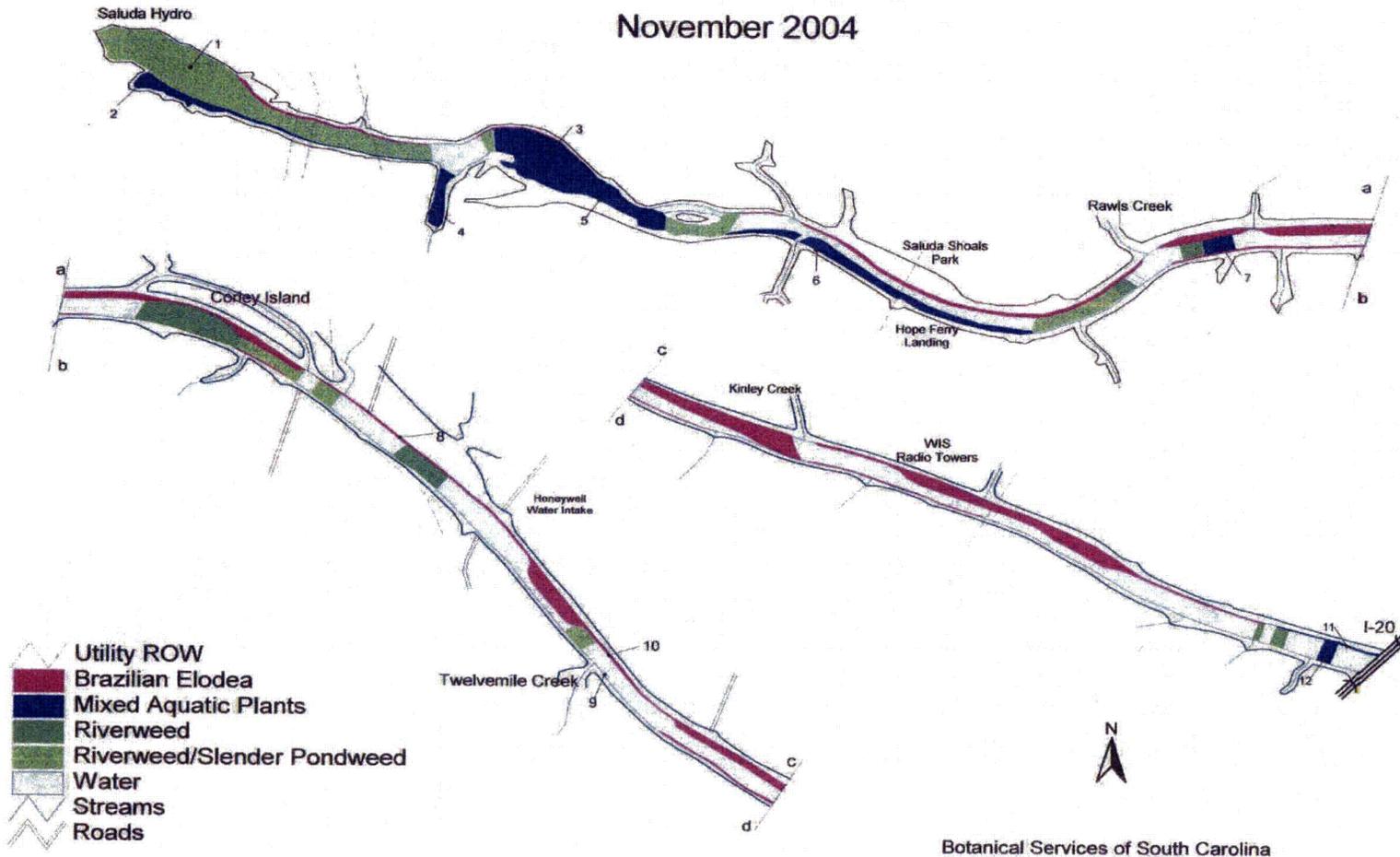


Figure E-13: Aquatic Plants of the Lower Saluda (Aulbach, 2004)

13.0 CULTURAL RESOURCES

13.1 Cultural Resource Studies

Three recent archaeological and historical studies have been conducted within the Project boundary (Trinkley and Southerland, 2001; Hendrix and Bailey, 2003; Lansdell and Bailey, 2003). The purpose of these reports was to identify any historic properties that lie within the Project boundary, to locate any known and potential *cultural resources*, and to make recommendations regarding eligibility for the National Register of Historic Places (NRHP). The studies were carried out in association with SCE&G's proposed construction of a backup dam to the Saluda Dam, a Federal undertaking. These studies present research compiled from the following sources:

- Saluda Dam Office (Irmo, SC)
- South Carolina Department of Archives and History (Columbia)
- South Carolina Historical Society (Charleston)
- South Carolina Institute of Anthropology and Archaeology (Columbia)
- South Carolina Library, University of South Carolina (Columbia)

All three studies relied on both published and unpublished secondary sources including previous archaeological and architectural surveys in the area surrounding the Project and literature on the history of the Columbia area and the midland and upstate regions of South Carolina. In addition, both Bailey and Hendrix (2003) and Bailey and Lansdell (2003) drew extensively upon oral interviews with archaeological collectors to assist in identifying previously unknown archaeological sites.

Trinkley and Southerland (2001)

Trinkley and Southerland conducted a cultural resources survey of four sites within the APE, which was defined as being a one-mile radius from the outer edge of the SCE&G boundary. These sites included the 550-acre Saluda Dam Complex, the 49.1-acre Operators' Village, a 54.9-acre tract adjacent to the spillway, and a 70-acre tract on

the Saluda River adjacent to Lot 44. The survey took into consideration both archaeological and above-ground resources. The archaeological survey included shovel testing at 100-foot intervals along transects laid out at 100-foot intervals, with the exception of the Saluda Dam Village (site 38LX411), which was surveyed at 50-foot intervals along transects laid out at 50-foot intervals. The survey also included identifying historic architectural resources and completing architectural survey forms.

Hendrix and Bailey (2003)

Hendrix and Bailey provided an overview of known and potential cultural resources within the APE, which was determined to be those portions of the Lake Murray basin between the maximum pond elevation at 360 feet PD and the minimum pond elevation at 345 feet PD. This study consisted primarily of background research, both in the site files at the South Carolina Institute for Anthropology and Archaeology to develop information about previously recorded cultural resources within the APE, and oral interviews with local informants, primarily amateur archaeological collectors, to locate potential archaeological sites. The information from this research was used to make recommendations regarding areas that have a high potential to contain both known and potential cultural resources. The report did not make any recommendations regarding eligibility for the NRHP.

Lansdell and Bailey (2003)

Lansdell and Bailey conducted an assessment of the known and potential archaeological sites that were identified in Hendrix and Bailey (2003). This survey assessed 31 locales that were either known to contain cultural resources or that research indicated may contain cultural resources; 16 of these locales were previously recorded archaeological sites and 15 were known but not formally recorded archaeological sites. Nine of the 31 sites were found to lie within the APE, which was defined in the same way as in Hendrix and Bailey (2003). The field methods used varied according to the conditions found at each site, but boundaries of the sites were established by excavating a cross pattern of shovel tests at 50-foot intervals. In areas of high artifact concentration,

test units measuring 1.5 feet square were excavated. The report included recommendations regarding eligibility for the NRHP.

13.2 Archaeological Overview

The following brief overview is drawn primarily from the outline presented in Lansdell and Bailey (2003).

Paleoindian Period (10000-8000 BC)

There is limited evidence for human occupation in South Carolina during the Paleoindian Period, which is coincident with the terminal Pleistocene age, when the climate was generally colder than it is today and when the sea level was approximately 200 feet lower than at present. The evidence for Paleoindian occupations in South Carolina suggests that cultures were located generally on terraces adjacent to the major river drainages. It is likely that the people who occupied South Carolina during the Paleoindian Period lived as part of mobile hunter and gatherer societies who focused primarily on smaller game and plant foods.

Early Archaic Period (8000-6000 BC)

This period featured the adaptation of local societies to the new climatic conditions of the Holocene, when the climate was still cooler and moister than at present. This is the earliest period for which archaeological evidence is found in the midlands of South Carolina, including along the drainages of the Broad, Saluda, and Congaree Rivers. Early Archaic sites tend to be small; various models of Early Archaic settlement patterns point to a highly mobile group of people who either came together in the winter months along different river drainages or who returned to specific base camps in areas that provide access to diverse natural resources. Exchanges of materials and people might have occurred between these winter settlement groups or base camps once they were settled for the season.

Middle Archaic Period (6000-2000 BC)

Sites that date to this period, when the climate was continuing to warm, tend to be more dense and suggest that groups tended to create long-term residential sites. This is a pattern that relates more closely to those experienced in the Coastal Plain of South Carolina than areas more into the Piedmont. Artifacts from this period tend to be stone projectile points and ground stone tools.

Late Archaic Period (2000-500 BC)

Several developments take place during this period. The earliest ceramic artifacts date to this period, primarily sand tempered with punctuate, incised, finger pinched, stamped, and dentate decorations. Also, this is the earliest period that shows evidence of intensive exploitation of aquatic resources, including anadromous fish. Finally, the evidence for sites in the midlands area of South Carolina also shows two concurrent settlement patterns. Small sites that appear to focus on single activities such as animal processing appear in the upland areas between river drainages and along smaller drainages, while sites within the floodplains of the major drainages tend to be larger and show a more diverse range of activities.

Early Woodland Period (500 BC-AD 200)

Artifacts from this period show an increasing diversity, particularly the ceramics. The range of decorations broadens considerably with an increase in linear and bold Deptford Check Stamped, Deptford Simple Stamped, fabric impressed, paddle stamped, and cord marked examples. Settlement patterns show a dispersal into previously unoccupied areas as groups, and often single families, moved away from the floodplains and into more upland areas above the drainages. Early Woodland sites therefore tend to be smaller with a reduced diversity of artifacts.

Middle and Late Woodland Periods (AD 200-1000)

This is a period of distinctly limited developments from the previous period, and is much less well understood. Most of the ceramic indicators from the Early Woodland period continue throughout the Middle and Late Woodland periods, including check stamped, cord marked, and fabric impressed artifacts. Settlement patterns appear to continue the diffused locales of the earlier period.

Mississippian Period (AD 1000-1543)

This was a period of much more rapid development in the complexities of social organization. Throughout the southeast, this period is marked by greater social stratification, an increasing emphasis on agriculture, public works, and ceremonial centers. While one of the principal centers of Mississippian society in South Carolina lies to the east of Columbia on the Wateree River (Mulberry Mound group), there is little evidence of Mississippian occupation in the immediate Columbia area. This is due to a settlement pattern that focused on distinctive rapids of local rivers in the upland portion of the state and on the major drainages that had extensive flood plains below the Fall Line, and not on the areas such as Columbia that served as transitions between the two areas. The end of this period also marked the beginnings of European explorations into South Carolina, notably DeSoto's visit in 1540. The introduction of European explorers, however, led to a rapid decline in Native American populations as disease, warfare, and slave raids decimated the area.

13.3 Historical Overview

Permanent European settlement in South Carolina began in 1670, when English adventurers from the island of Barbados settled on the west bank of the Ashley River near what is now Charleston; they relocated to the present site of Charleston in 1680. Settlers began moving inland relatively quickly, forming a trading post along the Congaree River as early as 1700. This trading post was located south of what is now Columbia, which was the furthest upriver point where boat traffic was possible.

Speculators began purchasing farm land along the Congaree River south of Columbia, creating plantations dedicated to cash crops that could be sent to Charleston. The pace of settlement increased in the 1740s and 1750s. At this time, new colonial policies encouraged the development of these areas through a township scheme using a headright system which allotted 50 acres to every individual who settled there. At the same time, colonial policies created a system of judicial districts throughout the colony.

In the wake of the Revolutionary War, the most important development in the midlands region was the creation of the new state capitol at Columbia, located on a plain above the Congaree River just below the confluence of the Broad and Saluda Rivers. Improvements in transportation became increasingly important in the early nineteenth century, in the attempt to allow goods from further north and west in the state to pass around the shoals of the Broad and Saluda River to get to the Congaree River, whence they could easily be shipped either to Charleston or Georgetown. This interest resulted in the Columbia Canal, which started at a diversion dam across the Broad River and followed the southern bank of the Broad and Congaree Rivers, and the Saluda Canal, which bypassed shoals in the Saluda River and directed boats to the entrance of the Columbia Canal. The various falls in the Broad and Saluda Rivers above Columbia also provided sources of power for new manufacturing enterprises, most notably the Saluda Factory along the southern bank of the Saluda River, approximately two miles from its confluence with the Broad River; begun in 1834, the plant was destroyed during the Civil War.

In the late nineteenth and early twentieth centuries, despite some promising manufacturing developments, including the Columbia Mills (the first textile plant in the country to be powered by *hydroelectric power*, using waters from the original Columbia Canal), the areas to the west of Columbia remained primarily agricultural. There were, however, a number of small, localized settlements with small houses, churches, and cemeteries. In the 1920s the Lexington Water Power Company (LWPC) began to develop plans for the creation of a dam and hydroelectric facility at Dreher's Shoals on the Saluda River. Agents for the LWPC began acquiring the large tracts of land necessary to develop the massive lake and surrounding lands, totaling approximately

100,000 acres. In the process, the LWPC removed or relocated three churches, six schools, and 193 graveyards.

Development of the hydroelectric facility began in 1927 with land-clearing operations and the beginning work on the Dam. Once completed, the Dam was 1.5 miles long and was the largest earthen Dam that had yet been built. By 1929, construction on the Dam was complete enough so that the lake could be partially filled. Storms in the autumn of that year flooded the Dam and damaged the unfinished powerhouse; by 1930, the repairs had been completed and the Project began generating electricity and the lake was named Lake Murray in honor of William Murray, who first conceived of the plan for the hydroelectric development. The lake was filled to the 360 foot elevation by 1933.

13.4 Historic Resources Within the Project

The cultural resources surveys by Trinkley and Southerland (2001), Hendrix and Bailey (2003), and Lansdell and Bailey (2003) identified 53 archaeological and historic architectural and engineering resources. Twenty-two of these resources have been identified through research but have not yet been assessed for their eligibility for inclusion in the NRHP (Lansdell and Bailey, 2003). Of the remaining thirty-one resources, eight have been determined eligible or potentially eligible for the NRHP. Table E-14 presents the sites that have been identified at the Saluda Project, and the NRHP status of each.

13.5 Protection and Preservation

13.5.1 National Historic Preservation Act Compliance

Section 106 of the National Historic Preservation Act of 1966 (as amended) provides for the review of Federal undertakings that have the potential to affect historic properties. The Section 106 review of these undertakings is described and implemented in 36 CFR 800. As defined by 36 CFR 800.16(I)(I), “historic property” means “any prehistoric or historic district, site, building,

structure, or object included in or eligible for inclusion in the National Register of Historic Places (NRHP) maintained by the Secretary of the Interior;” and includes “artifacts, records, and remains that are related to and located within such properties.” Moreover, “historic property” includes “properties of traditional religious and cultural importance to an Indian tribe ... and that meet the NRHP criteria.” Finally, “eligible for inclusion,” as set forth at 36 CFR 800.16(I)(2), means “both properties formally determined as such in accordance with the regulations of the Secretary of the Interior and all other properties that meet the NRHP criteria.” For purposes of inclusiveness, this term also applies to those properties that are known to exist but for which NRHP status has not yet been determined.

13.6 Properties Affected by Project Operations or Developments

The Project contains eight archaeological and architectural properties that have been determined eligible or potentially eligible for the NRHP, and an additional 22 sites, the eligibility of which has not yet been determined. The effect of present and future operations of the Saluda Project on all of these properties and potential historic properties must be taken into consideration. None of these properties or potential properties are now being affected by Project operations. Anticipated changes at the Property, including the construction of a new dam for the purposes of seismic stability, will likely adversely affect some of the known historic properties. Any other future activities that may affect these or undiscovered properties will be reviewed for compliance with all pertinent regulations as needed.

13.7 Management Plans

In order to comply with Section 106 in the most efficient and effective way possible, SCE&G will work with all relevant agencies, including at a minimum the State Historic Preservation Office and any federally-recognized Indian tribes that have a traditional connection to the land, to form a Programmatic Agreement (PA). The PA will commit SCE&G, through a Historic Properties Management Plan (HPMP), to specific

management strategies designed to provide all appropriate protection to historic properties during the life of the Project License. The HPMP will include provisions for future consultation in the event of discovery of previously unrecorded cultural resources and will outline the necessary steps to allow FERC to remain in compliance with Section 106.

Table E-14: Cultural Resources Identified at the Saluda Project

SITE NUMBER	TYPE	NRHP STATUS
38LX52	Archaeological	Not Assessed
38LX53	Archaeological	Not Assessed
38LX110	Archaeological	Not Assessed
38LX119	Archaeological	Not Assessed
38LX262	Archaeological	Not Assessed
38LX263	Archaeological	Not Assessed
38LX273	Archaeological	Not Assessed
38LX410	Architectural/Archaeological	Eligible
38LX434	Archaeological	Not Eligible
38LX435	Archaeological	Not Eligible
38LX436	Archaeological	Not Eligible
38LX437	Archaeological	Not Eligible
38LX438	Archaeological	Not Eligible
38LX439	Archaeological	Not Eligible
38LX440	Archaeological	Not Eligible
38LX452	Archaeological	Not Eligible
38LX453	Archaeological	Not Eligible
38LX455	Archaeological	Not Eligible
38LX497	Cemetery	Not Eligible
38LX498	Cemetery	Not Eligible
38LX499	Engineering	Not Eligible
38LX617	Cemetery	Not Eligible
38NE1	Archaeological	Not Assessed
38NE29	Archaeological	Not Assessed
38NE34	Archaeological	Not Assessed
38NE43	Archaeological	Not Eligible
38NE194	Archaeological	Not Assessed
38RD134	Archaeological	Potentially Eligible
38SA1	Archaeological	Potentially Eligible

SITE NUMBER	TYPE	NRHP STATUS
38SA13	Archaeological	Not Eligible
38SA104	Archaeological	Not Eligible
24330127.00	Engineering	Eligible
24330127.01	Engineering	Not Eligible
24330127.02	Engineering	Eligible
24330127.03	Engineering	Eligible
24330127.04	Architectural	Eligible
24330127.05	Architectural	Not Eligible
24330127.06	Architectural	Not Eligible
24330127.07	Architectural	Not Eligible
2430128	Bridge	Not Eligible
2430303	Landscape	Not Eligible
2430304	Cemetery	Potentially Eligible
Little Mountain Bridge Abutment	Engineering	Not Assessed
Cooter Scaffold Bridge	Engineering	Not Assessed
Derrick House Foundation	Architectural	Not Assessed
Fairbanks Community & Post Office	Architectural	Not Assessed
Lybrand-Raunch Slave Cemetery	Cemetery	Not Assessed
Jacob Ergle's Grist Mill	Architectural	Not Assessed
Wingard Cemetery	Cemetery	Not Assessed
Magnolia School	Architectural	Not Assessed
Chapin Road	Transportation/Landscape	Not Assessed
Zion Church	Architecture	Not Assessed
Zion Church Cemetery	Cemetery	Not Assessed

14.0 RECREATION RESOURCES

14.1 Regional Resources

Lake Murray and the four surrounding counties (Richland, Lexington, Saluda, and Newberry) make up one complete tourism region defined as the Capital City/Lake Murray Country region by the South Carolina Department of Parks, Recreation and Tourism (SCPRT) (Figure E-14). The region includes portions of the Sumter National Forest; Billy Dreher Island State Park, which is located on an island in Lake Murray; Sesquicentennial State Park, located in the City of Columbia; Harbison State Forest, located in the City of Columbia; and Congaree Swamp National Park, which is located in Richland County. Numerous trails and state heritage preserves are also located in close proximity to the Project.

Sumter National Forest consists of approximately 360,000 acres, partially located in Newberry and Saluda Counties (SCPRT, 2002). Portions of the forest are designated wildlife management areas where hunting is permitted. The forest also provides campgrounds, hunting camps, picnic areas, boating sites, rifle ranges, swimming areas, and 360 miles of trails. Billy Dreher Island State Park is one of two state parks within the Lake Murray Country region. It is 348 acres in size and is located on Lake Murray in the community of Prosperity. The park provides approximately 100 campsites, cabins, trails, picnic areas, and boat access to Lake Murray. Sesquicentennial State park is 1,419 acres in size and offers approximately 90 campsites, trails, and fishing and picnicking opportunities. Harbison State Forest is a 2,176 acre tract that provides hiking, mountain biking, picnicking, and canoe launching on the Broad River. Special events are also hosted at the forest. At 22,000 acres, Congaree Swamp National Park is reported to be the largest remaining tract of old-growth bottomland hardwood forest remaining in the U.S. It is a congressionally designated wilderness area that provides 18 miles of hiking trails, a 2.3 mile boardwalk, and a canoe trail.

Other popular trails nearby include the 0.5 mile trail in Lexington County at the Riverbanks Zoo; 2.5 mile riverfront trail at Riverfront Park in Columbia; the 11.5 mile

Sesquicentennial trail in Richland County; 7.5 mile Lynches Woods trail in Newberry County; and the 2.3 mile Boardwalk Loop in Richland County at the Congaree Swamp National Park (SCPRT, 2002).

Several state heritage preserves that are open to the public are also located nearby (SCPRT, 2002). Heritage preserves are properties that offer unique cultural or natural resource features. Congaree Creek, 627 acres, is located in Lexington County and offers a 6-mile Guignard Brickworks Loop trail. Shealy's Pond is a 62 acre site also in Lexington County. Both preserves are open year round. A third site, Nipper Creek, is open by appointment only. Nipper Creek is in Richland County and 90 acres in size.

There are no federally designated wild and scenic rivers in the Project study area; however, a portion of the Saluda River below the Saluda Project is designated by the SCDNR as State Scenic Rivers (SCPRT, 2002). Approximately 10 miles of the river hold this special designation, which begins approximately 1 mile downstream of the Dam and extends to the confluence with the Broad River.

14.2 Project Resources

Recreation activities within the Saluda Hydroelectric Project boundary are managed by a combination of state agencies, local governments, and SCE&G. Generally, within each recreation site, the site operator is responsible for management. However, boating, fishing, and hunting regulations and enforcement in South Carolina are the responsibility of the SCDNR.

SCDNR requires that all boat operators under the age of 16 complete a boating course approved by the Department to operate any watercraft with a 15 hp motor or greater unless accompanied by an adult 18 years old or older. SCDNR also regulates watercraft use within 50 feet of docks, piers, moored vessels, or people in the water; wake jumping; registration and titling; required boater equipment; hours of operation; and enforcement.

With respect to fishing, SCDNR regulates fishing methods and devices; creel limits; selling and importing species; licensing; and enforcement. SCDNR also regulates hunting, including waterfowl hunting that may occur within the Project area. SCDNR regulates hunting methods and bag limits; licensing and enforcement; and sets allowable seasons for each species.

14.2.1 Lake Murray

The Project provides both passive and active outdoor recreation opportunities, including scenic viewing, picnicking, boating, bird watching, fishing, golf, hunting, and camping. Other water sports that are available may include wake boarding, knee boarding, waterskiing, hydrofoiling, parasailing, and swimming.

Lake Murray supports an active recreational fishery and is an important boating resource. The lake is host to numerous national and local fishing tournaments annually, and is stocked with striped bass each spring by the SCDNR. Surplus bluegill and largemouth bass reared at the SCDNR hatcheries are occasionally stocked as well. The lake supports substantial boating activity, which includes both power boats, canoes and kayaks, and sail boats. Lake Murray is the site of 6-8 regattas annually (Mead and Hunt, 2002b). In addition, the lake is used as a focal point for holiday and tourist events such as the annual Lake Murray Poker Run and the Independence Day celebrations.

14.2.2 Saluda River

The river section immediately below Saluda Dam is referred to as the LSR. It extends 11 miles from the outflow of the Dam to its confluence with the Broad River to form the Congaree River near downtown Columbia. Similar to the Lake, the LSR also supports an active recreational fishery. The cold waters of the river support a trout and striped bass fishery and offer a range of paddling experiences from flat water to whitewater with class II to V rapids.

Approximately 10 miles of the LSR was designated as a State Scenic River in 1991. It is managed by the SCDNR in compliance with the South Carolina Scenic Rivers Act.

14.2.3 Recreation Sites

Numerous private, commercial, and public recreation sites have been developed to accommodate and provide for recreation. There are a total of 107 recreation sites in the Project boundary that support boat launches, marinas, boat slips, wet and dry storage, campgrounds, picnic areas, beaches, fishing areas and piers, trails, and playgrounds. Additionally, there are 23 impromptu areas that are primarily used for bank fishing. Table E-15 provides a list of formal recreation sites located in the Project area and the facilities present at each site.

For purposes of this ICD, public recreation sites refer to sites that are open to the public without discrimination, and which are operated by federal, state, and local agencies and SCE&G. A commercial site refers to a site operated by a business for profit. A private site refers to a site open only to specific individuals via membership or residency requirements. Of the total, formal recreation sites at the Project, 19 are public sites, 31 are commercial sites, and 57 are private sites.

Public Sites

SCE&G owns 19 public access areas on Lake Murray and the Saluda River, and has set aside 64 SCE&G-owned islands in Lake Murray as undeveloped areas that are available for public recreation. Of the 19 recreation sites, SCE&G operates 16 of them, and leases the remaining sites to others for use as public *recreation areas*.

Table E-15 provides a listing of the public access areas and a summary of the facilities and opportunities available at each. Figure E-14 presents the location of the sites, which are dispersed around the Lake. With the exception of Billy Dreher Island State Park, all sites are operated for day-use.

Collectively, the islands that SCE&G has set aside for recreational use encompasses 220 acres of land. Among them is Lunch Island, also known as Doolittle Island or Bomb Island, where the famous Doolittle Raiders practiced bombing runs prior to their bombing of Tokyo, Japan during World War II. The island is North America's first officially designated purple martin sanctuary where thousands of birds can be observed by visitors.

SCE&G also leases 54.6 acres of land to the Indian Waters Council, Boy Scouts of America, Inc. The property is called Camp Barstow and supports campsites, athletic and activity fields, staff quarters, adult lodge, adult training field, training shelter, swimming area, boat dock, ecology shelter, and dining hall. Other facilities include rifle and archery ranges, a volleyball court, a climbing/rappelling tower, a handicraft shelter, and a barrier-free campsite.

SCE&G's parent company, SCANA, owns and operates an 18 acre site on Pine Island, which is open to SCANA employees and their guests. The island supports a conference center, swimming pool and beach, picnic area with shelters, marina, and tennis courts.

Commercial Sites

Commercial sites in the Project boundary include marinas, campgrounds, restaurants, and hotels and resorts. Commercial operations sites offer significant public access and support services, such as marina services, restaurants, etc. Lake tours are also offered on a double decked, 65 foot tour boat, the Southern Patriot.

In general, marinas are dispersed along the lake and provide access to all portions of the lake. They typically provide boat ramps and launching facilities, fuel services, groceries and food, boat sales, rentals and/or repair, bait and tackle, and boat storage. There are currently 31 public marinas operating on Lake Murray (Table E-16). Most of these sites are commercially operated, with the notable exception of the marina at Billy Dreher Island State Park. Because these are commercial ventures, they are subject to changing hands frequently.

Private Sites

Fifty-seven sites around the lake are operated privately and are available to limited membership (Table E-17). Many of the private marinas and landings exist in conjunction with subdivisions located around the lake, private clubs, or condo associations. These sites are important in that they provide access for specific types of opportunities (e.g., sailing clubs), and to a large number of people at various locations around the lake.

14.3 Existing Use

14.3.1 Market Area

Lake Murray is a destination for nearby residents and tourists alike. The Lake offers boating, fishing, and other water-based activities, as well as golf, hiking, dining and shopping at shore and near-shore parks, marinas, restaurants, and businesses. There are many special events such as fishing tournaments, sailing regattas, the Lake Murray Poker Run, the Lake Murray Dam Run, and the lake-wide Independence Day celebration that draw locals and tourists to the lake community.

SCPRT reports that approximately 90 percent of participation in outdoor recreation occurs in an area close to a resident's home for day to day activities (SCPRT, 2002). Activities that require special environments, such as boating and fishing, generally occur within a region of slightly greater proportions around a resident's home, but still nearby to their residence.

If this trend is also true for the Saluda Project, then a majority of the recreation activity occurring at the Project would be attributed to residents of nearby local communities, and a smaller portion would be attributed to a more regional population from the outskirts of Richland, Lexington, Saluda, and Newberry Counties. Additional activity is attributed to tourists from further away in-state or out-of-state. The latter group would be smaller, but might be prone to

stay for longer periods of time. SCE&G recognizes that Lake Murray and the Saluda River are important resources for all user groups, regardless of where they reside.

14.3.2 Existing Use and Activities

SCE&G estimates that approximately 5 million people reside within a 100 mile radius of the Saluda Project (SCE&G, 2002a). Not surprisingly, annual recreational use is estimated to be substantial at approximately 1.5 million people (SCE&G, 2002a). This includes both residents and visitors. Participation in water-based activities such as boating, fishing, and swimming accounts for a majority of this use, though significant activity also occurs onshore, where people picnic, golf, camp, and hunt.

SCPRT estimates that Capital City/Lake Murray Country hosted 2.6 million visitors in 2003 (SCPRT, 2004). Visitors typically stayed an average of 2.8 days. Approximately 9 percent (234,000) of the visitors reported their primary purpose to be for recreation or entertainment. Local use of the lake can be estimated by examining trends in boat registration. Figure E-15 shows the number of registrations from 1993 to 2000 by county. Registration rates in Newberry, Richland, and Saluda Counties all appear to be relatively stable; registrations in Lexington, however, have increased substantially over this time from approximately 18,600 to about 26,700. Obviously not all these boats are used on Lake Murray, but it is likely that many of them are, and further, the volume of registered boats indicates significant interest in the activity within the area.

Not all boats can be expected to be on the lake at all times. A series of aerial photographs were taken of the lake on selected days in 2001 and boat counts were obtained from them (SCE&G, 2002a). Figure E-16 shows the results. Boating use of the lake is moderate during the late spring, builds through early summer, and is heaviest during the Fourth of July week. Use is fairly

constant during the summer months, and drops down to low levels in the early fall.

Other items of interest indicating the volume of recreational use of Lake Murray include (Mead & Hunt, 2002b):

- The Lake Murray Tourism and Recreation Association (LMT&RA) estimates that the annual Independence Day celebration is one of the largest celebrations in South Carolina, and that over 135,000 people participated in the event in 1999, with over 10,000 boats and over 40,000 viewers from land.
- LMT&RA estimated 1999 participation in the Lake Murray Poker Run and the Lake Murray Dam Run to be 10,000 and 3,000 people, respectively.
- LMT&RA estimated that 4,000 anglers participated in fishing tournaments in 1999.
- LMT&RA estimates that as many as 150 out-of-state sailboats participate in the 6 to 8 regattas that are held annually.

On the LSR, during the period of July 1, 1999 through June 30, 2000, the SCDNR conducted an angler survey on the river and estimated the angler effort to be 66,639 angler hours, with the majority of this effort (58%) occurring from the bank. The month with the most effort was June and more than 67% of the total effort occurred between April and July. 98% of the anglers interviewed were from South Carolina and the majority (84%) traveled less than 20 miles to fish in the river. An estimate of the total value of the recreational fishery (i.e., trip costs, consumer surplus, and durable goods) was approximately \$1.8 million (Beard, 2000).

15.0 LAND USE AND AESTHETICS

The Saluda Project is located in the Santee River Basin in the Piedmont region of South Carolina, near the City of Columbia. The Santee River Basin is comprised of the Santee, Congaree, Catawba-Wateree, Broad and Saluda Rivers.

15.1 Existing Land Use

The Project lies within Richland, Lexington, Newberry and Saluda Counties in South Carolina, with the majority of Project lands falling within Lexington County (Figure A-1). At 756 square miles in size, Richland County is the largest of the four counties, followed by Lexington County (699 square miles), Newberry County (631 square miles) and Saluda County (452 square miles) (South Carolina Association of Governments, 2004). Richland and Lexington Counties are among the most densely populated counties in the state, ranking 2nd and 5th respectively out of 46 counties total (Ibid).

Richland County supports Fort Jackson, the largest army-training military facility in the U.S., and the University of South Carolina. The county is viewed as being in the head of South Carolina's transportation hub (Richland County, 2003). It is served by three interstate highway systems, eight additional major U.S. highways, five passenger airlines, and bus and passenger rail services (South Carolina Association of counties, 2004). The City of Columbia is the county seat, and also the state capital.

The City of West Columbia is located in Lexington County, where a majority of Project lands and Lake Murray lie. The Lexington County is served by several major transportation routes connected to the capital city (South Carolina Association of Counties, 2004). The City of Lexington is the county seat.

Saluda and Newberry Counties are home to the southwestern and northwestern reaches of Lake Murray, respectively. Large tracts of the Sumter National Forest are located in both counties. The Long Canoe Ranger District occupies the most western

reaches of Saluda County and the Enoree Ranger District occupies the northern portion of Newberry County. Transportation infrastructure in the counties is substantial, though only Newberry County has a major highway system running through it. The communities of Saluda and Newberry serve as the county seats for these two counties.

Land use in the vicinity of the Project is influenced by topography, soil characteristics, and current allowable uses of land and water resources. Social and economic factors such as employment, population and development also influence land use patterns.

Richland, Lexington and Newberry Counties all have zoning and / or land use plans in place to guide development in unincorporated areas. Incorporated communities in these counties generally maintain separate zoning requirements. There is no zoning or land use plan in place for Saluda County, though incorporated areas within the county do have zoning.

Land use within the Project boundary is subject to various state, federal, and local regulations in addition to SCE&G's Land Use and Shoreline Management Program (LUSMP). The LUSMP was designed to conserve and maintain the area's natural and man made resources and is used to assist in providing a balance between recreation and environmental controls. SCE&G originally developed a shoreline permitting program in 1975, and added land use component to the program in 1980. The LUSMP is updated every five years in consultation with relevant federal, state and local agencies. The most recent plan was submitted to FERC on February 1, 2000 and was approved by FERC with modifications on June 23, 2004 (107 FERC ¶ 62,273) and further clarified and modified on October 28, 2004 (109 FERC ¶ 61,083). Currently, SCE&G is in the process of revising their land classifications within the project boundary as a part of the relicensing process. Once final, these classifications will be made available.

The LUSMP identifies the major land uses around the lake and the location of a majority of environmentally sensitive areas. Through the LUSMP, SCE&G is responsible for the management of approximately 17,152 acres of land within the Project boundary. Guidelines, including buffer zones and minimum construction setbacks, are in

place to define acceptable uses within each classification. The LUSMP is currently published in multiple separate documents; through relicensing, SCE&G will consolidate this into a single document.

SCE&G also has a shoreline permitting program which allows them to monitor construction, water withdrawals, maintenance and placement of docks, boat lifts, boat ramps, dredging and excavation, seawalls, rip rap, vegetation clearing and other shoreline developments (SCE&G, 1995). Permitting fees are assessed for most structures to help defray some of the costs of the program management. The permitting program and associated fees are available on SCE&G's Project website. In conjunction with its relicensing work, SCE&G plans to conduct an evaluation of the sufficiency of its fee schedules, with the objective of adjusting fees and/or implementing a more comprehensive fee schedule to fully support increasingly complex and labor-intensive shoreline management and environmental protection requirements.

Approximately 6,225 acres of watershed land within and adjacent to the Project are leased to the SCDNR as part of the statewide Game Management Program. This land is located adjacent to the western portions of the Lake.

15.2 Aesthetics Resources

FERC (2002) provided an excellent summary of the aesthetic characteristics of the Saluda Project. Except where noted, the information reported in this section is taken directly from that document.

The Saluda Project is located in an area of low, rolling hills between 300 and 1000 feet above sea level and has a local relief of approximately 100 feet. The lake is characterized by multitudes of irregularly shaped peninsulas and numerous inlets and islands, most of which are heavily forested.

At about 48,000 acres, Lake Murray is the fifth largest lake in South Carolina, following Lakes Marion, Thurmond, Hartwell and Moultrie (SCPRT, 2002). It is located

in close proximity to South Carolina's capital city and it supports a significant recreation industry. Since its development, the lake has become a natural draw for residents and tourists alike. The early 1970s saw a marked increase in development pressure on the lake, and today, the lake is approximately 60 percent developed, primarily for residential use (FERC, 2003). Parkland, protected lands, and the required 75-foot buffer around the lake provides a natural buffer between Project waters and the homes that were constructed after the buffer zone was implemented in 1991. Shoreline development consists primarily of residences, docks, gazebos and boat lifts, and in some places, particularly prior to the implementation of the SMP, clearing has resulted in some areas having a maintained and manicured appearance.

The eastern half of the lake comprises the main body of the reservoir and has an expansive viewshed over several miles of open water and a few large inlets. The majority of the shoreline in this area is tree covered and interspersed with extensive shoreline development, ranging from individual private docks and large houses to marinas, landings, and park sites. A few large forested islands are located in the main body of the reservoir. The light to moderate tree covered shoreline and the lake's forested islands dominate most distant views across the open water and soften the contrasting shoreline development. The Project's Dam and five large intake towers are clearly visible from the main body of the reservoir. With the extended viewshed of the main body of the reservoir and the tree-covered shoreline, these manmade structures do not detract significantly from the overall visual character of the reservoir.

The western half of the lake is more riverine in nature than the main body of the reservoir and branches out into narrow arms that extend up into many drainage ways and creeks that enter the reservoir. Viewsheds in this area are varied and shortened by the encroaching shoreline and the increased number of small coves, creek beds, and drainage ways. Overall, the shoreline contains less intensive development and more trees and vegetation than the main body of the reservoir. Much of the development in this area includes individual private boat docks and small houses. Typically, the upper ends of the coves in this area are narrow, undeveloped, and heavily vegetated.

The downstream area affected by the Project includes the south side of the river downstream of the existing Dam. The north side of the river is disturbed by existing

development, primarily the Project powerhouse, McMeekin Station and various appurtenant facilities. The area downstream of the Dam is primarily visible from Highway 6, a state highway with north and southbound lanes, as it crosses over the Dam and at either end of the Dam from secondary roads. Views of the open water and distant shoreline of the reservoir as well as the Project's intake structures are prominent from the highway and create a generally pleasing viewshed. Motorists have somewhat fleeting views of the areas upstream and downstream of the Dam as they drive on Highway 6. Given the relatively limited, fleeting views of the downstream area and its partially developed nature, the aesthetic quality of the downstream area is considered to be moderate.

During normal water levels, portions of the lake bottom along the periphery of the reservoir shoreline and islands and bars are exposed. At elevation 350, the reservoir has a surface area of about 40,066 feet and about 7,400 acres of lake bottom is exposed. The lake bottom appears as a dark band of substrate around the periphery of the reservoir and around islands and bars. Exposed aquatic vegetation, tree stumps and woody debris are present throughout much of the dewatered area. In general, the shoreline around the main body of the reservoir, including the back ends of small coves, have moderate to highly steep slopes. The shoreline along upper reaches of the lake, including the longer, narrower coves and inlets tend to have gentle gradual slopes. As a result, there is less lake bottom exposed in the main body at elevation 350 than in the upper reaches.

16.0 SOCIOECONOMICS

16.1 Demographics

A summary of the demographic profile of Lexington, Newberry, Richland, and Saluda Counties is provided in Table E-19. Population figures from the U.S. Bureau of the Census (2002) indicate that, in 2000, the combined population of the counties was approximately 592,000. This represents a change of about 89,000 people since 1990, or an increase during the 1990s of 17.7 percent (Table E-18). The rest of South Carolina grew by about 436,000 people or 14.6 percent between 1990 and 2000. In 2002,

Lexington, Newberry, Richland and Saluda Counties ranked 5th, 27th, 2nd and 42nd, respectively, in population in the state (out of 46 counties). South Carolina's population is expected to increase to 4,229,990 in 2005, 4,458,930 in 2010, and 4,687,920 in 2015.

Table E-19 shows demographic characteristics of Lexington, Newberry, Richland, and Saluda Counties in 2000. The gender distribution in the four-county area is similar to that of the entire state of South Carolina. Richland County has the highest proportion of people age 18-64 and the lowest proportion of people age 65 or older. The number of high school graduates was similar between Lexington and Newberry Counties and the state as a whole. A lesser percent of the population in Richland County holds high school diplomas while slightly more of the population of Saluda County graduated from high school. The percent of college graduates on the other hand differs from this distribution. There were a high percentage of college graduates in Lexington and Richland Counties, as compared to the state as a whole, and a lesser percentage in Newberry and Saluda Counties.

The number of persons per residence is similar between Lexington and Newberry Counties and the state as a whole. There are slightly fewer people per household in Richland County and slightly more people per household in Saluda County. Richland County is a very urbanized county with the highest percentage of urban residents when compared with Lexington, Newberry and Saluda Counties and statewide. Saluda County, on the other hand, is very rural with over 80 percent of the population comprised of rural residents.

16.2 Economy

A summary of economic information pertaining to the State of South Carolina, Lexington County, Newberry County, Richland County, and Saluda County is provided in Table E-20.

The estimated median household income in 1999 for the Lexington, Newberry, Richland, and Saluda Counties was \$44,659, \$32,867, \$39,961, and \$35,774,

respectively. Lexington had the highest estimate, 17 percent higher than the state median of \$37,082, while Newberry County had the lowest estimate at almost 13 percent lower than the state median. Per capital income (Table E-20) follows the same general distribution with Lexington County having the highest at 118 percent of South Carolina per capita and Newberry having the lowest at 84 percent of the state per capital.

Unemployment follows the inverse distribution with Newberry County having the highest level of unemployed residents over the age of 16 and Lexington County having the lowest. Newberry County also has the greatest percentage of county population living below the poverty level. Lexington County, on the other hand, has the least with 9 percent of county population below poverty level. The other counties were generally equal to or higher than the overall percentage of state residents below poverty level at 14 percent.

The region offers a wide variety of major businesses and industries but also relies heavily on services and government. Employment figures indicate that the civilian labor force in Lexington, Newberry, Richland, and Saluda Counties was approximately 302,000 (Table E-21). Government was the largest employer with services and retail trade being the two largest non-governmental sectors. According to FERC (2002), total payroll in the four-county area was nearly \$8 billion, with the highest proportions belonging to government (26.01 percent), services (22.05 percent), manufacturing (13.67 percent), and retail (10.29 percent). The highest earnings per worker were \$41,308 for mining, which also has one of the lowest percentages of employees, and \$38,490 for wholesale trade (FERC, 2002).

16.3 Social Infrastructure

Lexington, Newberry, Richland, and Saluda Counties provide many services including law enforcement and fire protection, county roads, sanitation, judicial, emergency medical, health care facilities, education, civic organizations and municipal management.

In 1999-2000, Richland County reported 35 private schools with an enrollment of 5,017 students and 68 public schools, with a total of 44,559 students enrolled. By comparison, Saluda County reported only 1 private school having 252 students and 4 public schools with 2,165 students. During the same period, Lexington County reported 13 private schools with an enrollment of 1,136 students and 57 public schools with a total of 46,356 students enrolled. Newberry County had 2 private schools having 260 students and 14 public schools with 5,840 students (SCIway, 2004).

Newberry College and Piedmont Technical College are located in Newberry County. Richland County is home to 8 colleges and universities, as well as, the South Carolina Criminal Justice Academy and the South Carolina Fire Academy. There are no colleges or universities in Saluda or Lexington Counties (SCIway, 2004).

The Project area is served by the Lexington County, Newberry County and Richland County sheriff's offices and several local town police departments. The South Carolina Highway Patrol also has jurisdiction across the state and has its headquarters located in Richland County. The State Fire Marshall's Office is also located in Richland County (South Carolina State Government, 2004). There are a total of 6 hospitals in the quad-county area (SCIway, 2004).

16.4 Access and Transportation

Lexington, Newberry, Richland, and Saluda Counties are served Columbia Metropolitan Airport, Greenville-Spartanburg Airport, and several municipal airports; Amtrak and Greyhound, and a system of highways. Interstate 20 runs from Interstate 95 in the eastern part of South Carolina west to Georgia, intersecting both Richland and Lexington Counties. Interstate 26 runs north from Interstate 20 in Richland County and runs northwest through Newberry County, passing Lake Murray just to the east and continuing to North Carolina. Interstate 77 also runs north from Interstate 20 in Richland County and runs north to North Carolina. There are no major interstates running through Saluda County, which is served primarily by Highways 378 and 178 (SCIway, 2004).

The Saluda Project area is accessible via secondary roads from Interstate 20 to the east, Highway 76 to the north, Highway 378 to the south and State Routes 391 and 194 in Saluda County to the west (SCIway, 2004).

Table E-15: Public Recreation Sites in the Project Area

Site Name (Site Number)	Acres	Fee	Picnicking	Hiking	Camping	Lodging	Swimming	Fishing	Dock Fishing	Multi-Ramp	Ramp	Canoe Access	Docks	Food	Marina	Restrooms	Playground	Store	Owned by SCE&G	Operated by SCE&G	Leased to Other Entity
Lake Murray																					
Billy Dreher State Park (1-11)	348.0	●	●	●	●	●		●		●			●	●	●	●	●	●	●		●
Dam (1-8)	6.8		●						●	●			●						●	●	
Higgins Bridge (1-13)	1.1										●									●	●
Hilton (1-7)	4.4		●					●	●		●					●			●	●	
Kempson Bridge (1-14)	1.1										●									●	●
Lake Murray Estates (1-22)											●									●	●
Macedonia Church (1-12)	5.3		●																	●	●
Murray Shores (1-3)	1.6		●								●		●							●	●
Parksite (1-1)	17.9		●				●							●						●	●
River Bend (1-4)	11.6		●					●			●		●							●	●
Rock Creek (1-6)	1.7		●								●									●	●
Shull Island (1-2A)																				●	●
Shull Island (1-2B)											●									●	●
Shull Island / Larry Koon (1-2)	2.2		●								●		●			●				●	●
Sunset 1-(5)	2.3		●								●									●	●

Site Name (Site Number)	Acres	Fee	Picnicking	Hiking	Camping	Lodging	Swimming	Fishing	Dock Fishing	Multi-Ramp	Ramp	Canoe Access	Docks	Food	Marina	Restrooms	Playground	Store	Owned by SCE&G	Operated by SCE&G	Leased to Other Entity
----------------------------	-------	-----	------------	--------	---------	---------	----------	---------	--------------	------------	------	--------------	-------	------	--------	-----------	------------	-------	----------------	-------------------	------------------------

Lower Saluda River

Gardendale												•							•		•
Hope Ferry (1-10)	1.0									•									•	•	
Saluda River Canoe Portage (1- 15)	2.0											•							•	•	
Saluda	240.								•	•									•		•
Shoals Park (1-9)	0																				
64 Islands	220. 0																		•		

Table E-16: Marinas on Lake Murray

Marina Name (Site Number)	Acres	Multi slips	Ramp	Dock	Bait and/or Tackle	Dry Storage	Fuel	Restaurant	Food	Motel	Camping
Acapulco, USA (2-20)			●	●							
Adams Campground (2-24)			●	●							●
Agnew Lake Services (2-2)			●								
Barn (2-15)		●			●				●		●
Billy Dreher Island State Park (2-10)		●	●				●				●
Blacks Bridge Marina (2-14)			●	●	●				●		
Bucks (2-9)			●	●							
Eptings Landing (2-8)											●
Hendrick Landing (2-29)			●	●							
Holiday Shores Point (2-25)			●	●							
Holland Landing (2-12)		●			●				●		●
Hollow Creek Marina (2-22)		●									
Jakes Landing (2-31)		●							●		
Johnny Shealy (2-3)			●	●							●
Lake Murray Marina (2-1)		●						●			
Lighthouse Marina (2-4)		●				●		●			
Little Marina (2-17)			●	●	●				●		
Little River Landing (2-16)			●		●				●		
Lockhart Landing (2-5)			●	●							
Old Palmetto Landing (2-6)			●	●							
P-L Landing (2-11)			●	●					●	●	
Putnams Landing (2-7)		●			●				●		
Robinsons Lakeside Marina (2-26)		●			●				●		
Roys Landing (2-23)			●	●							
Saluda River Resort (2-13)			●		●				●		●
Siesta Cove (2-27)		●			●				●		●

Marina Name (Site Number)	Aeris	Multislips	Ramp	Dock	Bait and/or Tackle	Dry Storage	Fuel	Restaurant	Food	Motel	Camping
Snelgrove Landing (2-30)			●	●							
Spinners Marina (2-19)		●	●	●	●				●		
Swygerts Landing (2-21)			●	●							
Top-of-the-Lake (2-18)			●								
Turners Landing (2-28)			●	●							

Table E-17: Private Marinas and Landings on Lake Murray

Marina Name (Site Number)	Aeris	Private Club	Condominium	Subdivision
Ballentive Cove (3-10)				●
Boardwalk Villa (3-56)			○	
Cedar Cove Subdivision (3-15)		●		
Clearwater Cove (3-6)				
Clouds Creek Estates (3-36)				●
Coast Guard Auxiliary (3-13)				
Columbia Farms Employee Club (3-41)		●		
Columbia Sailing Club (3-1)		○		
Crystal Springs Creek (3-37)				●
Edgewater Shores (3-32)				○
Fort Love Point Subdivision (3-16)		●		
Friendly Boating Club (3-57)		○		
Hallmark Shores (3-46)				●
Harbor Place (3-53)				○
Harborside (3-51)			●	
Hilton Place (3-20)				○
Indian Fork (3-17)		●		
J.B. Martin Employee Club (3-40)		○		
Lake Murray Boating/Sporting Club (3-18)		●		
Lake Murray Docks (3-3)		○		
Lake Murray Sailing Club (3-19)				●
Lake View Subdivision (3-35)				○
Lake Wood (3-28)				●
Lands End (3-50)			○	
Leesville Fire Department (3-44)		●		
Lexington County Law		○		

Marina Name (Site Number)	Acres	Private Club	Condominium	Subdivision
Enforcement (3-42)				
Mallard Cove (3-54)			●	
Mallard Shores (3-48)			●	
Moss Rock Subdivision (3-45)				●
Nautical Shores Subdivision (3-38)				●
Newberry Exchange Club (3-31)		●		
Newberry Firemen's Association (3-34)				
Newberry Lions Club (3-30)		●		
Night Harbor (3-25)				●
North Lake Development (3-11)				●
Optimist Club (3-21)				
Pine Island Club (3-4)		●		
Plantation Hills (3-23)				●
Plantation Point (3-33)				●
Sandhill Landing Property (3-39)				●
Secret Cove (3-55)				●
Selwood Shores (3-5)				●
Shadowood Subdivision (3-12)				●
Shady Acres (3-24)				●
Ship Yard (3-22)				
Smallwood (3-29)				●
Spences Point (3-49)			●	
Stephenson Lakes (3-27)				●
Tattlers Wharf (3-9)				●
The Landings (3-47)				●
The Village (3-8)				●
Timberlake (3-26)				●
Waxford Subdivision (3-7)				●
Willows End (3-43)				●

Marina Name (Site Number)	Acres	Private Club	Condominium	Subdivision
Winward Pointe (3-52)				●
Woodmen of the World (3-14)		●		
Yacht Cove (3-2)			●	

Table E-18: Study Area Population Trends, 1990-2000: Average Annual Percent Change

COUNTY	1990	2000	PERCENT CHANGE
Lexington	167,611	216,014	28.9
Newberry	33,172	36,108	8.85
Richland	285,720	320,677	12.2
Saluda	16,357	19,181	17.3
TOTAL	502,860	591,980	17.7
Rest of South Carolina	2,983,843	3,420,032	14.6

Source: U.S. Bureau of Census, 2002, reported in FERC 2002.

Table E-19: Demographic Characteristics of Residents of Lexington, Newberry Richland and Saluda Counties and South Carolina in 2000.

STATISTIC	SOUTH CAROLINA	LEXINGTON	NEWBERRY	RICHLAND	SALUDA
Percent Male	48.6	48.6	48.2	48.3	49.6
Percent 18 - 64	62.7	63.7	61.2	66.0	60.6
Percent High School Graduates ^a	30.0	29.5	33.5	22.8	38.6
Percent College Graduates ^a	27.1	32.7	21.3	39.2	17.8
Persons per Occupied Housing Unit (1990)	2.53	2.56	2.5	2.44	2.65
Percent Urban	60.5	66.3	33.1	87.2	18.7
Percent Rural	39.5	33.7	66.9	12.8	81.3

Sources: U.S. Bureau of Census, 2002 and South Carolina Office of Research and Statistics, 2004, Reported in FERC, 2002.

^a This information pertains to persons in 2000 over the age of 25

Table E-20: Economic Characteristics of Residents of Lexington, Newberry Richland and Saluda Counties and South Carolina in 2000

STATISTIC	SOUTH CAROLINA	LEXINGTON	NEWBERRY	RICHLAND	SALUDA
Per Capita Personal Income (1999)	\$24,426	\$28,906	\$20,552	\$27,114	\$20,992
Civilian Labor Force ^a	1,938,195	114,600	17,203	160,969	9,156
Unemployment Rate (percent) ^a	5.9	3.5	7.8	6.7	5.0
Percent Persons Below Poverty Level (1999)	14.1	9	17	13.7	15.6

Sources: FERC, 2002 and South Carolina Office of Research and Statistics, 2004.

^a This information pertains to persons in 2000 over the age of 16.

Table E-21: Employment by Sector: Lexington, Newberry, Richland, and Saluda Counties in 2000

SECTOR	JOB	% OF	ANNUAL	% OF	ANNUAL
		TOTAL	PAYROLL	TOTAL	EARNINGS
					/ WORKER
Agriculture & Forestry	2,762	0.90	\$53,845,243	0.15	\$19,495
Mining	3,240	1.00	\$13,383,791	0.15	\$41,308
Construction	16,162	5.27	\$476,359,161	5.42	\$29,474
Manufacturing	34,244	11.16	\$1,201,624,718	13.67	\$35,090
Transport & Utilities	14,694	4.79	\$545,664,145	6.21	\$37,135
Wholesale Trade	14,422	4.70	\$555,106,829	6.32	\$38,490
Retail Trade	54,488	17.76	\$904,573,419	10.29	\$16,601
F.I.R.E.	21,933	7.15	\$813,188,054	9.25	\$37,076
Services	73,018	23.81	\$1,937,779,148	22.05	\$26,538
Government	74,675	24.35	\$2,286,070,529	26.01	\$30,614
TOTAL	306,722		\$8,787,595,037		

Source: FERC, 2002.

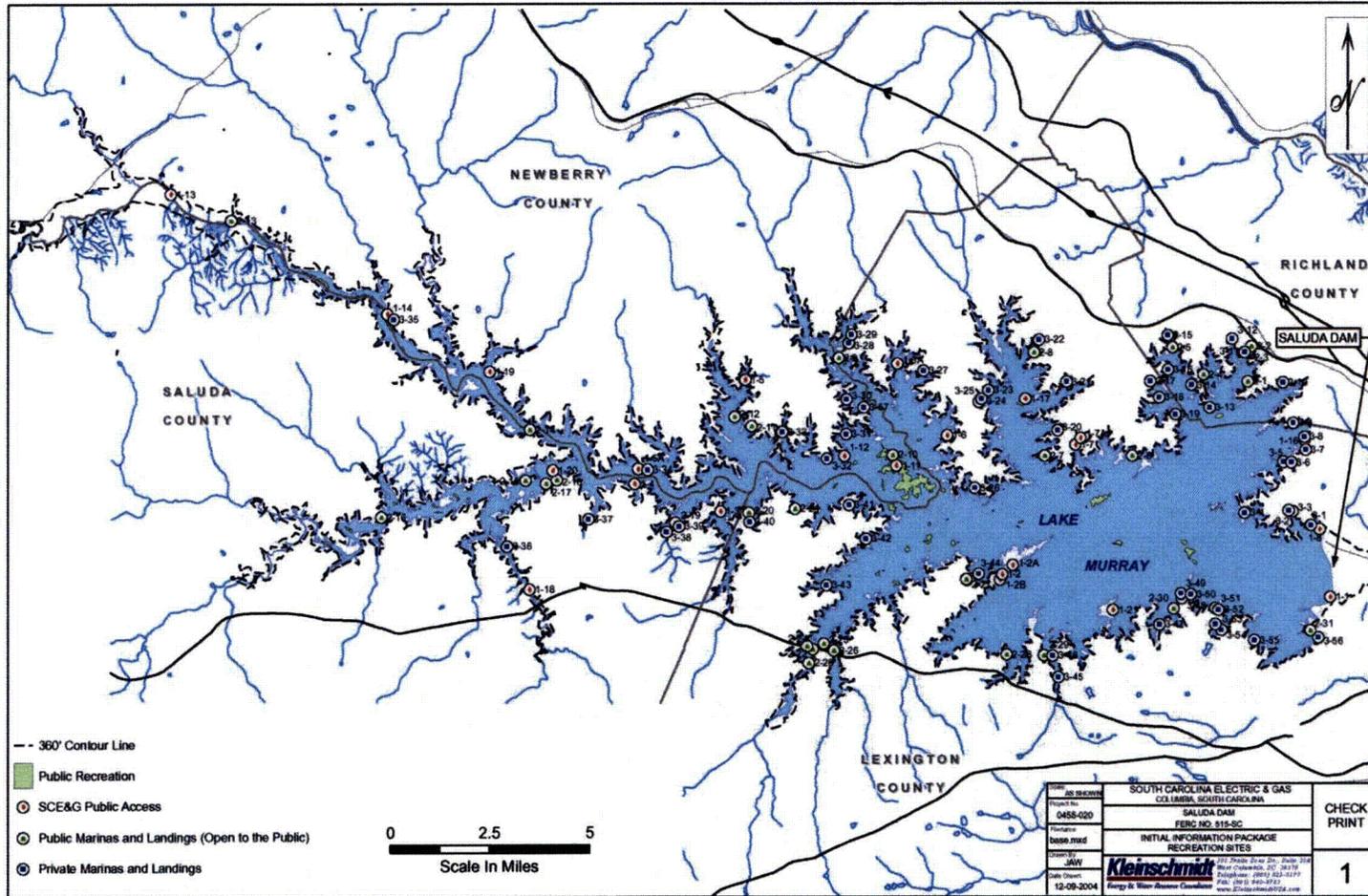


Figure E-14: Public Access and Recreation sites around Lake Murray

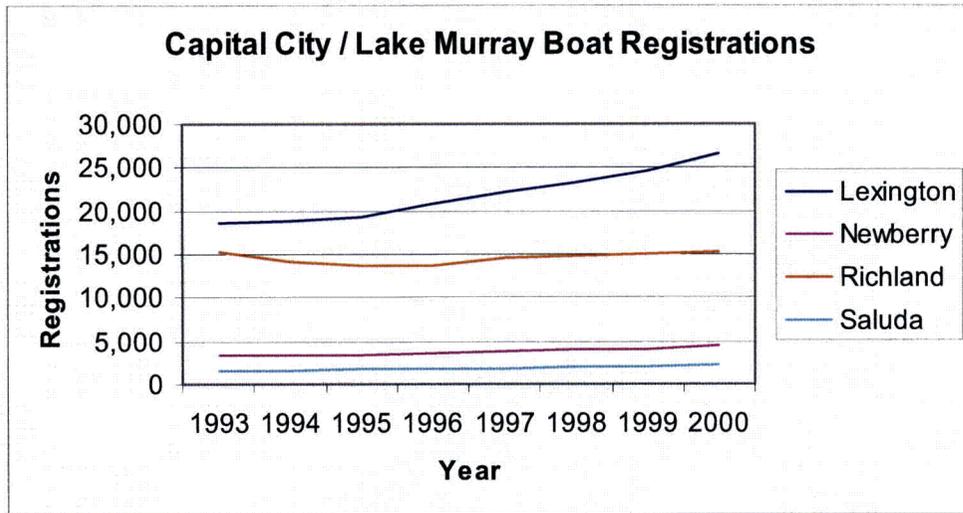


Figure E-15: Capital City Boat Registrations (SCBCB, 2004 and Mead and Hunt, 2002; as modified by Kleinschmidt)

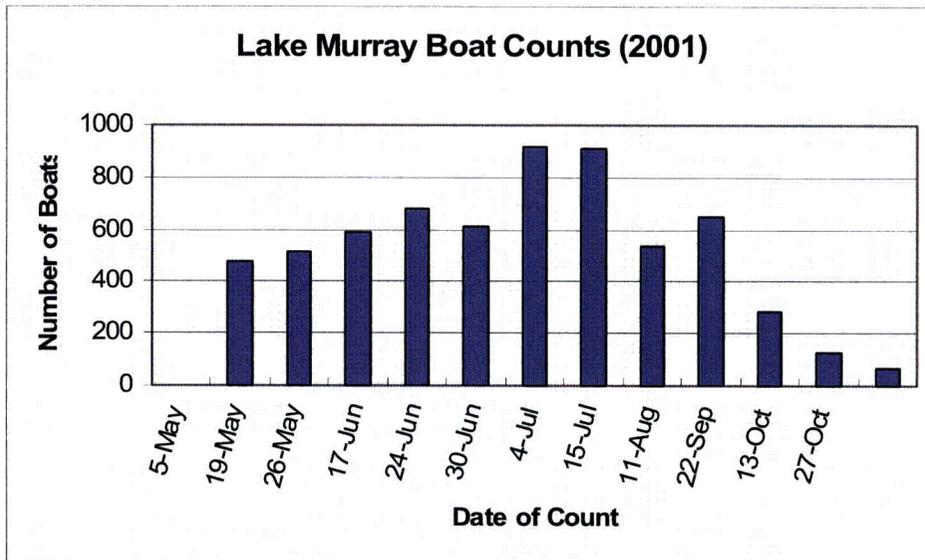
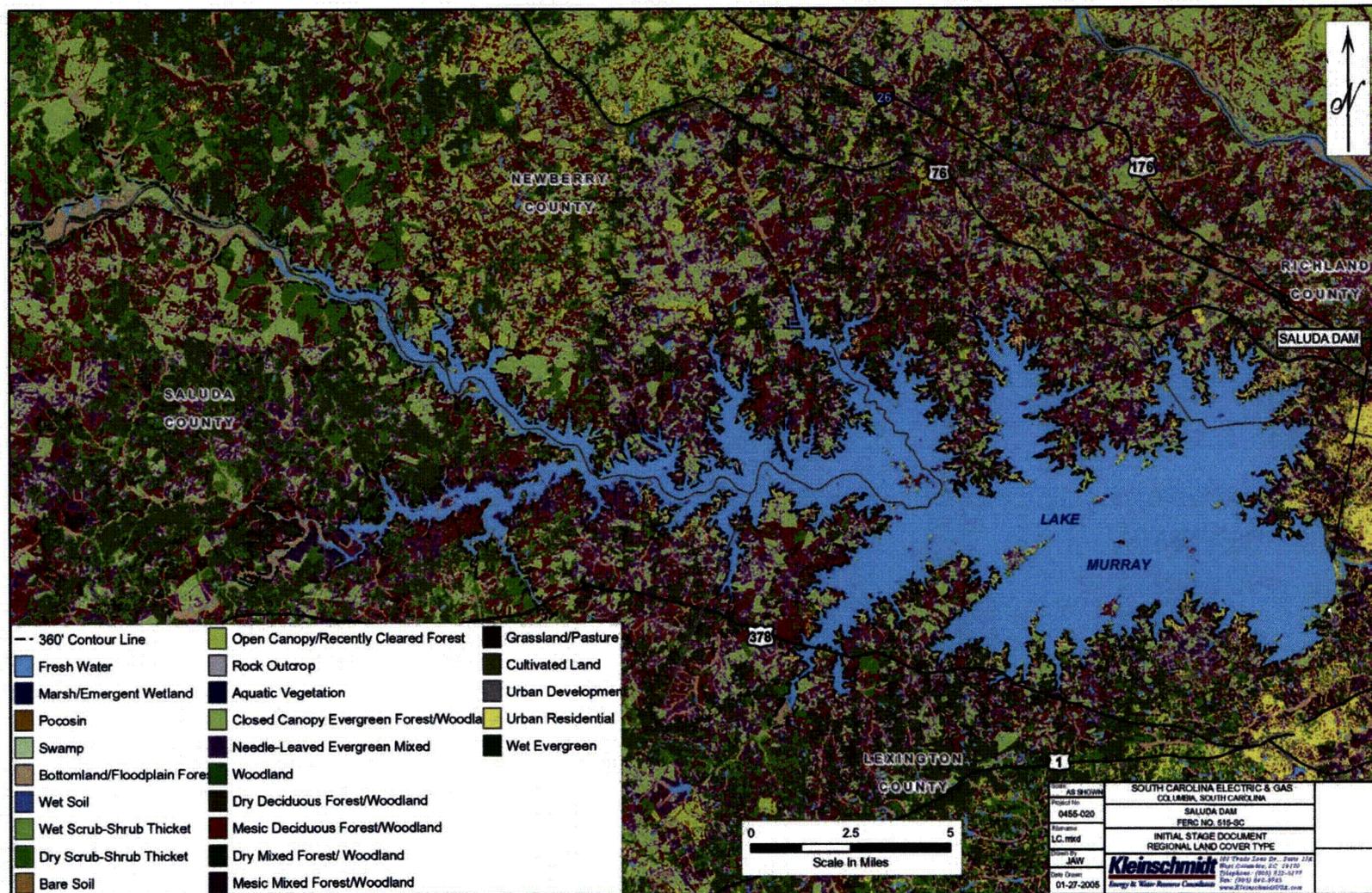


Figure E-16: Lake Murray Boat Counts (Source: The Louis Berger Group, Inc., 2002, cited in Mead & Hunt, 2002b)



South Carolina GAP Analysis data developed by USGS, 2001.

Figure E-17: Land Cover in the Vicinity of Lake Murray

F: GENERAL DESIGN DRAWINGS OF PRIMARY PROJECT WORKS

**THIS INFORMATION IS CONSIDERED NON-INTERNET PUBLIC UNDER THE
FEDERAL ENERGY REGULATORY COMMISSION'S CRITICAL ENERGY
INFRASTRUCTURE INFORMATION POLICY**

**THIS INFORMATION IS CONSIDERED NON-INTERNET PUBLIC UNDER THE
FEDERAL ENERGY REGULATORY COMMISSION'S CRITICAL ENERGY
INFRASTRUCTURE INFORMATION POLICY**

**THIS INFORMATION IS CONSIDERED NON-INTERNET PUBLIC UNDER THE
FEDERAL ENERGY REGULATORY COMMISSION'S CRITICAL ENERGY
INFRASTRUCTURE INFORMATION POLICY**

**THIS INFORMATION IS CONSIDERED NON-INTERNET PUBLIC UNDER THE
FEDERAL ENERGY REGULATORY COMMISSION'S CRITICAL ENERGY
INFRASTRUCTURE INFORMATION POLICY**

**THIS INFORMATION IS CONSIDERED NON-INTERNET PUBLIC UNDER THE
FEDERAL ENERGY REGULATORY COMMISSION'S CRITICAL ENERGY
INFRASTRUCTURE INFORMATION POLICY**

G: PROJECT MAPS

**THIS INFORMATION IS CONSIDERED NON-INTERNET PUBLIC UNDER THE
FEDERAL ENERGY REGULATORY COMMISSION'S CRITICAL ENERGY
INFRASTRUCTURE INFORMATION POLICY**

**THIS INFORMATION IS CONSIDERED NON-INTERNET PUBLIC UNDER THE
FEDERAL ENERGY REGULATORY COMMISSION'S CRITICAL ENERGY
INFRASTRUCTURE INFORMATION POLICY**

**THIS INFORMATION IS CONSIDERED NON-INTERNET PUBLIC UNDER THE
FEDERAL ENERGY REGULATORY COMMISSION'S CRITICAL ENERGY
INFRASTRUCTURE INFORMATION POLICY**

APPENDIX A
LITERATURE CITED

APPENDIX A: LITERATURE CITED

- Access Washington Homepage. 2004. General Information about Hydrilla.
<http://www.ecy.wa.gov/programs/wq/plants/weeds/hydrilla.html>. December 20, 2004
Ann. Prog. Rpt. F-63-1-8: 82 pp.
- ARM Environmental. 2001. Assessment of Threatened and Endangered Species for the proposed Lake Murray Dam Remediation project, June 2000.
- Aulbach, Cynthia. 2001a. 2001 Aquatic Macrophytes of the Lower Saluda River, SC. SCE&G Unpubl. Rpt.
- Aulbach, Cynthia. 2001b. Summary of Hydrilla and Pondweed Survey, Lake Murray, SC. SCE&G Unpubl. Rpt.
- Aulbach, Cynthia. 2002. Aquatic macrophytes of the Lower Saluda River, SC. SCE&G Unpubl. Rpt.
- Aulbach-Smith, Cynthia. 1998. Distribution of Aquatic Plants in Lake Murray, SC, 1989-1997. SCE&G Unpubl. Rpt.
- Baker, O.E., III and B. Carmichael, Jr. 2003. South Carolina's Furbearers. South Carolina Department of Natural Resources, Division of Wildlife and Freshwater Fisheries.
<http://www.dnr.state.sc.us/wild/img/furbearer.pdf>. March 12, 2003.
- Beard, H. 1996. Fisheries investigations in lakes and streams – District VIII. SCDNR Ann. Prog. Rpt. F-63-1-8: 125 pp.
- Beard, H. 1997. Fisheries investigations in lakes and streams – District VIII. SCDNR
- Beard, H. 2000. Fisheries Investigations in Lakes and Streams, District VIII. South Carolina Department of Natural Resources Study Progress Report F-49.
- Beard, H. 2001. Fisheries investigations in lakes and streams – District VIII. SCDNR Ann. Prog. Rpt. F-63-1-9: 36 pp.
- Beard, H. 2002. Fisheries investigations in lakes and streams – District VIII. SCDNR Ann. Prog. Rpt. F-63-1-10: 43 pp.
- Behler, J.L. and F.W. King. 1979. National Audubon Society Field Guide to North American Reptiles and Amphibians. Alfred A. Knopf, New York.
- Birrenkott, A.H., S.B. Wilde, J.J. Haines, J.R. Fischer, T.M. Murphy, C.P. Hope, P.G. Parnell, and W.H. Bowerman. 2004. Establishing a food-chain relationship between aquatic plants and avian vacuolar myelinopathy in mallards (*Anas platyrhynchos*). Journal of Wildlife Diseases 40(3)485-492.
- Brown, C.R. 1997. Purple martin (*Progne subis*). In the Birds of North America, no. P287 (A. Poole and F. Gill, Editors). The Academy of Natural Sciences, Philadelphia, Pennsylvania; The American Ornithologists' Union, Washington, DC.
- Campbell, W.M. and J.M. Dean. 1976. "Environmental Inventory of Lake Murray, South Carolina—Volumes I and II," prepared for SCE&G, January 1976.
- Carr, Martha, 1978, "Structural Chronology of Lake Murray Spillway, Central South Carolina", in Snoke, A.W., Geologic Investigations of the Eastern Piedmont, Southern Appalachians, Carolina Geological Society Field Trip Guidebook.

- Clendenin, C.W. and C.A. Niewndorp, 1997, "Geology of the Lake Murray Area- A Progress Report Focused on Mappable Relations of the South Shore", South Carolina Geology, Vol. 39, pp. 31-44.
- Colinvaux, P. 1993. Ecology 2. John Wiley and Sons, New York, NY. 688pp.
- Crane, J. S. 1987. Lower Saluda River fishery study, preliminary report. South Carolina Wildlife and Marine Resources Department, Columbia, SC.
- Dallmeyer, D. R., Wright, J. E., Secor, D.T., and A.W. Snoke, 1986, "Character of the Alleghanian Orogeny in the Southern Appalachians: Part II Geochronological Constraints on the Technothermal Evolution of the Eastern Piedmont in South Carolina", Geol. Soc. of America Bull. Vol. 97, pp. 1329 – 1344.
- Degraff, R.M. and D.D. Rudis. 1986. New England Wildlife: Habitat, Natural History and Distribution. Gen. Tech. Rep. NE-108. U.S. Department of Agriculture, Forest Service, Northeast Forest Experiment Station, PA. 491pp.
- Dennis, A. J., Sacks, P. E. and H. D. Maher, 1987, "Nature of the Late Alleghanian Strike-Slip Deformation in the Eastern South Carolina Piedmont: The Irmo Shear Zone", in Secor, Donald T., (editor), Anatomy of the Alleghanian Orogeny as seen from the Piedmont of South Carolina and Georgia, Carolina Geological Society Field Trip Guidebook, pp. 54-66.
- Department of Health and Environmental Control (DHEC). 1995. Watershed Water Quality Management Strategy—Saluda-Edisto Basin. Technical Report No. 003-95, prepared by South Carolina Department of Health and Environmental Control.
- Department of Health and Environmental Control (DHEC). 1998. Watershed Water Quality Assessment—Saluda River Basin. Technical Report No. 005-98, prepared by South Carolina Department of Health and Environmental Control, Bureau of Water, December, 1998.
- Environmental Protection Agency (EPA). 2001. Evaluation Of Hydropower Projects And Identification Of Opportunities For Pollutant Trading—Final Report. Prepared by John Crossman and RJ Ruane, John Crossman and Associates, May 2001.
- Federal Energy Regulatory Commission (FERC). July 22, 2002. Final Environmental Assessment; Saluda Dam Seismic Remediation.
- Federal Energy Regulatory Commission (FERC). June 1, 1984. Order Issuing New License (Major); Saluda Hydroelectric Project.
- Federal Energy Regulatory Commission (FERC). June 23, 2004. Order Approving Land Use and Shoreline Management Plan with Modifications and Amending Exhibit R; Saluda Hydroelectric Project.
- Federal Energy Regulatory Commission (FERC). October 30, 2003. Final Environmental Assessment, Sale of Land for Future Private Development; Saluda Hydroelectric Project.
- Gibbons, W., P. West, L.L. Janecek and D.E. Scott. 1998. Snakes of Georgia and South Carolina. University of Georgia's Savannah River Ecology Laboratory, Aiken, SC.
- Hare, J.C., Gault, H. W., Charlton, J., McCarney, K. J., and J. Harrison, 2004, "Detailed Mapping of Recently Exposed Mid-Crustal Rock Along the Modoc Shear Zone, Central

- South Carolina.: 4-D Framework of the Continental Crust”, presented at the 17th International Basement Tectonics Conference.
- Hatcher, R.D., Howell, D., and P. Talwani, 1977, “Eastern Piedmont Fault System: Speculations on its Extent”, *Geology*, Vol. 5, pp. 636-640.
- Hayes W.E. 1986. Fisheries investigations in lakes and streams – District III. SCWMRD Ann. Prog. Rpt. F-18-12: 46 pp.
- Hayes W.E. and G. M. Penny. 1990 Fisheries investigations in lakes and streams – District III. SCWMRD Ann. Prog. Rpt. F-18-16: 122 pp.
- Hayes W.E. and G. M. Penny. 1991 Fisheries investigations in lakes and streams – District III. SCWMRD Ann. Prog. Rpt. F-18-17: 130 pp.
- Hayes W.E. and G. M. Penny. 1992 Fisheries investigations in lakes and streams – District III. SCWMRD Ann. Prog. Rpt. F-18-19: 136 pp.
- Hayes W.E. and G. M. Penny. 1993. Fisheries investigations in lakes and streams – District III. SCDNR Ann. Prog. Rpt. F-18-19: 125 pp.
- Hayes W.E. G. M. Penny and Roosen. 2000. Fisheries investigations in lakes and streams – District III. SCDNR Ann. Prog. Rpt. F-63-5-3: 93 pp.
- Hayes W.E., and G. M. Penny, 1995. Fisheries investigations in lakes and streams – District III. SCDNR Ann. Prog. Rpt. F-18: 84 pp.
- Hayes W.E., G. M. Penny and K J Roosen. 2002. Fisheries investigations in lakes and streams – District III. SCWMRD Ann. Prog. Rpt. F-63—5-5.
- Hayes W.E., J. G. M. Penny and K. J. Roosen. 2001. Fisheries investigations in lakes and streams – District III. SCWMRD Ann. Prog. Rpt. F-63 5-4.
- Hayes W.E. and G. M. Penny. 1989 Fisheries investigations in lakes and streams – District III. SCWMRD Ann. Prog. Rpt. F-18-15: 110 pp.
- Hayes, W.E. 1994. Lake Murray Fishery Management Plan. South Carolina Wildlife Marine Resources Department. Freshwater Fisheries District.
- Heiskary and Walker. 1987. Developing Phosphorous Criteria For Minnesota Lakes. Presented at Annual Symposium of the North American Lake Management Society, Orlando, FL.
- Hendrix, M. Patrick, and Ralph Bailey. 2003. Overview of Known and Potential Cultural Resources in the Saluda Project at Lake Murray; Lexington, Newberry, Richland and Saluda Counties, South Carolina. Prepared for South Carolina Electric & Gas by Brockington and Associates, Inc., Charleston, South Carolina.
- Hibbard, J.P., Stoddard, E.F., Secor, D.T., and A.J. Dennis, 2002, “The Carolina Zone: Overview of Neoproterozoic to Early Paleozoic Peri-Gondwanan Terranes Along the Eastern Flank of the Southern Appalachians”, *Earth-Science Reviews*, Vol. 57, pp. 299-339.
- Horton, J. Wright, Jr., and Victor A. Zullo, eds. 1991. *The Geology of the Carolinas*. The University of Tennessee Press, Knoxville.
- Howard, C.S., 2004, “Progressive Folding and Deformation in the Carolina Terrane, Columbia, South Carolina”, *South Carolina Geology*, SC Department of Natural Resources, Vol. 44.
- Jeffers, R.D. 2000. The mystery of the dying eagles. *Endangered Species Bulletin* 25(5):4-5.

- Jobsis, G. J. 1991. Assessment of Tailwater Fisheries, South Carolina. Wildlife and Marine Resources Department, Columbia, SC. F-30.
- Kleinschmidt Associates, Loginetics, Inc., Paladin Water Quality Consulting, and Reservoir Environmental Management, Inc. 2003. Lower Saluda River DO Technical Study Report. Prepared for South Carolina Electric and Gas Company.
- Kleinschmidt Associates. 1998. Saluda Hydroelectric Project Turbine Venting Aeration Study 1997. Prepared for SCE&G, July 1998.
- Lansdell, Brent, and Ralph Bailey. 2003. Assessment of Known and Potential Archaeological Sites in the Saluda Dam Remediation Project at Lake Murray; Lexington, Newberry, Richland and Saluda Counties, South Carolina. Prepared for South Carolina Electric & Gas Company by Brockington and Associates, Inc., Charleston, South Carolina.
- Matmon, A., Bierman, P.R., Larsen, J., Southworth, S., Pavich, M., and M. Caffee, 2003, "Temporally and Spatially Uniform Rates of Erosion in the Southern Appalachian Great Smoky Mountains", Geology, Vol. 31, No. 2, pp. 155-158.
- Matthews, DA, S.W. Effler, C.M. Brooks-Matthews, CA Siegfried, and ME Spada. 2001. Responses of Onondaga Lake, New York, to Early Stages of Rehabilitation: Unanticipated Ecosystem Feedbacks. Water Environmental Research, Vol. 73, pp. 691-703, November/December 2001.
- May, O.D. Fisheries investigations in lakes and Streams – District III. SCWMRD Ann. Prog. Rpt. F-18-2:11 pp.
- Mead & Hunt. 2002b. Recreational Element: Initial Consultation Package. Mead & Hunt, Madison, WI. 21pp.
- Mead and Hunt. 2000. Environmental Assessment. Saluda Hydroelectric Project; FERC Project No. 516-SC.
- Mead and Hunt. 2002a. Environmental Assessment. Saluda Dam remediation Prepared for SCE&G.
- Memorandum of Agreement Between South Carolina Electric and Gas Company and the South Carolina Department of Health and Environmental Control. Lower Saluda River Flow Regime. Signed April 22, 1988.
- Niewendorp, Clark, 1996, "Fault Map of the Lake Murray Dam Spillway, Lexington County, South Carolina", South Carolina Geologic Survey Open File Report.
- Paul C Rizzo Associates, Inc., 2005, Foundation Design Basis and Geologic Mapping , Rockfill and RCC Berm, Saluda Dam Remediation Project. Prepared for SCE&G, Columbia, SC, Prepared by Paul C. Rizzo Associates, Inc., Monroeville, PA.
- REMI. 2002. Draft Lake Murray Water Quality Report. Prepared for SCE&G, April 2002.
- Richland County. 2003. Future Horizons for Richland County: Trends, Issues, and Policy Implications. 43pp.
- Ruane, RJ, and GE Hauser, 1991, Factors Affecting Dissolved Oxygen in Hydropower Reservoirs. Proceedings of the ASCE Waterpower '91 Conference, Denver, CO.
- Ruane, RJ, Reservoir Environmental Management, Inc. 2004. Draft Lake Murray CE QUAL 2E Lake Wide Water Quality Model. Prepared for SCE&G.

- Ruane, R.J., C.E. Bohac, W.M. Seawell, and R. M. Shane. 1986. Improving the downstream environment by reservoir release modifications. Reservoir fisheries management and strategies. American Fisheries Society, Southern Division, Bethesda Md. 273 p.
- Russell, K.R. and S.A. Gauthreaux, Jr. 1999. Spatial and temporal dynamics of a purple martin pre-migratory roost. *Wilson Bulletin* 111:354-362.
- Sacks, P. E. and Dennis, A. J., 1987, "The Modoc Zone - D2 (Early Alleghanian) in the Eastern Piedmont, South Carolina and Georgia", in Secor, D.T., Jr. ed., Anatomy of the Alleghanian Orogeny as Seen from the Piedmont of South Carolina and Georgia, Carolina Geological Society Field Trip Guidebook, pp. 19-34.
- SCE&G. 2002a. FERC Project 516: Project 516 Additional Information Request 5 Year Review of Land Use and Shoreline Management Plan. Exhibit AIR4-A. Submitted March 26, 2002.
- SCIway: South Carolina Information Highway. 2004. South Carolina Counties and County Resources. <http://www.sciway.net>. November 4, 2004.
- Secor, D.T., 1987, "Regional Overview", in Secor, Donald T., (editor), Anatomy of the Alleghanian Orogeny as Seen from the Piedmont of South Carolina and Georgia, Carolina Geological Society Field Trip Guidebook.
- Secor, D.T., and A.W. Snoke, 1978, "Stratigraphy, Structure, and Plutonism, in the Central South Carolina Piedmont", in Snoke, A.W., ed., Geological Investigation of the Eastern Piedmont, Southern Appalachians: Carolina Geological Society 1978 Guidebook, Division of Geology, S.C. State Development Board.
- Secor, D.T., Snoke, A.W., Bramlett, K. W., Costello, O.P., and O.P. Kimbrell, 1986, "Character of the Alleghanian Orogeny in the Southern Appalachians: Part I – "Alleghanian Deformation in the Eastern Piedmont of South Carolina", Geological Society of America Bulletin, Vol. 97, pp. 1319-1328.
- Shealy Environmental Services, Inc. 2004. Macroinvertebrate Assessment of the Saluda River. Downstream of the Lake Murray Hydroelectric Dam Operated by South Carolina Electric and Gas Company. Lexington, South Carolina. Submitted to SCE&G.
- Snoke, A.W., and Frost, B.R., 1990, "Exhumation of High Pressure Pelitic Schist, Lake Murray Spillway, South Carolina: Evidence for Crustal Extension During Alleghanian Strike-Slip Faulting", American Journal of Science, Vol. 290, pp. 853-881.
- South Carolina Association of Counties. 2004. County Profiles: Land Area and Population Density. <http://www.sccounties.org>. August 19, 2004.
- South Carolina Budget and Control Board, Office of Research and Statistics (SCBCB). 2004. South Carolina Statistical Abstract 2004. Available at: <http://www.ors2.state.sc.us/abstract/index.asp>. Last Accessed December 15, 2004.
- South Carolina Department of Natural Resources Homepage (SCDNR). 2002. South Carolina Drought News Release. <http://www.dnr.state.sc.us/climate/sco/drought/release90602.html>. 8 Oct. 2004.
- South Carolina Department of Parks Recreation and Tourism (SCDPRT). 2001. Birds of Dreher Island State Park, Newberry County, SC. Available: www.midnet.sc.edu/audubon/dreherislandweb.htm. Accessed: March 30, 2003.

- South Carolina Department of Parks, Recreation & Tourism (SCPRT). 1998. The Tourism Industry in South Carolina Annual Report.
- South Carolina Department of Parks, Recreation & Tourism (SCPRT). 2002. 2002 South Carolina State Comprehensive Outdoor Recreation Plan. Recreation, Planning & Engineering Office. 1205 Pendleton Street, Columbia, SC. 157pp.
- South Carolina Department of Parks, Recreation & Tourism (SCPRT). 2004. Domestic Visitation to South Carolina by Region. Available at: [http://www.discoverouthcarolina.com/documents/Travel to SC by Region_revised.htm](http://www.discoverouthcarolina.com/documents/Travel%20to%20SC%20by%20Region_revised.htm). Last Accessed December 15, 2004.
- South Carolina Electric and Gas Company (SCE&G). 1994. Shoreline Inventory Saluda Hydroelectric Project FERC 516 Lake Murray. Columbia, SC.
- South Carolina Electric and Gas Company (SCE&G). 1999a. Application For New License Columbia Hydroelectric Project Submitted to the Federal Energy Regulatory Commission, Columbia, SC pp. E-22.
- South Carolina Electric and Gas Company (SCE&G). 1999b. Saluda Hydroelectric Project Turbine Venting Study—1998. Prepared by Kleinschmidt Associates, Reservoir Environmental Management, Inc., and TVA. April 1999.
- South Carolina Electric and Gas Company (SCE&G). 2000. Lake Murray Shoreline Management Program. 22 pps.
- South Carolina Electric and Gas Company (SCE&G). 2002. Licensed Hydropower Development Recreation Report, FERC Form 80; Saluda Hydroelectric Project.
- South Carolina Electric and Gas Company (SCE&G). January 30, 1975. Exhibit M: Saluda Hydroelectric Project Major Equipment. Edited by Kristinia Massey on July 21, 2004 and sent to Bill Argentieri in support of the resource utilization study.
- South Carolina Office of Research and Statistics. 2004. South Carolina Community Profiles. <http://www.sccommunityprofiles.org>. November 4, 2004.
- South Carolina State Government. 2004. South Carolina State Government Office Website. <http://www.mysc.gov>. November 4, 2004.
- Stone and Webster Engineering Corporation. 1995. Sixth Periodic Safety Inspection Report. Saluda Hydroelectric Project; FERC Project No. 516-SC.
- Trinkley, Michael and Nicole Southerland. 2001. Cultural Resources Survey of the SCE&G Saluda Dam Complex. Prepared by Chicora Foundation.
- U.S. Fish and Wildlife Service, National Marine Fisheries Service and South Carolina Department of Natural Resources. 2001. Santee Cooper Diadromous Fish Passage Restoration Plan.
- U.S. Fish and Wildlife Service: Environmental Conservation Online System. 2003. Carolina Heelsplitter. http://ecos.fws.gov/docs/life_histories/F02L.html. 8 Dec. 2004.
- U.S. Geological Survey (USGS). 2001. Avian Vacuolar Myelinopathy. USGS, National Wildlife Health Center, Madison, WI. Available: www.nwhc.usgs.gov/mainavm.html. Accessed: April 5, 2003.
- United States Department of Agriculture- Soil Conservation Service (USDA). 1960. Soil Survey of Newberry County, South Carolina.

- United States Department of Agriculture- Soil Conservation Service (USDA). 1962. Soil Survey of Saluda County, South Carolina.
- United States Department of Agriculture- Soil Conservation Service (USDA). 1976. Soil Survey of Lexington County, South Carolina.
- United States Department of Agriculture- Soil Conservation Service (USDA). 1978. Soil Survey of Richland County, South Carolina.
- Vidal, O., Parra, T., and F. Trotet, 2001, "A Thermodynamic Model for Fe-Mg Aluminous Chlorite using Data from Phase Equilibrium Experiments and Natural Pelitic Assemblages in the 100° to 600°C, 1 to 25kb Range", American Journal of Science, Vol. 301, pp. 557-592.
- Whitaker, J.O., Jr. 1998. National Audubon Society Field Guide to North American Mammals. Alfred A. Knopf, New York.
- Wilde, S.B., T.M. Murphy, and C. Hope. Lake Murray Monitoring Project: 2002-2003. Report prepared by South Carolina Department of Natural Resources and University of South Carolina, Baruch Institute. 34 pp.
- Williams, V.P. 2001. Effects of Point-Source Removal on Lake Water Quality: A Case History of Lake Tohopekaliga, Florida. Lake and Reservoir Management, Vol. 17, No. 4, December 2001.

APPENDIX B

ADDITIONAL INFORMATION FOR THE SALUDA HYDROELECTRIC PROJECT

APPENDIX B: ADDITIONAL AVAILABLE STUDY REFERENCE LIST

- Adams, S. M., A. M. Brown, and R. W. Goede. 1993. A quantitative health assessment index for rapid evaluation of fish condition in the field. *Transactions of the American Fisheries Society*. 1993; 122 (1): 63-73.
- American Public Health Association, American Water Works Association and Water Pollution control Federation. 1992. *Standard methods for the examination of water and wastewater*. 18th ed. Washington, D.C.
- American Public health Association, American Water Works Association and Water Pollution Control Federation. 1995. *Standard methods for the examination of water and wastewater*. 19th edition. Washington, D.C.
- Bailey, N. M. 1975. An evaluation of striped bass introductions in the southeastern United States. *Proceedings of the southeastern association of Game and Gish Commissioners* 28: 54-68.
- Bain, M. B., J. T. Finn, and H. E. Brooke. 1988. Streamflow regulation and fish community structure. *Ecology* 69: 382-392.
- Bayne, C. 1992. *Lake Murray: Legend and Leisure*, 2nd ed. Bayne Publ. Co., Sunset, SC. 151pp.
- Beard, Hal. 1996. *Fisheries Investigations in Lakes and Streams- District VIII*. SCDNR Annual Progress Report F-63-1-8.
- Beard, Hal. 1999. *Fisheries Investigations in Lakes and Streams- District VIII*. SCDNR Study Progress Report F-49.
- Beard, Harold, Willard E. "Gene" Hayes, Gayland M. Penny. 1995. *Life History of Redear Sunfish in Lake Murray*. SCDNR Annual Progress Report F 18-21.
- Bjorgo, K. A. 1999. *Seasonal movement and habitat use of striped bass in the Combahee River, South Carolina*. Master's Thesis. Clemson University, Clemson, SC. USA.
- Boyd, C.E. 1979. *Water Quality in Warm Water Fish Ponds*. Auburn Univ. Ag. Expt. Sta. Auburn, AL. 359pp.
- Campbell, W. M. and J. M. Dean. 1976. *Environmental Inventory of Lake Murray, South Carolina*. Environ. Res. Ctr., Inc. Col., S.C.
- Carlson, R. E. 1977. A trophic state index. *Limnology and Oceanography*. 22(2): 361-369.
- Cheek, T. E., M. J. Ban Den Avyle, and C. C. Coutant. 1985. Influences of water quality on distribution of striped bass in a Tennessee river impoundment. *Transactions of the American Fisheries Society* 114:67-76.
- Coutant, C. C. 1985. Striped bass, temperature, and dissolved oxygen: A speculative hypothesis for environmental risk. *Transactions of the American Fisheries Society* 114-31-61.
- Coutant, C. C. and D. S. Carroll. 1980. Temperatures occupied by ten ultrasonic-tagged striped bass in freshwater lakes. *Transactions of the American Fisheries Society* 109: 195-202.
- Cox, J. P. 1984. *Evaluating reservoir trophic status: The TVA approach*. Lake and Reservoir Management. Proc. 3rd Annual Conference N. Am. Lake Management Society. U.S. EPA, Washington, D.C.

- Dudley, R. G., A. W. Mullis, and J. W. Terrell. 1977. Movements of adult striped bass (*Morone saxatilis*) in the Savannah River, Georgia. *Transactions of the American Fisheries Society* 106: 314-322.
- Environmental Protection Agency (EPA). 1986. Quality criteria for water 1986. Office of Water Regulations and Standards. U. S. Environmental Protection Agency. Washington, D.C.
- Environmental Protection Agency (EPA). 1990. The lake and reservoir restoration guidance manual, 2nd edition. EPA – 440/4-90-006. U.S. Environmental Protection Agency, Office of Water, Washington, D.C.
- Environmental Research Center, Inc. 1976. Environmental Inventory of Lake Murray, SC. Prepared for SCE&G.
- Fogg, G.E. 1965. Algal cultures and phytoplankton ecology. University of Wisconsin Press. Madison, WI.
- Freeman, M.C., Z. H. Bowen and J. H. Crance. 1997. Transferability of habitat suitability criteria for fishes in warmwater streams. *North American Journal of Fisheries Management*. 1997; 17(1): 20-31.
- Glysson, D. G. and T. K. Edwards. 1988. Field methods for measurement of fluvial sediment. Open-file report 86-531, United States Geological Survey, Reston, Virginia.
- Grogan, C. S. and J. Boreman. 1998. Estimating the probability that historical populations of fish species are extirpated. *North American Journal of Fisheries Management*. 1998; 18(3): 522-529.
- Hart, L. G. and R. C. Summerfelt. 1975. Surgical procedures for implanting ultrasonic transmitters into flathead catfish (*Pylodictis olivaris*). *Transactions of the American Fisheries Society* 104: 56-59.
- Hayes, W. E. 1985. Fisheries investigations in lakes and streams- District III. SCWMRD Ann. Prog. Rpt. F-18-11:39 pp.
- Hayes, W. E., G. M. Penny and H. Beard. 1995. Life history of readear sunfish in lake Murray. SCDnR Ann. Prog. Rpt. F-18-21:6-17.
- Hayes, W.E. 1986. Fisheries investigations in lakes and streams- District III. SCWMRD Ann. Prog. Rpt. F-18-12:46 pp.
- Hayes, W.E. 1987. Fisheries investigations in lakes and streams- District III. SCWMRD Ann. Prog. Rpt. F-18-13:86 pp.
- Hayes, W.E. 1988. Fisheries investigations in lakes and streams- District III. SCWMRD Ann. Prog. Rpt. F-18-14:89 pp.
- Hayes, W.E. 1990. Summer striped bass kill on Lake Murray, August 19, 1990. SCWMRD rpt. 16pp.
- Hayes, W.E. and G.M. Penny. 1990. Fisheries investigations in lakes and streams- District III. SCWMRD Study Compl. Rpt. F-18-16:110 pp.
- Hayes, W.E. and G.M. Penny. 1991. Fisheries investigations in lakes and streams- District III. SCWMRD Study Compl. Rpt. F-18-17:130 pp.

- Hayes, W.E. and G.M. Penny. 1992. Fisheries investigations in lakes and streams- District III. SCWMRD Study Compl. Rpt. F-18-18:132 pp.
- Hayes, W.E. and G.M. Penny. 1993. Fisheries investigations in lakes and streams- District III. SCWMRD Study Compl. Rpt. F-18-19:125 pp.
- Hayes, Willard, E., and Gayland M. Penny. 1994. Fisheries Investigations in Lakes and Streams- District III. SCDNR Annual Progress Report F-18-20.
- Hayes, Willard, E., and Gayland M. Penny. 1996. Life History Aspect of Redear Sunfish in Lake Murray-District III. SCDNR Job Completion Report F 63-3-3.
- Hayes, Willard, E., and Gayland M. Penny. 1999. Fisheries Investigations in Lakes and Streams- District III. SCDNR Annual Progress Report F-63-4-3.
- Hayes, Willard, E., Gayland M. Penny, and Kevin J. Roosen. 2000. Fisheries Investigations in Lakes and Streams- District III. SCDNR Annual Progress Report F-63-5-3.
- Hill, M. T., W. S. Platts, and R. L. Beschta. 1991. Ecological and geomorphological concepts for instream and out-of-channel flow requirements. *Rivers* 2: 198-210.
- Kimsey, C. D. Jr., A. C. Boozer, J. N. Knox, L. E. Turner, K. K. Cain, and G. W. Long. 1982. South Carolina Clean Lakes Classification Survey. SCDHEC Techn. Rpt. No. 019-82:202 pp.
- Kinsolving, A.D. 1989. Flow regulation and shoreline fish assemblages in two southeastern rivers. M.S. Thesis. Auburn University: Auburn, Alabama.
- Kinsolving, A.D. and M.B. Bain. 1993. Fish assemblage recovery along a riverine disturbance gradient. *Ecological Applications*, 3(3).
- Kirk, J.P. 1989. Determining the harvest potential of largemouth bass in South Carolina reservoirs. SCWMRD Compl. Rpt. F-19:28 pp.
- Lind, O.T. 1985. Handbook of common methods in limnology. 2nd Ed. Kendall/Hunt Publishing Co., Dubuque, Iowa.
- Marcus, M. 1982. An intensive water quality survey of the Little Saluda River, Saluda County, South Carolina. SCDHEC Techn. Rpt. No. 002-82. 117pp.
- May, O. D. Jr. 1960. An evaluation of stocking striped bass in reservoirs. SCWRD Comb Ann. And Quart. Prog. Rpt. F-9-R-1:12 pp.
- May, O. D., Jr. 1963. Fisheries investigations and an evaluation of stocking striped bass in reservoirs. SCWRD Comb. Ann. And Quart. Prog. Rpt. F-9-R-4:29 pp.
- May, O. D., Jr. 1964. Fisheries investigations and an evaluation of stocking striped bass in reservoirs. SCWRD Comb. Ann. And Quart. Prog. Rpt. F-9-R-5:71 pp.
- May, O. D., Jr. 1965. Fisheries investigations and an evaluation of stocking striped bass in reservoirs. SCWRD Comb. Ann. And Quart. Prog. Rpt. F-9-R-6:69 pp.
- May, O. D., Jr. 1968. Creel census in reservoirs. SCWRD Compl. Rpt. F-9-R-9;77 pp.
- May, O. D., Jr. 1970. Fisheries investigations in lakes and streams – District III. SCWMRD Ann. Prog. Rpt. F-9-11:34 pp.
- May, O. D., Jr. 1972. Fisheries investigations in lakes and streams – District III. SCWMRD Ann. Prog. Rpt. F-19-13:99 pp.

- May, O. D., Jr. 1974. Age-growth study of striped bass in lakes Greenwood and Murray. SCWMRD Ann. Prog. Rpt. F-9-15:50 pp.
- May, O. D., Jr. 1974. Fisheries investigations in lakes and streams – District III. SCWMRD Ann. Prog. Rpt. F-9-15:41 pp.
- May, O. D., Jr. 1975. Fisheries investigations in lakes and streams – District III. SCWMRD Ann. Prog. Rpt. F-18-1:10 pp.
- May, O. D., Jr. 1976. Fisheries investigations in lakes and streams – District III. SCWMRD Ann. Prog. Rpt. F-18-2:11pp.
- May, O. D., Jr. 1977. Fisheries investigations in lakes and streams – District III. SCWMRD Ann. Prog. Rpt. F-18-3:14 pp.
- May, O. D., Jr. 1978. Fisheries investigations in lakes and streams – District III. SCWMRD Ann. Prog. Rpt. F-18-4:18 pp.
- May, O. D., Jr. 1979. Fisheries investigations in lakes and streams – District III. SCWMRD Ann. Prog. Rpt. F-18-5:20 pp.
- May, O. D., Jr. 1980. Fisheries investigations in lakes and streams – District III. SCWMRD Ann. Prog. Rpt. F-18-6:18 pp.
- May, O. D., Jr. 1981. Fisheries investigations in lakes and streams – District III. SCWMRD Ann. Prog. Rpt. F-18-7:19 pp.
- May, O. D., Jr. 1982. Fisheries investigations in lakes and streams – District III. SCWMRD Ann. Prog. Rpt. F-18-8:11 pp.
- May, O. D., Jr. 1984. Tables for computing relative condition factors for South Carolina's common freshwater fishes. South Carolina Wildlife and Marine Resources Commission. Study Completion Report F-18. 45pp.
- Mayer, K. S., E. P. Multer, and R. K. Schreiber. 1984. Acid rain: effects on fish and wildlife. Fish and Wildlife leaflet 1, Fish and Wildlife Service, U. S. Department of the Interior, Washington, D.C.
- McIlvaine, C.M. 1990. A Water Quality Assessment of Lake Murray, South Carolina 1987-1988. SCDHEC Techn. Rpt. SCP 002-90:117 pp.
- Merriman, D. 1941. Studies on the striped bass of the Atlantic coast. U.S. Fish and Wildlife Service fishery bulletin 50:1-77.
- Miranda, L.E. 1999. A typology of fisheries in large reservoirs of the United States. Transactions of the North American Journal of Fisheries Society. 1985; 114(1): 77-83.
- Nestler, J. M., L. T. Schneider, D. C. Latka, and P. N. Johnson. 1995. Physical Habitat Analysis Using the Riverine community Habitat Assessment and Restoration Concept (RCHARC): Missouri river Case History. U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi. Technical Report EL-95-18.
- Palmer, C. M. 1969. A composite rating of algae tolerating organic pollution. Journal of Phycology 5:78-82.
- Pearson, J. C. 1938. The life history of the striped bass, or rockfish, *Roccus saxatilis* (Walbaum). U. S. Fish and Wildlife Service Fishery Bulletin 48:825-851.

- Penny, G.M. 1982. Life History studies of White Perch for the Period of July 1, 1979-June 30, 1982. SCWMRD Study Compl. Rpt. G-18-8:37.
- Porcella, D. B. and M. L. Cleave. 1981. The use of bioassay approaches for assessing phytoplankton growth in lakes and reservoirs. Pages 276-314 m M.W. Lorenze, ed. Phytoplankton environmental interactions in reservoirs. Technical Report E-81-13. Office, Chief of Engineers, U.S. Army, Washington, D.C.
- Raschke, R. L. and D. A. Schultz. 1987. The use of the algal growth potential test for data assessment. *Journal of Water Pollution Control Federation* 59(4): 222-227.
- Richter, B. D., J. V. Baumgartner, R. Wigington, and D. P. Braun. 1997. How much water does a river need? *Freshwater Biology* 37:231-249.
- Rosgen, D. 1996. Applied river morphology. Wildland Hydrolog, Pasosa Springs, Colorado.
- Savvyer, C. N. 1960. Chemistry for sanitary engineers. McGraw-Hill Book Co., Inc. New York, New York.
- Scheidegger, K. F. and M.B. Bain. 1995. Larval Fish distribution and microhabitat use in free-flowing and regulated rivers. *Copeia* 1995: 125-135.
- Scruggs, G. D. Jr. 1957. Reproduction of resident striped bass in Santee-Cooper Reservoir, South Carolina. *Transactions of the American Fisheries Society* 85:144-159.
- Sharpley, A. N. 1997. Dispelling common myths about phosphorous in agriculture and the environment. Technical Paper. Watershed Science Institute. U.S. Department of Agriculture, National Resources Conservation Service. NRCS-WSI, Aiken Center, SNR, University of Vermont, Burlington, Vermont.
- South Carolina Department of Health and Environmental Control. 1990. Water Classification and Standards (Reg. 61-68) and Classified Waters (Reg. 61-69)
- South Carolina Land Resources Conservation Commission. 1977. Land Use Data Analysis (LUDA) SCLRCC Techn. Rpt.
- South Carolina Land Resources Conservation Commission. 1987. Land Use Data Analysis (LUDA) SCLRCC Techn. Rpt.
- South Carolina Water Resources Commission. 1988. South Carolina Rivers Assessment. SCWRC Rpt. No. 164:249.
- South Carolina Water Resources Commission. 1991. Inventory of Lakes in South Carolina Ten Acres or More in Surface Area. SCWRC Rpt. No. 171.
- Sparks, R. E. 1995. Need for ecosystem management of large rivers and their floodplains. *BioScience* 45.
- Steeger, T. A. and H. R. Beard. 1997. Lower Saluda River recreational angler survey -April, 1996 through March 31, 1997. Interim Rpt. 68pp
- Thornton, K. W., B. L. Kimmel, and F. E. Payne (eds.). 1990. Reservoir limnology, ecological perspectives. John Wiley and Sons, Inc. New York, New York.
- Travnichek, V. H., M. B. Bain, and M. J. Maceina. 1995. Recovery of a warmwater fish assemblage after the initiation of a minimum-flow release downstream from a hydroelectric dam. *Transactions of the American Fisheries Society*. 1995; 124(6): 836-844.

- Trinkley, Michael. 2001. Cultural Resources Survey of the SCE&G Saluda Dam Complex, Lexington County, South Carolina. Prepared for SCE&G.
- U. S. Fish and Wildlife Service. 1992. Regional Wetlands Concept Plan, Southeast Region.
- Walker, W. W. 1996. simplified procedures for eutrophication assessment and prediction: User manual, Instruction Report W-96-2, U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.
- Walsh, M. G. 1999. Effects of implantation method and temperature on mortality and loss of simulated transmitters in hybrid striped bass. Master's Thesis. Clemson University, Clemson, SC. USA.
- Williams, James D., et al. 1992. conservation status of freshwater mussels of the United States and Canada. Fisheries, 18(9): 6-22. American Fisheries Society, Bethesda, Maryland.

APPENDIX C

GLOSSARY

APPENDIX C: GLOSSARY

acre-foot (feet)	The amount of water it takes to cover one acre to a depth of one foot, 43,560 cubic feet or 1,233.5 cubic meters
active storage	The volume of water in a reservoir between its minimum operating elevation and its maximum normal operating elevation.
anadromous fish	Fish that live in saltwater habitats most of their lives, but periodically migrate into freshwater to spawn and develop to the juvenile stage (e.g., alewife).
anticline	a fold with strata sloping downward on either side
aquatic life	Any plants or animals which live at least part of their life cycle in water.
argillic horizon baseline	the horizon of clay accumulation shows evidence of clay illuvation A set of existing environmental conditions upon which comparisons are made during the NEPA process.
benthic	Associated with lake or river bottom or substrate.
benthic macroinvertebrates	Animals without backbones, which are visible to the eye and which live on, under, and around rocks and sediment on the bottoms of lakes, rivers, and streams.
bypass reach	The original water channel of the river that is directly affected by the diversion of water through the penstocks to the generating facilities. This portion of the river, the "bypassed reach" may remain watered or become dewatered.
capacity	The load for which an electric generating unit, other electrical equipment or power line is rated.
Clean Water Act (CWA)	The Federal Water Pollution Control Act of 1972 and subsequent amendments in 1977, 1981, and 1987 (commonly referred to as the Clean Water Act). The Act established a regulatory system for navigable waters in the United States, whether on public or private land. The Act set national policy to eliminate discharge of water pollutants into navigable waters, to regulate discharge of toxic pollutants, and to prohibit discharge of pollutants from point source without permits. Most importantly it authorized EPA to set water quality criteria for states to use to establish water quality standards.
creel census	Counting and interviewing anglers to determine fishing effort and catch. Usually conducted by a census clerk on systematic regularly scheduled visits to significant fishing areas.
cubic feet per second (cfs)	A measurement of water flow representing one cubic foot of water moving past a given point in one second. One cfs is equal to 0.0283 cubic meters per second and 0.646 mgd.
cultural resources	Includes items, structures, etc. of historical, archaeological, or architectural significance.

dam	A structure constructed across a water body typically used to increase the hydraulic head at hydroelectric generating units. A dam typically reduces the velocity of water in a particular river segment and increases the depth of water by forming an impoundment behind the dam. It also generally serves as a water control structure.
demand	The rate at which electric energy is delivered to or by a system at a given instant or averaged over a designated period, usually expressed in kilowatts or megawatts.
diabase	dark, fine-textured, igneous rock
dike	A raised bank, typically earthen, constructed along a waterway to impound the water and to prevent flooding.
dissolved oxygen (DO)	Perhaps the most commonly employed measure of water quality. Low DO levels adversely affect fish and other aquatic life. The total absence of DO leads to the development of an anaerobic condition with the eventual development of odor and aesthetic problems.
distribution lines	Power lines, like those in neighborhoods, used to carry moderate voltage electricity which is "stepped down" to household levels by transformers on power poles.
drawdown	The distance the water surface of a reservoir is lowered from a given elevation as the result of releasing water.
energy	Average power production over a stated interval of time, expressed in kilowatt-hours, megawatt-hours, average kilowatts and average megawatts.
Eutrophic/eutrophication	Waters with a high concentration of nutrients and a high level of primary production.
Exotic species	Those species which are not native to a particular area
fault	A crack or fracture in the earth's surface
Federal Energy Regulatory Commission	The governing federal agency responsible for overseeing the licensing/relicensing and operation of hydroelectric projects in the United States.
Federal Power Commission (FPC)	Predecessor of FERC
flow	The volume of water passing a given point per unit time.
flow duration curve	A graphical representation of the percentage of time in the historical record that a flow of any given magnitude has been equaled or exceeded.
forebay	That portion of a hydroelectric project impoundment immediately upstream of the intake to the turbines (see also headwaters).
generation	The process of producing electricity from other forms of energy, such as steam, heat, or water. Refers to the amount of electric energy produced, expressed in kilowatt hours.

gross storage	The sum of the dead storage and the live storage volumes of a reservoir, the total amount of water contained in a reservoir at its maximum normal operating elevation.
habitat	The locality or external environment in which a plant or animal normally lives and grows.
head	The distance that water falls in passing through a hydraulic structure or device such as a hydroelectric plant. Gross head is the difference between the headwater and tailwater levels; net head is the gross head minus hydraulic losses such as friction incurred as water passes through the structure; and rated head is the head at which the full-gate discharge of a turbine will produce the rated capacity of the connected generator.
headwater	The waters immediately upstream of a dam. For power dams, also referred to as the water in the impoundment which supplies the turbines (see also forebay).
hydraulic	Relating to water in motion.
hydroelectric plant	A facility at which the turbine generators are driven by falling water.
hydroelectric power	Capturing flowing water to produce electrical energy.
hydroelectric project	The complete development of a hydroelectric power site, including dams, reservoirs, transmission lines, and accessories needed for the maintenance and operation of the powerhouse and any other hydroelectric plant support facilities.
hypolimnetic	The deeper cooler portions of a reservoir or lake that result from stratification.
igneous rock	Rock formed from the cooling and solidification of molten mineral matter.
impoundment	The body of water created by a dam.
Initial Consultation Document (ICD)	A document containing detailed information on a hydroelectric project; the document is used to describe the project and its resources and to start the applicant's consultation process with resource agencies and the public.
kilowatt (kW)	A unit of electrical power equal to 1,000 watts.
lacustrine	Related to standing water, (e.g., a lake).
lapilli	Small, round to angular rock fragments which may have been volcanically ejected in a solid or molten state.
license	FERC authorization to construct a new project or continue operating an existing project. The license contains the operating conditions for a term of 30 to 50 years.
littoral	Associated with shallow (shoreline area) water (e.g., the littoral zone of an impoundment).
load	The total customer demand for electric service at any given time.

lotic	Flowing or actively moving water including rivers and streams.
megawatt (MW)	A unit of electrical power equal to one million watts or 1,000 kW.
metamorphic rock	Rock formed by alterations of igneous and sedimentary rocks under intense heat and pressure.
normal operating conditions	The reservoir elevation approximating an average surface elevation at which a reservoir is kept.
outage	The period during which a generating unit, transmission line, or other facility is out of service.
palustrine forested wetland	Dominated by woody vegetation less than 20 ft tall (i.e., willows, dogwood)
palustrine scrub/shrub wetlands	Comprised of woody vegetation that is 20 ft tall or greater (i.e., American elm, swamp white oak).
peaking operations pegmatite	A powerplant that is scheduled to operate during peak energy demand. coarse-grained granite
phytoplankton	Algae floating in the water column. These are mostly microscopic single-celled and colonial forms.
piezometer	A device that measures water pressure.
plutonic structures	large igneous intrusions that are formed deep within the earth's crust
Pool	Refers to the reservoir (impounded body of water).
powerhouse	The building that typically houses electric generating equipment.
Probable Maximum Flood (PMF)	A statistical formula used to calculate a hypothetical flood event that could occur on a particular river basin over a particular duration. This is derived from the probable maximum precipitation over time.
project	One or more hydroelectric plants collectively included in a single Federal Energy Regulatory Commission license. Projects typically consist of a dam, reservoir, powerhouse and appurtenant facilities.
Project area	SCE&G lands and waters within the project boundary.
project boundary	A line established by the FERC to enclose the lands, waters and structures needed to operate a licensed hydroelectric project.
Project vicinity	Lands and waters within which studies were conducted for baseline environmental data. These lands and waters include the Project area.
recreation area	A formal or informal area which people use for leisure activities.
relicensing	The administrative proceeding in which FERC, in consultation with other federal and state agencies, decide whether and on what terms to issue a new license for an existing hydroelectric project at the expiration of the original license.

reserve capacity	Extra generating capacity available to meet unanticipated demand for power or to generate power in the event of loss of generation.
reservoir	An artificial lake into which water flows and is stored for future use.
resident fishery	Fish that spend their entire life cycle in freshwater, such as trout and bass.
resource agencies	Federal, state, or interstate agency with responsibilities in the areas of flood control, navigation, irrigation, recreation, fish or wildlife, water resource management, or cultural or other relevant resources of the state in which a project is or will be located.
riparian area	A specialized form of wetland with characteristic vegetation restricted to areas along, adjacent to or contiguous with rivers and streams. Also, periodically flooded lake and reservoir shore areas, as well as lakes with stable water.
seepage	The amount of water that leaks through a structure, such as a dam.
spawn	The act of fish releasing and fertilizing eggs.
spillway	The section of a dam that is designed to pass water over or through it.
stakeholder	any individual or organization (government or non-governmental) with an interest in a hydroelectric project
stock	The existing density of a particular species of fish in an aquatic system.
stratification	A physical and chemical process that results in the formation of distinct layers of water within a lake or reservoir (i.e., epilimnion, metalimnion, and hypolimnion).
streamflow	The rate at which water passes a given point in a stream, usually expressed in cubic feet per second (cfs).
submerged aquatic vegetation	Plants with rigid stems and/or leaves rooted in substrate and generally covered by deep water (greater than 6.6 ft depth), with all of the plant parts covered by water.
synclinal fold axis	a fold in rocks layers, where rock from both sides dips inward towards a center axis
tailrace	The channel located between a hydroelectric powerhouse and the river into which the water is discharged after passing through the turbines.
tailwater	The waters immediately downstream of a dam. For power dams, also referred to as the water discharged from the draft tubes.
tainter gates	A gate with a curved skin or face plate connected with steel arms to an axle. It is usually lifted or lowered by a cable connected to a hook at the top of the gate rotating on the axle as it is moved.
transformer	Equipment vital to the transmission and distribution of electricity designed to increase or decrease voltage.
transmission	The act or process of transporting electric energy in bulk from one point to another in the power system, rather than to individual customers.

transmission lines	Power lines normally used to carry high voltage electricity to substations which then is "stepped down" for distribution to individual customers.
tuff	Rock formed of pyroclastic material.
turbidity	A measure of the extent to which light passing through water is reduced due to suspended materials.
turbine	A machine for generating rotary mechanical power from the energy in a stream of fluid (such as water, steam, or hot gas). Turbines covert the energy of fluids to mechanical energy through the principles of impulse and reaction, or a mixture of the two.
volt	The unit of electromotive force or electric pressure, akin to water pressure in pounds per square inch.
warmwater fish	Species tolerant of warm water (e.g., bass, perch, pickerel, sucker).
watershed	An entire drainage basin including all living and nonliving components of the system.
wetlands	Lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. Wetlands must have the following three attributes: 1) at least periodically, the land supports predominantly hydrophytes; 2) the substrate is predominantly undrained hydric soil; 3) the substrate is on soil and is saturated with water or covered by shallow water at some time during the growing season of each year.

APPENDIX D
SERVICE LIST

APPENDIX D: SERVICE LIST

Office of Project Review
Advisory Council on Historic Pres.
The Old Post Office Building
1100 Pennsylvania Ave NW Ste 809
Washington, DC 20004-2501

Julie A Gantenbein , Staff Attorney
Natural Heritage Institute
2104 Shattuck Avenue
Berkeley, CA 94704

Executive Director
Appalachian Council Of Governments
PO Box 6668
Greenville, SC 29606-6668

James S Meggs, Esquire
City of Columbia, South Carolina
PO Box 667
Columbia, SC 29202-0667

Robin Carter, President
Columbia Audubon Society
4165 E Buchanan Dr
Columbia, SC 29206-2846

Gregory L Hogue, Acting Reg. Env.
Officer
Department of the Interior
75 Spring St SW
Room 1144
Atlanta, GA 30303-3309

Dick Christie
South Carolina Department of Natural
Resources
1771-C Hwy 521
Bypass S.
Lancaster, SC 29720

Richard Roos-Collins, Senior Attorney
Natural Heritage Institute
2140 Shattuck Ave Fl 5
Berkeley, CA 94704-1210

Kevin R Colburn
Eastern Conservation Associate
American Whitewater
20 Battery Park Ave Ste 302
Asheville, NC 28801-2879

James Kardatske
Bureau of Indian Affairs
711 Stewarts Ferry Pike
Nashville, TN 37214-2751

Parkin Hunter
Columbia Audubon Society
PO Box 5923
Columbia, SC 29250-5923

Frances E Francis, Esquire
Spiegel & McDiarmid
1333 New Hampshire Ave NW
Washington, DC 20036-1511

Jerry Gotzmer, Regional Engineer
Federal Energy Regulatory Commission
Atlanta Regional Office
3125 Presidential Pkwy Ste 300
Atlanta, GA 30340-3700

Charles G Ditmer, President
Hawleek Creek Homeowners Association
108 Robbie Rd
Lexington, SC 29073-7814

Dan Wojoski, President
Hawley Creek Homeowners Association
PO Box 876
Chapin, SC 29036-0876

Mr. Prescott Brownell
National Marine Fisheries Service
Habitat Conservation Division
Charleston Area Office
219 Fort Johnson Road
Charleston, SC 29412-9110

Publisher – Editor
IRMO News
PO Box 175
Irmo, SC 29063-0175

Bob Keener
Lake Murray Association
151 Heron Ln
Gilbert, SC 29054-9749

Steve Bell, President
Lake Watch
2116 Kennedy St
Columbia, SC 29205-4350

Publisher - Editor
Lake Murray News
PO Box 175
Irmo, SC 29063-0175

James Leslie Jr.
PO Box 327
Irmo, SC 29063-0327

Mary T Kelly, Ph.D, Consultant
League of Women Voters - Columbia Area
PO Box 12541
Columbia, SC 29211-2541

National Marine Fisheries Service
Southeast Regional Office
9721 Executive Center Dr N
Saint Petersburg, FL 33702-2449

Murray Point Homeowners
111 Murray Point Ln
Chapin, SC 29036-7842

Jeffrey R Duncan, Regional Rivers
Program Manager
National Park Service
175 Hamm Rd. Suite C
Chattanooga, TN 37405

Chief
National Oceanic & Atmospheric Admin.
14th & Constitution Ave N. W. RM. 6117
Ecology and Conservation Office – HCHB SP
Washington, DC 20230-0001

Chairman
County of Newberry
PO Box 156
Newberry, SC 29108-0156

Mary Roundtree
National Park Service
Southeast Regional Office, Atlanta Federal
Center
1924 Building 100-Alabama St. SW
Atlanta, GA 30303

Malcolm Leaphart, Chair
SC Council Trout Unlimited
115 Conrad Cir
Columbia, SC 29212-2619

Steven M Bradley P.E., Acting Director
SC Dept. of Health & Environmental Cntl
Dam Safety
2600 Bull St
Columbia, SC 29201-1708

Jonathan Leader, State Archaeologist
SC Institute of Archaeology and
Anthropology
1321 Pendleton Street - USC
Columbia, SC 29208-0001

Mr. Gerrit Jobsis
South Carolina Coastal Conservation League
1207 Lincoln Street, Suite 203-C
Columbia, SC 29201

Chairman
South Carolina Council for Economic
Development
1201 Main St Ste 1600
Columbia, SC 29201-3261

Bernard Q Epps, Program Manager
South Carolina Department of Health and
Environmental Control
2600 Bull St.
Columbia, SC 29201

Gina Kirkland
South Carolina Department of Health and
Environmental Control
2600 Bull St.
Columbia, SC 29201

Tony Bebber
South Carolina Department of Parks,
Recreation and Tourism
1205 Pendleton St
Columbia, SC 29201-3731

Ms. Mary Edmonds, SHPO Director
South Carolina Department of Archives &
History
8301 Parklane Rd
Columbia, SC 29223-4905

Mr. Leonard B. Sossamon, Administrator
Newberry County, South Carolina
1309 College Street
P.O. Box 156
Newberry, SC 29108

Buford S. Mabry, Jr., Chief Counsel
Office of Attorney General
1000 Assembly St Ste 337
PO Box 167
Columbia, SC 29202-0167

John E Frampton
South Carolina Dept of Natural Resources
PO Box 167
Columbia, SC 29202-0167

B. J. Willoughby, General Counsel
South Carolina Department of Parks,
Recreation and Tourism
1205 Pendleton St
Columbia, SC 29201-3731

Director
South Carolina Department of Parks,
Recreation and Tourism
1205 Pendleton St
Columbia, SC 29201-3731

Sally C. Knowles, Director
South Carolina Department of Health and
Environmental Control
2600 Bull St
Columbia, SC 29201-1708

Randolph R Mahan
South Carolina Electric & Gas Company
Columbia, SC 29218-0001

Alton Boozer, Chairman
South Carolina Department of Health and
Environmental Control
2600 Bull St
Columbia, SC 29201-1708

Neville O. Lorick, President
South Carolina Electric & Gas Company
1426 Main St.
Columbia, SC 29201

State Forester
South Carolina Forestry Commission
PO Box 21707
Columbia, SC 29221-1707

The Honorable Charles L.A. Terreni
Chief Clerk & Administrator
Public Service Commission of South
Carolina
101 Executive Center Drive
Columbia, South Carolina 29210

State Conservationist
US Soil Conservation Service
Room 950
1835 Assembly St,
Columbia, SC 29201-2430

Southeast Office Director
U.S. National Park Service
US Department of the Interior
100 Alabama St SW
Atlanta, GA 30303-8701

Sam D Hamilton, Regional Director
US Fish and Wildlife Service
1875 Century Blvd NE
Atlanta, GA 30345-3319

Commander
US Army Corps of Engineers
S. Atlantic Div. – Attn: CESAD-ET-CO-H
60 Forsyth St SW Rm 9M15
Atlanta, GA 30303-8801

Tommy Boozer
Land Management
South Carolina Electric & Gas Company
Columbia, SC 29218-0001

Beth W. Trump, Coordinator
South Carolina Electric & Gas Company
Columbia, SC 29218

Office Director
South Carolina Office of Ocean and Coastal
Resource Management
1362 McMillan Ave Ste 400
Charleston, SC 29405-2035

Mitch Perkins, Director
South Carolina State Energy Office
1201 Main St, Suite 820
Columbia, SC 29201-3200

Larry Craft , President
Trout Unlimited, Saluda River Chapter
1524 Alpine Dr
West Columbia, SC 29169-6006

Courtney Taylor
United States Department of Interior
1849 C St NW # MS6546
Washington, DC 20240-0001

Development Director
Savannah Council of Governments
PO Box 1366
Greenwood, SC 29648-1366

Mr. William A. Brooks, Administrator
Lexington County, South Carolina
212 South Lake Drive
Lexington, SC 29072

Franklin Keel, Regional Director
Bureau of Indian Affairs
Eastern Region
711 Stewarts Ferry Pike
Nashville, TN 37214

Diana Weigmann, Program Manager
US Bureau of Indian Affairs
1849 C St NW
MS 3061 MIB
Washington, DC 20240-0001

Field Manager
US Bureau of Land Management
626 E Wisconsin Ave, Ste 200
Milwaukee, WI 53202-4618

Commanding Officer
US Coast Guard
MSO Charleston
196 Trade St
Charleston, SC 29401-1800

Commissioner
US Department of Agriculture
PO Box 11280
Columbia, SC 29211-1280

Bureau of Indian Affairs
Eastern Region
3701 North Fairfax Drive
MS: 260-VASQ
Arlington, VA 22203

Cynthia Bohn
US Fish and Wildlife Service
Ecological Services
1875 Century Blvd NE Ste 200
Atlanta, GA 30345-3319

John H. Harrington, Solicitor
US Department of the Interior
Russell Federal Building
75 Spring St SW Ste 304
Atlanta, GA 30303-3311

Horace CG. Clark, Regional Solicitor
US Department of the Interior
75 Spring St SW Ste 304
Atlanta, GA 30303-3311

Susan Cielinski
Fish and Wildlife Service
1875 Century Blvd NE Ste 200
Atlanta, GA 30345-3319

Kevin Tanaka
US Department of the Interior
1849 C Street NW, MS 6210
Washington, DC 20240-0001

Manager
US Department of Transportation
2100 2ND ST, SW
U.S. Coast Guard
Washington, DC GM2

Amanda Hill
US Fish and Wildlife Service
176 Croghan Spur Road,
Suite 200
Charleston, SC 29407

Diana M. Woods
US Environmental Protection Agency
61 Forsyth St Fl 13
Atlanta, GA 30303-8931

Tim Hall
US Fish and Wildlife Service
176 Croghan Spur Road,
Suite 200
Charleston, SC 29407

Regional Forester
US Forest Service
U.S. Department of Agriculture
1720 Peachtree St NW Ste 800
Atlanta, GA 30309-2449

The Honorable James E. Clyburn
United States House of Representatives
2135 Rayburn House Office Building
Washington, D.C. 20515-4006

The Honorable John M. Spratt, Jr.
United States House of Representatives
1401 Longworth House Office Building
Washington, D.C. 20515-4005

Brian McManus
Jones Day
51 Louisiana Street
Washington DC 20001

The Honorable Gresham Barrett
United States House of Representatives
1523 Longworth House Office Building
Washington, D.C. 20515-4003

The Honorable Jim Demint
United States Senate
290 Russell Senate Office Building
Washington, DC 20510

Alan W. Stuart
Senior Licensing Coordinator
Kleinschmidt, Energy and Water Resource
Consultants
101 Trade Zone Drive Suite 21A
West Columbia, SC 29170

Ted Cooney, District Chief
US Geological Survey
720 Gracern Rd, Ste 129
Columbia, SC 29210-7658

The Honorable Joe Wilson
US House of Representatives
212 Cannon
Washington, D.C. 20515

The Honorable Henry E. Brown, Jr.
United States House of Representatives
1124 Longworth House Office Building
Washington, D.C. 20515-4001

Thomas Eppink
South Carolina Electric & Gas Company
Columbia, SC 29218-0001

The Honorable Lindsey Graham
United States Senate
290 Russell Senate Office Building
Washington, D.C. 20510-4001

Martha C. Bogle, Superintendent
US Department of the Interior
National Park Service
Congaree National Park
100 National Park Road
Hopkins, SC 29061

Lee Barber
Lake Murray Association
306 Basing House Rd
Columbia, SC 29212

Richard Kidder, President
Lake Murray Association
1400 Camping Rd
Gilbert, SC 29054

Roy Parker, Environmental Chair
Lake Murray Association
118 Beechcreek Court
Lexington, SC 29072

Aleda Anderson, Recording Secretary
Lake Murray Association
8 Scott Branch Rd
Chapin, SC 29036-8966

Dr. Dwayne Porter
Norman J. Arnold School of Public Health
and the Baruch Institute
University of South Carolina
Columbia, SC 29208

Joy Downs, Exec Director & Secretary
Lake Murray Association
PO Box 444
Ballentine, SC 29002

Phil Gaines, Assistant Director
State Park Service
South Carolina Department of Parks,
Recreation
and Tourism
1205 Pendleton Street
Columbia, SC 29201

Dr. Wenonah G. Haire, Tribal Historic
Preservation Officer
The Catawba Indian Nation
PO Box 750
Rock Hill, SC 29731

Mr. Irvin Pitts, Biologist
South Carolina Department of Parks,
Recreation
and Tourism
1205 Pendleton Street
Columbia, SC 29201

Russell Townsend, Tribal Historic Preservation
Officer
Eastern Band of Cherokee
PO Box 455
Cherokee, NC 28719

Mr. T. Cary McSwain, County
Administrator
Richland County, South Carolina
2020 Hampton Street
Columbia, SC 29204

Tim Flach
The State
P.O. Box 1333
Columbia, SC 29202

Ms. Sandra Padget, Director
Saluda County, South Carolina
700 W. Highland Street
Saluda, SC 29138

The Honorable Avery B. Wilkerson, Mayor
City of Cayce
1800 12th Street Ext.
P.O. Box 2004
Cayce, SC 29171-2004

The Honorable James E. Wiszowaty,
Mayor
Town of Batesburg-Leesville
244 West Columbia Avenue
P.O. Box 2329
Batesburg-Leesville, SC 29070-2329

Mr. Mark Williams, City Administrator
City of Forest Acres
5205 N. Trenholm Road
P.O. Box 6587
Forest Acres, SC 29206-6587

The Honorable Robert D. Coble, Mayor
City of Columbia
1737 Main Street
P.O. Box 147
Columbia, SC 29217-0147

The Honorable T. Randall Halfacre, Mayor
Town of Lexington
111 Maiden Lane
P.O. Box 397
Lexington, SC 29072

The Honorable John L. Gibbons, Mayor
Town of Irmo
7300 Woodrow Street
P.O. Box 406
Irmo, SC 29063-0406

The Honorable Amelia Herlong, Mayor
Town of Saluda
100 South Jefferson Street
Saluda, SC 29138-1633

The Honorable T. Edward Kyzer, Mayor
City of Newberry
1330 College Street
P.O. Box 538
Newberry, 29108-0538

Mr. James P. Black
111 Law Range
Saluda, SC 29138

The Honorable Bobby Horton, Mayor
City of West Columbia
200 N. 12th Street
P.O. Box 4044
West Columbia, SC 29169

Mr. Charles Rentz
215 Scooter Bridge Road
Batesburg, SC 29006

Mr. William Ellis
744 Gold Nugget Pt
Prosperity, SC 29127-9432

Mr. Henry Black
2713 Highway 194
Prosperity, SC 29127

Mr. Robert Anderson
127 Saluda Shores Cir
Leesville, SC 29070-7235

Mr. Tom Shealy
274 Bedford Way
Prosperity SC 29127

Mr. Steven G. Davis
10 Vera Circle
Columbia, SC 29204

Ms. Teresa Powers
Newberry County
PO Box 381
Newberry, SC 29638

Ms. Fran Merchant
2619 St Lukes Church Rd.
Prosperity, SC 29127

Mr. Yoder Bedenbaugh
1605 Harrington St
Newberry, SC 29108

Mr. Joseph Boozer
251 Holland Boozer Rd
Prosperity, SC 29127

Mr. Ronald R. Boozer
360 Holland Boozer Rd.
Prosperity, SC 29127

Mr. Clint Shealy
400 Barbaras Way
Little Mountain, SC 29075

Mr. Tom Brooks
Newberry County Flood Mgt. Dept.
1226 College Street
Newberry, SC 29108

Mr. Ron Ahle
South Carolina Department of Natural
Resources
P O Box 167
Columbia, SC 29202

Mr. George Duke
637 Webster Pt
Chapin, SC 29036-7623

Mr. Michael T. Dawson
The River Alliance
506 Gervais St.
Columbia, SC 29201

Ms. Kirsten Lackstrom
6 Williamstown Ct.
Columbia, SC 29212

Mr. Tom Ruple
102 Lake Estates Ct
Irmo, SC 29063

Mr. Robert Seibels
Riverbanks Zoo and Garden
7419 Broad River Rd
Columbia, SC 29063-9667

Ms. Ann B. Dawson
1136 Statler Rd
Columbia, SC 29210

Ms. Kim Westburg
Saluda Economic Development
111 Law Range
Saluda, SC 29138

Mr. Tim Burgess
Milmont Shores Rd Assoc.
308 Milmont Shores Rd
Chapin, SC 29036

Mr. Jim Black
207 Archers Ct
Columbia, SC 29212

Mr. Joseph C. Barrett
332 Flicker Ln.
Chapin, SC 29036

Mr. Patrick Moore
South Carolina Coastal Conservation League
1207 Lincoln St. Suite 203-C
Columbia SC 29201

Mr. Thomas Rawl
1347 Counts Ferry Rd
Lexington, SC 29072

Mr. Curtis Hipp
Lake Murray Association
210 Oak Lane
Cayce, SC 29033

Mr. Randy Snow
125 Cobblestone Ct.
Chapin, SC 29036

Mr. Raymond Clepper
208 Rucker Rd
Chapin, SC 29036

Mr. Woody Ford
Saluda River TU
1813 Terrace View Drive
West Columbia, SC 29169

Mr. Richard Connor
138 Old Orchard Rd
Gilbert, SC 29054

Ms. Charlene Coleman
Am. Whitewater
3351 Makeway Drive
Columbia, SC 29201

Joy Downs, Exec Director & Secretary
Lake Murray Association
PO Box 495
Ballentine, SC 29002
(Hard copy only)

Mr. Archie Trawick Jr.
220 Jakes Landing Rd
Lexington, SC 29072-9690

Kenneth G. Fox
355 Prices Bridge Rd
Leesville, SC 29070

APPENDIX E
LAKE MURRAY WATER QUALITY REPORT

**South Carolina Electric & Gas
Columbia, South Carolina**

**Saluda Project (FERC No. 516)
Lake Murray Water Quality Report**

1.0 BACKGROUND

1.1 FERC Relicensing

The Saluda Hydroelectric Project (Saluda Project) is a federally licensed hydroelectric project located on the Saluda River in Lexington County, South Carolina. The Saluda Project is owned and operated by South Carolina Electric & Gas Company (SCE&G) and licensed by the *Federal Energy Regulatory Commission* (FERC) as Project No. 516 and is due to expire in 2010. As part of the relicensing process, SCE&G has contracted with Reservoir Environmental Management, Inc. (REMI) to consolidate current and historical water quality information for the Saluda Project and the Saluda River immediately downstream of the Project. This report presents this consolidated water quality information to be used as part of the relicensing process for the Saluda Project.

1.2 Water Quality Data Available

A considerable amount of water quality information has been collected on Lake Murray over the last six decades. The first data were collected in 1947 and these early efforts continued up to the early 1970's by the South Carolina Pollution Control Authority, the South Carolina Department of Health and Environmental Control (SCDHEC), and the U.S. Geological Survey (USGS). In 1974, the Environmental Protection Agency (EPA) included Lake Murray in its National Eutrophication Survey under which data were collected from significant reservoirs and lakes located all over the United States. As part of the relicensing process for the current FERC license for operating The Saluda Project, SCE&G contracted with ERC, Inc., to conduct a comprehensive assessment of Lake Murray in 1974 and 1975. The SCDHEC has monitored the lake and its inflowing waters monthly since about 1973 and continues to the present time. SCE&G in cooperation with USGS collected data on Lake Murray

during the period 1990-1996. SCE&G has continued to monitor water quality on the lake since 1996.

Maps of the study area are presented in Figures 1 through 5. The main body of Lake Murray is presented in Figure 1. The dark blue lines on the map represents the original river channel for the Saluda River as well as the major creeks, and the number of Saluda River miles upstream from the *dam* are indicated on the map. The sampling locations for the SCDHEC and SCE&G are also shown on the maps. Figure 2 shows the upper portion of Lake Murray as well as the inflow region where the Bush and Little Rivers enter the lake and the Saluda River up to Chappells. Figure 3 shows the Little Saluda River watershed and embayment. Figure 4 shows the area above Chappells, and Figure 5 shows the upper portions of the watersheds for the Bush and Little Rivers.

Pertinent characteristics of Lake Murray are presented in Table 1. The reservoir has a maximum depth of 175 feet. The lake is approximately 40 miles long and has a maximum width of 14 miles. The shoreline length is 524 miles, with 330 miles developed for residential use. The shoreline development ratio is 17.7 which means that the lake has 17.7 times the shoreline length that would exist if the lake were circular. Therefore, processes related to the lake margin (e.g., shoreline development, recreational development, and housing development) can be expected to be significant.

Hydrology of the watershed flows is presented in Table 2 and shows the percent distribution of flows from the various sub-basins. It is interesting to note that ERC reported that 56% of inflow enters during the first four months of the year. Annual flows into Lake Murray vary year to year and can affect water quality significantly. Figure 6 presents the annual and summer month flows at Chappells, which is downstream from Greenwood Hydro.

1.3 Important Issues for Lake Murray

The most important water quality parameters are those that might affect the water uses of Lake Murray, i.e., recreation, fishing, drinking water supply, and aesthetics. The following water quality parameters are considered to be the most important. The most

important factors that affect these parameters are major sources of wastewater discharges in the watershed and other watershed activities.

- Pathogens are organisms in water that cause diseases in people and are always a concern of those who use water in the natural environment, especially those who are in direct “full-body” contact with the water.
- Temperature and DO are two parameters which are perhaps the most important indicators of the fundamental characteristics of water quality in reservoirs. Temperature affects the physical structure of the reservoir by causing summer thermal stratification which essentially causes the lake to set up in three layers of water: the surface layer, or epilimnion; the bottom layer, or hypolimnion; and the middle layer, or metalimnion. These three layers do not mix with one another, so the surface layer is the only layer that is contact with the atmosphere and sunlight. The surface layer usually has sufficient dissolved oxygen concentration (DO); however, the other two layers usually suffer DO depletion due to inadequate re-aeration. Both temperature and DO significantly affect the fishery that occurs in the reservoir.
- Nutrients also influence the water quality in reservoirs. The primary nutrients required for growth of algae and aquatic plants include carbon, nitrogen, and phosphorus. Phosphorus and nitrogen are usually the most important water quality constituents that control the growth of algae and aquatic plants. The concentrations of phosphorus and nitrogen are most often evaluated for lake eutrophication assessments. Attached aquatic plants are also significantly affected by reservoir pool level operations (i.e., wide variations in pool levels reduce the amount of attached aquatic plants in reservoirs).
- Chlorophyll *a* is a water quality measurement that indicates the amount of lake productivity due to algae that occurs in the water.
- Water Clarity is one of the most important water quality parameters to essentially all users of the lake. The measurement of water clarity is also a key indicator of the levels of algae and suspended solids (usually clay particles) in the water.

2.0 WATER QUALITY DATABASE & ANALYSIS

2.1 Sources of Information

Data from three agencies and SCE&G were consolidated into a database for Lake Murray and its drainage area up to Greenwood Reservoir. The primary source of data used to evaluate trends was from the SCDHEC stations. These data provided monthly, quarterly and yearly measurements of many parameters collected throughout the Lake Murray watershed. The data density in the SCDHEC database is relatively consistent from 1974 to 1998. At the time of this report, SCDHEC data collected after 1998 had not been released, and therefore was not used in this assessment.

The other two agencies that collected water quality data in the Lake Murray watershed were EPA and USGS. EPA collected samples at 7 different locations in March, July and September of 1973. USGS collected data in the 1960s and early 1970 at multiple stations in the watershed.

In 1996 SCE&G took over thirteen USGS water quality sampling stations. Twelve of these stations are located in Lake Murray and one is downstream from the Saluda Dam. SCE&G collects monthly field samples at all the stations, and chemical samples twice a year at seven of the stations.

Table 3 is a general summary of the type and location of the data collected since 1970. The stations in the table are grouped and organized by distance from the Saluda Dam.

2.2 Description of DASLER (Data Management and Analysis System for Lakes, Estuaries, and Rivers)

The DASLER software program was used to build the water quality database. DASLER is a Windows-based program designed to manage and report water quality data. It serves as an interface to database programs such as Microsoft Access and Oracle. DASLER was chosen for building the database because it dictates a strict format for the data, as well as, the metadata. If this format is not followed, DASLER will not accept the data and therefore not include it in the database. This non-imported data can then be

corrected and re-entered. This characteristic of DASLER greatly improves the quality of the database and therefore creates a valuable and user-friendly resource.

The Lake Murray database is designed to include all field water quality data, as well as, nutrient, organic, metals and bacteriological data collected in the Lake Murray watershed. Pesticide and other toxic data were not imported into the database, but in many cases were downloaded from STORET and are available in Excel spreadsheets. Table 4 lists and describes the location of all stations that have data in the database. A description of the ID code is at the top of the table. Table 5 provides an overview of data density throughout the Lake Murray watershed. All results in the database were counted without regard for parameter or depth. In other words, lake stations where data was collected at multiple depths will have a larger number than a station where only the surface was sampled even though the stations may have been monitored the same number of times. This table is intended to be used as a quick reference of how much data were collected at each station in each year. Both tables are sorted in the same order and therefore allow easy cross-referencing.

2.3 Types of Analysis Used to Compile the Data

Various types of plots were used to aid in the water quality assessment of Lake Murray. For lake stations with adequate data, contour plots of dissolved oxygen and temperature data were created. These contour plots were prepared for both longitudinal plots across multiple stations as well as across time at the same station and were used to determine water quality patterns over space and time. Time series plots of many different parameters were done for all stations of interest. These plots show all surface samples of a particular parameter for the period of record.

Daily flow data from USGS gages in the watershed including below the Saluda Dam were also analyzed. Daily flow values were averaged for each year, as well as for certain parts of each year such as May through September. Data from the gage at Chappells from 1930 to 1998 were plotted. Since the gage at Chappells represents the primary inflow into Lake Murray, this plot was used to compare hydrology from year to year and allow for categorization of years as low, normal or high flow years. After the

years were categorized by flow, water quality patterns for different types of hydrology were determined.

3.0 RESULTS AND DISCUSSION

3.1 Applicable Water Quality Standards

All water in Lake Murray and its inflowing waters are classified as “freshwaters,” or FW. The Saluda River below the dam is classified for trout waters, and this reach of river is further classified for “trout put, grow, and take,” or TPGT where DO is to maintained at not less than a daily average of 5 mg/l. The FW and TPGT classifications are described in the 1998 report as follows:

- Class FW are freshwaters that are 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. These waters are suitable for fishing, and the survival and propagation of a balanced indigenous aquatic community of fauna and flora. This class is also suitable for industrial and agricultural uses.
- Class TPGT are freshwaters suitable for supporting the growth of stocked trout populations and a balanced indigenous aquatic community of fauna and flora.

3.2 Literature Review

We present the following synopsis of several water quality reports available for Lake Murray for the last 25 years. Two major sources are ERC and SCDHEC.

3.2.1 Environmental Research Center, Inc. Report

SCE&G funded a comprehensive water quality and biological assessment of Lake Murray that was conducted over the period September 1974 through August 1975 in conjunction with their previous FERC license application for the Saluda Hydroelectric Project (ERC, Inc., 1976). The ERC report provided a review of the historical database on Lake Murray, for the period 1947 through

1974. The ERC report also provided a comprehensive limnological assessment of Lake Murray. ERC collected and assessed data from 33 stations in and around Lake Murray.

Data were collected for numerous years by federal and state agencies to assess the water quality, flow, and discharge characteristics of Lake Murray and its tributaries. These agencies included the South Carolina Pollution Control Authority, the SCDHEC, and the USGS. The value of these data was limited for several reasons. Generally only single-depth samples easily reached from shore were collected. For the most part data collections were made only in the spring and summer months therefore these data were not representative of open waters and subsurface waters for all months of the year.

Recognizing the limitations of the historical water quality data, seasonal trends were evaluated and changes in selected water quality parameters were evaluated over the length of the lake. In general, noticeable differences occurred between the upper and lower stations in Lake Murray. For example, the concentration of nitrates, phosphates, fecal coliforms and BOD were generally higher at upper lake stations compared to lower lake stations. In part, this was attributed to the change from rapidly flowing waters in the upper part of the lake compared to slow-moving waters in the lower part of the lake. Historical data from the Bush River suggested an especially high nutrient concentration in this tributary.

ERC estimated that there were 100 houses on Lake Murray shoreline in 1951. Including summer homes, year-round houses, and mobile homes, the number of dwellings had increased to 5000 by 1973. About 40 commercial recreation-oriented establishments, such as gas docks, boat storage, rental and repair, boating and fishing supply sales, and food services had also been established by 1973.

At the time of the ERC study, at least five point source discharges existed on Lake Murray, with two additional discharges proposed. The ERC report also

included an assessment of the McMeekin Steam Generating Plant, and ERC concluded that it caused minimal, if any, effects on the ecology of Lake Murray and the Saluda River.

ERC conducted a comprehensive limnological study over the period September 1974 through August, 1975. The stream flows into Lake Murray in the summer of 1975 were the fourth highest over the period of record (see Figure 6).

Sediments

ERC studied the sediments of the lake and found that most of the sedimentation in the lake takes place over a distance from about miles 19 (near Rocky Creek) to 25 (Blacks Bridge) above the dam (see Figures 1 and 2.) They found that these sediments were comprised of a greater percentage of small particles in comparison to other parts of the lake, with the exception of the lower part of the Little Saluda embayment (i.e., near the Hwy. 391 bridge). The lower deepwater stations exhibited very little sediment deposition since the Saluda Dam had been completed.

Water Quality

Twenty-four physical and chemical parameters were sampled at Lake Murray at 33 selected stations over a period of 12 months. Following are some of the ERC results:

- Lake Murray alkalinity values were generally low.
- The pH of Lake Murray seldom deviated outside the limits for Class A waters (6.0 to 8.0) as defined by the South Carolina State Pollution Control Authority. Over the complete 12 months of sampling, the pH of Lake Murray had a range of 5.3 to 9.1 pH units.
- The highest concentrations of chlorophyll *a* were measured at the upper lake tributary stations that included the Saluda River, the Little Saluda River, the Bush River, and Lake Murray near Blacks Bridge and Rocky Creek. The highest

concentration recorded was 64.8 $\mu\text{g/L}$ in the Clouds Creek embayment. The following table summarizes average concentrations of chlorophyll *a* by locations in the lake for the months of May through October.

Location	Chlorophyll <i>a</i> , $\mu\text{g/L}$	
	May-Oct	Annual
Upper lake (down to Rocky Creek)	12.9	10.1
Mid-Lake	6.8	5.9
Lower Lake	4.6	4.0
Mean for all stations	8.1	6.7

- The concentration of dissolved phosphorus varied from 0.42 mg/l in the Bush River to undetectable levels at numerous downstream deepwater stations. The Bush River registered the highest reading in 11 out of 12 monthly sampling periods, with the lower part of the Little Saluda River recording the remaining high value during September, 1974. The lowest readings almost always occurred in the lower part of the lake. They recorded that dissolved phosphorus values for Lake Murray were high in relation to most lakes. As shown in the following table the upper lake area had the highest concentrations, the lower Lake had the lowest concentrations, and the middle lake areas had intermediate values.

Location	Dissolved Phosphorus, mg/l
Upper lake (down to Rocky Creek)	0.10
Mid-Lake	0.09
Lower Lake	0.07
Mean for all stations	0.09

- Total phosphorus concentrations ranged from undetectable to 1.15 mg/l. The Bush River exhibited the highest concentrations in the Lake Murray system in 9 out of 12 monthly sampling periods. The following table summarizes total phosphorus concentrations measured by ERC in Lake Murray.

Location	Total Phosphorus, mg/l
Upper lake (down to Rocky Creek)	0.16
Mid-Lake	0.10
Lower Lake	0.04
Mean for all stations	0.10

- Fecal and total coliforms occasionally reached high levels in Lake Murray, especially after periods of heavy runoff from the watershed. Part of the water quality standards indicated that no more than 10 percent of the total samples shall exceed 400 per 100 ml during any thirty-day period. This part of the standard was exceeded on several occasions at upper lake stations.
- ERC reported that the historical BOD₅ averaged 2.7 mg/l. We assumed that this is the inflow BOD. (page 254, ERC report)

Phytoplankton (Algae)

ERC reported...“The phytoplankton community of most large, freshwater lakes contains the organisms that provide *energy* to the lake ecosystem through photosynthetic conversion of solar energy to stored biochemical energy as food to consuming biological organisms. In some lakes attached algae and aquatic plants also play a substantial role as primary producers, but this is not the case in Lake Murray. The Lake Murray ecosystem appears to be regulated in the upper part of the lake by both autotrophic production and a considerable amount of allochthonous material (i.e., autotrophic production is the production of algae within the lake and allochthonous materials include all organic materials produced in the watershed, both algae and other organic matter.) The mid-region and lower area of the lake and most large lake arms are almost entirely under an autotrophic regime and are not as productive as the upper end of the lake.”

“On an annual basis, species composition of the algal community followed a commonly observed pattern, i.e., diatoms made up the greatest percentage of the algal community during colder months while other algal types were more prevalent in the main body of the lake during warmer months. April showed a large increase in green algal species. Shallower upstream and tributary stations, which normally exhibited higher nutrient concentrations than in the main lake, often showed extremely diverse populations and high numbers of individuals.”

“As the lake surface and tributaries cleared and warmed in spring, blue-green algae became abundant and dominated the algal populations. Species of

Chroococcus, Anabaena, Oscillatoria, Anabaenopsis, Merismopedia, and Rhaphidiopsis increased to bloom proportions at upper lake stations in summer reaching an average density of 9,050 units/ml in August, 1975. Those lake areas that consistently showed high densities of blue-green algae included the main channel of the lake down to Rocky Creek, the Little Saluda River embayment (including the Cloud Creek arm), and the Bush River. However, the phytoplankton populations in the Saluda River did not increase to densities as high as in the smaller tributaries. Blue-green algae never reached densities that cause floating, odorous masses to develop and were never evident along the shoreline in visible quantities. The mid-region and lower area of the lake had August concentrations of blue-green algae of 2,032 and 2,584 units/ml, respectively.”

During the years 1974-1975, Lake Murray was highly productive with regard to phytoplankton densities.

Trophic Status

ERC reported on the results of 24 trophic status determinations for Lake Murray. Twelve of these classifications were determined to be mesotrophic, and 11 of these classifications were reported to be eutrophic. “To classify Lake Murray in any manner other than meso-eutrophic would be erroneous. With further shoreline development and additional nutrient inputs from the watershed and septic tanks, Lake Murray will show symptoms of greater eutrophication. It is unlikely that the lake will ever go back to a total mesotrophic condition but management toward a majority of mesotrophic criteria would be a reasonable objective.”

3.2.2 SCDHEC Reports

The SCDHEC has a long history of monitoring, evaluating, and protecting water quality in Lake Murray. The lake has received considerable attention especially over the last 25 years.

The SCDHEC recently published two reports on water quality in the Saluda River basin:

1. Watershed Water Quality Management Strategy—Saluda-Edisto Basin, Technical Report No. 003-95, Bureau of Water Pollution Control
2. Watershed Water Quality Assessment—Saluda River Basin, Technical Report No. 005-98, December, 1998, Bureau of Water

The information in these reports, especially the second report, will be summarized here since they are the most significant assessments of water quality over the last 25 years. SCE&G (in cooperation with USGS) has partnered with SCDHEC over the last 10 years to undertake the water quality assessments on Lake Murray, and the results of all this monitoring are presented in later sections of this report.

SCDHEC Results Reported In the 1995 And 1998 Reports

Table 6 presents the results of the SCDHEC findings for Lake Murray that are described in the above reports. The results of the SCDHEC findings as they apply to water quality and water uses in Lake Murray are summarized as follows:

- The results reported in Table 6 are summarized in Table 7.
- The findings of the 1995 and 1998 reports are generally similar with one big exception: the 1998 report listed a greater number of locations as “not supporting” and “partially supporting.” Only 9 locations in Lake Murray and its associated watersheds were found to be fully supporting the *aquatic life* use in 1998 compared to 18 locations in 1995. Locations only on Lake Murray (including embayments) that were fully supporting the aquatic life use were especially reduced: from 11 locations fully supporting in 1995 to only 5 locations fully supporting in 1998. This large decrease is attributable to the effects of metal concentrations exceeding the water quality criteria.
- From a total of 12 stations on Lake Murray (including embayments), 7 stations were listed as non-supporting or only partially supporting water uses. Metal concentrations were listed as the cause for 6 of these stations and nutrients were

listed as the cause for 2 stations (note: the causes for 1 station listed both metals and nutrients.)

- The cause for non-supporting designations at five stations on the lake is copper which exceeds the acute water quality criteria for aquatic life. Two additional stations on the lake were listed as only partially supporting aquatic life due to copper, which exceeds the acute water quality criteria for aquatic life. Copper as well as all other metals were measured as “total” concentrations in the water and sediment samples. Only a part of the total copper would be toxic to aquatic life. The report also states that elevated copper concentrations are reported for many locations all around the State and that these copper concentrations do not appear to cause toxic conditions in waters of the State. The elevated metal concentrations in the lake are consistent with those reported for inflows to the lake; hence, the likely cause for elevated metal concentrations is the natural geology of the watershed.
- Fecal coliforms were identified as the cause for impacting recreation at 6 locations in 1995 and 8 locations in 1998. All of these locations were either in the inflows to Lake Murray or in the tailwater. The elevated fecal coliform designations were all attributable to point or nonpoint sources, or both. All locations in Lake Murray were reported to be fully supporting of the recreational use of the lake; however, increasing trends in fecal coliforms were reported for much of the main channel of the lake, in both 1995 and 1998.
- The eutrophication assessments, which uses a multi-parameter index with a statewide *baseline* from a 1980-81 assessment, indicate that conditions at the upper end of the lake had improved, except at Rocky Creek and in the Bush River arm of Lake Murray. The 1998 report stated that the two upper locations on the Saluda River arm (S-310 and S-223) and the Little Saluda River arm had improved from Category I ratings to Category II ratings, or intermediate trophic status. However, the locations at Rocky Creek and in the Bush River arm of Lake Murray were reported to be among the most eutrophic sites on large lakes in South Carolina. All the locations between Rocky Creek and the dam, including the embayment locations, were reported to be among the least eutrophic in South Carolina. In addition, these same locations were reported to have decreasing

trends in total phosphorus, and a few of the locations were also reported to have decreasing trends in nitrogen and BOD concentrations. The multi-parameter index is based on data for the following parameters: water clarity, total phosphorus, total inorganic nitrogen, chlorophyll *a*, and DO.

- Low DO in the tailwater was the cause for non-supporting and partially supporting ratings in the tailrace and the first station below the dam (S-149). The 1998 report indicated that conditions at this latter location had improved due to a lower percentage of the DO data being less than the water quality criteria. Low pH levels were also given as a reason of non-supporting aquatic life uses in the tailrace.

Miscellaneous Information Provided in the Reports

Except for a very small wastewater discharger (i.e., Dreher Island), there are no direct dischargers to the lake.

SCDHEC is currently considering a “No Discharge” designation for boats on the lake to protect water quality for the water supplies for Columbia and West Columbia as well as for recreation. A final decision was expected in 1999 [?]

Watershed management was recommended to reduce phosphorus loading to a number of areas of the lake:

- Rocky Creek area of Lake Murray (S-279)
- Bush River arm of Lake Murray (S-309)

There was a watershed study conducted on the Bush River and Camping Creek to address nonpoint sources. The 1998 report the following: “This was a comprehensive watershed project in a predominantly agricultural watershed. The project was implemented with several cooperating agencies, with the SCDNR as the lead agency. The project area lies mostly in Newberry County and the watershed drainage is to Lake Murray. The project began in 1990 and was concluded in August of 1998. The project provided funding for technical and financial assistance to farmers in the watershed for Best Management Practices (BMPs) related to rowcropping and confined animal operations. Innovative BMP

demonstrations funded by the project included provision of manure nutrient testing by a mobile laboratory, portable animal waste lagoon pumpout and spray irrigation equipment available for rent to farmers in the watershed, and the effective pesticide management.”

Growth potential in the area around the lake was discussed for several specific regions, and the following information is taken from selected sections of the 1998 report:

- The area around Lake Murray: “There will be continued growth in areas bordering and surrounding Lake Murray. The widening of US 378 to four lanes has increased the expansion rate on the Lexington side of the lake. US 76 runs along the opposite shoreline of the lake, as does a rail line. The widening of I-26 toward the Chapin\Pomaria Exit is encouraging growth on both sides of the interstate. Residential development continues to grow within the region. The area around the dam is the most developed and has water and sewer. The Richland County portion of the lake is also well developed and has several residential subdivisions where water and sewer are available. A study has been prepared and the findings are currently being reviewed to determine the feasibility of providing sewer service to areas surrounding Lake Murray within the 208 management areas of the Town of Chapin, the City of Columbia, Richland County, the Town of Lexington, and the Lexington County Joint Municipal Water and Sewer Commission (those portions of Lexington and Richland Counties bordering the lake). This will facilitate continued development along the shoreline as well as development along US 378. SC 6 is undergoing a corridor study, and the portion crossing the dam will be widened. The City of Columbia and Lexington County are currently in the discussion phase in working together to solve Lexington County’s water and sewer needs. The Bush River continues to be limited in terms of assimilating capacity, and as such there has been discussion among various sewer providers in the county for a larger regional facility that would discharge within this watershed, as well as some discussion for a single entity water and sewer provider for the lower part of Newberry County. Lake

Murray, as the main water-based recreational resource in the region, draws millions of visitors annually to its numerous parks, recreational areas, and waterways. All aspects of growth surrounding Lake Murray (tourist industry, residential development, agricultural activities) are expected to continue.”

- The area around the tailwater: “There is high potential for future residential and industrial development in this watershed. The area surrounding the Town of Lexington has grown rapidly during the past several years and the trend should continue. Several important highways run through the area including: SC 6, which runs from the Lake Murray dam south through the Town of Lexington, and US 1 and US 378, which run west from the City of West Columbia and intersects with Highway 6 in Lexington; I-20 also serves the area. The watershed’s industrial corridor is one of the most economically attractive in the Midlands Area for future development. Once sewer is readily available, residential development is expected to increase and large industrial prospects can be attracted to the area. The recent construction of a water plant on the shore of Lake Murray north of the Town of Lexington, has made available a water supply sufficient to support development. The City West Columbia and Lexington County have extended major water mains in the area. Non-industrial discharges in the basin are targeted for elimination with effluent transported to the City of Cayce’s wastewater treatment plant through a regional system. This will decrease discharge levels into the lower portion of the Saluda River.”
- The City of Greenville is located in the Saluda River watershed and has high potential to continue as an urban growth area and source of point and non-point pollution.

Table 8 summarizes the NPDES Permits and lists the major sources and number of minor sources in each sub-basin that drains to Lake Murray (downstream from Greenwood Dam).

Table 9 presents a list of reaches/issues on the SCDHEC 303(d) and Total Maximum Daily Load (TMDL) lists. Fecal coliform is the only issue listed as a cause for TMDLs: two sites on the Bush River and one site on Rawls Creek

which discharges to the Saluda River downstream from the dam. Eight sites are designated as being potential TMDL sites, and six of these are caused by fecal coliform. Two of these sites are caused by low DO, which can be attributed to discharges from the Saluda Project.

There are a total of 51 sites listed on the 303(d) list. The most significant cause for listing is fecal coliform, which is shown as the cause at 21 sites. It is important to note that most all of these sites indicate a significant potential concern to recreation where these streams enter Lake Murray or the Saluda River. Although the sampling sites on Lake Murray do not indicate a concern for fecal coliform, it is important to note that inflow regions of Lake Murray and the Saluda River are likely to be contaminated periodically by fecal coliform and unfit for recreation during these times. Recreational uses are likely to be particularly threatened following rainfall/runoff events.

It should be noted that phosphorus is listed as the cause for two sites on the 303(d) list: Bush River arm of Lake Murray (S-309) and Rocky Creek area of Lake Murray (S-279). But these sites are not listed as potential TMDLs even though they are listed at the level of priority 2. The phosphorus concentrations in the inflows to Lake Murray probably contribute to the low DO in the discharges from the Saluda Project.

Table 9 also lists pH as a concern below Saluda Dam. Low pH in reservoir releases is caused by decomposition of organic matter in the lake, and this commonly occurs in lake waters that have low alkalinity like Lake Murray. Organic matter in lakes comes from algal growths (primarily in the lake), wastewater discharges in the watershed, and natural sources in forested watersheds. Such minor low pH excursions (in magnitude as well as frequency) have minor effects on aquatic life (probably immeasurable), and cannot be remedied practically except possibly through watershed reductions of man-made sources of nutrients and organic loads and, possibly, reductions in internal nutrient cycling.

3.3 Analysis of Water Quality Data

3.3.1 Nutrients, Algae, and Water Clarity

Inflow Stations

A considerable amount of data are available for assessing the sources and trends of nutrients that enter Lake Murray, as well as the nutrient concentrations, algal productivity and water clarity in Lake Murray.

The main flow entering Lake Murray comes from the Saluda River. Greenwood Dam can be viewed as the main source of water to the Saluda River that enters Lake Murray. SCDHEC has a sampling station, S-186, a short distance downstream from Greenwood Dam, and water quality data from this location were analyzed to determine the concentrations, patterns, trends, and loads of nutrients and organic matter from this source.

Figure 7 shows the Total Phosphorus (TP) concentrations over the period 1974 to 1998. There was an apparent upward trend in concentrations until 1985 when the concentrations were substantially reduced and an apparent downward trend began. This dramatic change is probably attributable to the implementation of tertiary wastewater treatment for Greenville's wastewater discharges to the Reedy River. The current mean concentration of TP at this station is about 0.02 mg/l. Biological Oxygen Demand (BOD₅) also decreased as shown in Figure 8, dropping from a mean of about 2.5 mg/l during the period 1969 through 1986 to a mean of about 1.3 mg/l for the period 1987 through 1998. The decrease in BOD lagged the decrease in TP perhaps due to the release of methane and other decomposition products from the sediments of Lake Greenwood sometime after the drop of TP in the water column. Total Kjeldahl nitrogen (TKN, a measure of the organic nitrogen and ammonia nitrogen) followed a pattern similar that for TP, probably attributable to the TKN associated with algal growths (see Figure 9.) Nitrate+Nitrite concentrations appeared to decrease over the period 1985 through 1987. However, as shown in Figure 10, there is another interesting observation.

Nitrate+nitrite concentrations drop to near zero every year during the summer and autumn months. This drop in nitrate+nitrite is significant because it indicates that the only algae that may be able to grow during this time in the upper end of Lake Murray are blue-green algae, which are often more troublesome than other algal species such as diatoms and green algae.

There is one additional SCDHEC sampling station on the Saluda River prior to its flowing into Lake Murray: S-295, located at SC 39 near Chappells. Figure 11 presents TP data for the period 1988 through 1998. It is important to note the apparent increase in TP between the Greenwood Dam and station S-295: TP increases from about 0.02 mg/l at S-186 (just below Greenwood Dam) to about 0.06 mg/l at S-295 (approximately 3.5 miles downstream). This 200 % increase in TP is highly significant because TP can result in organic matter (i.e., through algal growths) being generated that is about 100 times the weight of TP available. The water quality in most hydropower reservoirs is very sensitive to the concentration of TP in their inflows. Figure 12 presents the results of a study conducted for EPA to determine the TP concentrations in the inflows to hydropower reservoirs. This figure shows that Lake Murray could be among the cleanest 10-20 % of the reservoirs included in the study if the TP concentration was in the range of 0.02 mg/l like that reported for the station below Greenwood Dam. However, with the TP concentration found at S-295 Lake Murray receives TP concentration that near the 70 percentile ranking for reservoirs that are not considered to be TMDL sites.

An examination of the TP data in Ninety-Six Creek (SCDHEC's station S-093) shows that it has a mean concentration of about 0.7 to 1 mg/l (see figure 13), about 40 times the concentration of TP in the Saluda River below Greenwood Dam. Using the mean concentrations of TP in the Saluda River below Greenwood and in Ninety-Six Creek in combination with their mean annual flows, the respective TP loads exerted on Lake Murray can be estimated. This approximate analysis shows that Ninety-Six Creek has a TP load of 410 lbs/day and the Saluda River has a load of 210 lbs/day. The station at S-295 has a load of

about 620 lbs/day, so it's apparent that Ninety-Six Creek accounts for essentially all the increase in TP between Greenwood Dam and Chappells.

The Bush River near its inflow point to Lake Murray also contains a relatively high concentration of TP (see Figure 14): about 0.8 mg/l. Using the same approach for estimating its TP loading to Lake Murray, the Bush River has an estimated load of 280 lbs/day. After the Bush River enters Lake Murray and the Saluda River, the estimated concentration of TP in the Saluda River would be about 0.08 mg/l. This concentration of TP is greater than the mean TP concentration in the Congaree River at the inflow to Lake Marion and ranks at the 80-percentile level when compared to the other reservoirs as discussed above.

The Little Saluda River near the inflow to the Little Saluda River arm of Lake Murray (station S-123) has been monitored by SCDHEC since 1974 (see Figure 15). Their data show a significant decreasing trend over the years, with a significant drop in 1989. The current concentration of TP is about 0.2 mg/l, which leads to an estimated daily load of about 96 lbs/day.

Clouds Creek near the inflow to the Little Saluda River arm of Lake Murray (station S-255) has been monitored by SCDHEC since 1979 (see Figure 16). Their data show a significant increasing trend over the years. The current concentration of TP is about 0.3 mg/l, which leads to an estimated daily load of about 56 lbs/day.

Significant aquatic plant communities at the upper end of Lake Murray (see page 73 in 1998 report) could contribute to high organic and nutrient loads in the upper area of the lake due to their die-off each year and settling in areas of the upper end of the lake. An annual lake draw down would probably help reduce the impacts of these plants on algal production in the upper area of the lake. However, these decomposing plants could then result in higher concentrations of anoxic products in the hypolimnion of the lake and possibly increase the levels of anoxic products that would end up in the discharge through the Saluda Project turbines.

Upper End of Lake Murray, Including Embayments

SCDHEC's station in the Bush River arm of Lake Murray (S-309) was reported in both the 1995 and 1998 reports to be among the most eutrophic sites on large lakes in South Carolina. The TP for this station is plotted in Figure 17, and the mean TP was about 0.1, indicative of eutrophic-hypereutrophic conditions (Heiskary and Walker, 1987).

SCDHEC's and SCE&G's station in the Little Saluda River arm of Lake Murray (S-222 and 8M, respectively) was reported in both SCDHEC reports to be in intermediate trophic condition. However, SCDHEC only had data for 1976-1980, 1992 and 1996-1997. The plot of TP in Figure 18 is based on SCE&G's data that are collected only twice each year. This plot indicates that the mean TP concentration is about 0.04 mg/l.

At Blacks Bridge (S-223, about 25 miles upstream from Saluda Dam), SCDHEC commented in their 1995 report that this was among the most eutrophic sites on large lakes in South Carolina, but in their 1998 report they revised this site to intermediate trophic status. Figure 19 presents the TP data collected at this site since 1974 and shows that the current mean TP concentration is about 0.06 mg/l, about the same as the mean concentration observed at the inflow station at S-295 and about 25 % less than the estimated concentration entering Lake Murray due to the added TP entering from the Bush River. This decrease in TP by the time inflows reach this point can be attributed to precipitation of TP to the sediments, either in the form of inorganic suspended solids or associated with dead algae.

At Lake Murray in the Rocky Creek area (S-279, about 18 miles upstream from the dam), SCDHEC commented in their 1998 report that this was among the most eutrophic sites on large lakes in South Carolina, but in their 1995 report they reported this site to be intermediate trophic status—in essence the opposite of their 1995 and 1998 ratings for the Blacks Bridge site. Figure 20 presents the TP data collected at this site since 1975 and shows that the current

mean TP concentration is about 0.05 mg/l, only a slight decrease from the mean concentration observed at Blacks Bridge. This marginal decrease in TP shows that this station is still strongly influenced by inflow water quality and processes that are characteristic of what limnologists often consider the riverine and transition zones of a reservoir. This observation is consistent with the two SCDHEC reports as well as the ERC report.

The Lower End of Lake Murray, Including the Embayments

For the forebay of Lake Murray (S-204 and 1SP, near the towers upstream from the dam), SCDHEC commented in their 1998 report that this was among the least eutrophic sites in South Carolina. Figure 21 presents the TP data collected at this site since 1976 and shows that the current mean TP concentration is about 0.02 mg/l, and possibly 0.01 mg/l at times as shown for the SCE&G data (these latter data had a lower minimum detectable concentration.) A closer look at the SCDHEC data for this station in comparison with the data collected at Rocky Creek and Blacks Bridge shows that one major difference between the forebay and the upstream stations is that the TP is low essentially all year round in the forebay. The upstream stations occasionally experience TP values as low as 0.02 mg/l (especially in the summer when inflow can be lower and algae consume the TP), but they increase significantly at times.

Comparison of TP, Chlorophyll a, and Secchi Depth at Various Locations

Table 10 summarizes the TP, chlorophyll a, and Secchi *depth* conditions at various locations in the inflows and Lake Murray. Compared to the results reported in the ERC report, the more recent SCDHEC data indicate that TP concentrations are about 50 % less than reported by ERC, but chlorophyll a concentrations are about the same as reported by ERC. This inconsistency (i.e., the lower TP concentration but similar chlorophyll a concentrations) could be caused by a number of factors, but the most likely causes are the higher flows (and associated inorganic suspended solids) during the ERC study and possibly differences in water sample analytical methods.

Nutrient Loads to the Upper End of Lake Murray

Figures 22 and 23 as well as Table 11 show the distribution of flow and TP loadings between the major waterways that enter the upper end of Lake Murray. It is obvious from these charts and table that several smaller waterways contribute much greater TP loads than would be expected for the amount of water that they contribute. Four of the tributaries (i.e., Ninety-Six Creek, Bush River, Little Saluda River, and Clouds Creek) contribute 75 percent of the TP to Lake Murray while their streamflow contributions total 12 percent. As discussed above, the TP concentrations in these smaller waterways are caused by point source discharges and development in the watershed. If these TP loads were reduced, the upper areas of Lake Murray would have less algae and greater water clarity, and the DO in the reservoir and the releases from the Saluda Project likely would be increased (Matthews et al., 2001; Williams, 2001; this report, re: Greenwood).

3.3.2 Dissolved Oxygen and Temperature

Lake Data

SCE&G has collected (or sponsored USGS to collect) water quality profiles throughout Lake Murray during the 1990's. The data collected on DO are the most useful for gleaning understanding of water quality dynamics in the lake. The data collected during the period 1996 through 2000 are plotted in Figures 24 through 28, respectively. A major factor that affects water quality is annual and summer flows through Lake Murray, and these flows are proportional to the flows at Chappells as shown in Figure 6. Figure 6 shows that flows were near normal levels in the years 1996 through 1998 while the flows in 1999 and 2000 were low.

Here are some general patterns of DO that can be gleaned from Figures 24-28:

- DO starts decreasing in the upper part of Lake Murray in May and June each year

- DO is low (< 2 mg/L) in the metalimnion and near the sediments in the upper end of the lake by June each year
- At specific locations within Lake Murray, DO is often lower at some point in the water column than near the sediments, indicating significant DO demands in the water column. This is significant because it suggests that a dominant DO demand can be attributed to inflow water quality parameters like nutrients, algae, and organic matter.
- In July, the DO in the forebay is much greater in low flow years (1999 and 2000) than in normal flow years. In low flow years the DO was generally greater than 5 mg/L at all depths in the forebay, whereas in normal flow years the DO was generally less than 5 mg/L and minimum DO levels varied from < 1 mg/L to < 3 mg/L.
- In August, the DO in the forebay is much greater in low flow years (1999 and 2000) than in normal flow years. In low flow years the DO was generally greater than 3 mg/L at all depths in the forebay, whereas in normal flow years the DO was generally less than 3 mg/L and minimum DO levels were < 0.5 mg/L. Also, the DO in the metalimnion was generally lower than near the sediments in the forebay of Lake Murray. These observations in July and August suggest that water displacement within the reservoir affects the DO distribution within the reservoir, i.e., in normal and wet years, water movement through Lake Murray is greater and moves poor water quality (e.g., low DO) down through the hypolimnion more rapidly.
- In August, the hypolimnion beginning 10 miles above the dam and metalimnion throughout the lake typically experienced DO < 2 mg/L (in all years).
- In September, the DO in the forebay is marginally greater in low flow years (1999 and 2000) than in normal flow years. In low flow years the DO was generally greater than 1.5 mg/L at all depths in the forebay, whereas in normal flow years the DO was generally about 0.5 mg/L and less.
- In September, most of the hypolimnion and metalimnion experienced DO < 0.5 mg/L throughout the lake, except in 1999 and 2000 when the forebay area experienced slightly higher DO concentrations.

- In October, the DO in the hypolimnion was less than 0.5 mg/L at all locations except in 2000 when the DO was about 1 mg/L for about the first eight miles above the dam. It is interesting to note that the elevation of the metalimnion in 1996 was about 10 m lower than in the other years. This was caused by high flows preceding the sampling date that drew the low DO water out of the lake more rapidly than usual.

It is important to note that the low DO values in the upper end of the lake are caused by decomposition of algae and other inflowing organic matter that takes place in the water column as well as in the form of sediment oxygen demand (Ruane and Hauser, 1991). If Lake Murray is like many other hydropower reservoirs, the low DO in the metalimnion all the way to the dam is caused by this decomposition of algae and other organic matter that initiates at the upper end of the lake. Although the DO in the metalimnion appears to be only marginally lower than the DO levels observed near the sediments of the lake, the contour plots do not reveal the difference in the volumes of water with low DO in these two areas of the lake (i.e., the metalimnion volume compared to the volume of water near the sediments.)

The volume of the metalimnion (in July, this layer of the lake occupies an average elevation range from about 94 m to 99.5 m and ranges in temperature from about 17° C to 25° C) is about 350,000 ac-ft whereas the volume of the water with low DO consumed by the sediments is estimated to be about 15,000 ac-ft. There is about 25 times the volume of water with DO depression in the metalimnion as there is in the water with DO depression over the sediments. A rough estimate of the mass of the DO demands in these two areas of the lake is approximately proportional to the volumes of water in these two areas. Hence, it is estimated that the DO demands in the metalimnion (caused primarily by inflow water quality, algae, and sediment oxygen demand in the inflow region of the lake) are about 25 times greater than the DO demand attributed to the sediments in the deeper water of the lake. Following DO depletion in the metalimnion, DO consumption in the hypolimnion speeds up because more organic material (e.g., dead algae) settles through the metalimnion without being decomposed. Hence,

even the low DO in the hypolimnion in the late summer can be attributed to DO demands that initiate in the water column (as opposed to the deep reservoir sediments.)

Figure 29 presents contour plots for the temperature dynamics in Lake Murray for the year 1996. It is instructive to track the 16° C contour line over the period of June through October. This shows how a dominant body of water moves through the lake. In June this layer of water is at about elevation 95 m; in July, about elevation 92 m; in August, about elevation 89 m; in September, about elevation 78 m; and in October, all the water having a temperature of 16° C had been drawn out of the lake. This illustrates how water in the metalimnion is drawn down in the lake to where it is eventually all drawn out of the lake through the turbines.

Hypothesis: a major portion of the water with low DO that is passed through the turbines derives from low DO water in the metalimnion and much of the hypolimnion, which is low in DO due to the nutrients and organic matter in the Bush River, Ninety-Six Creek, and Little Saluda River. Sediment oxygen demand in the inflow region of Lake Murray also causes low DO in the metalimnion, but this sediment oxygen demand as well as nutrient releases from these sediments can be attributed to the impacts of these same watershed nutrient and organic sources. As illustrated using the temperature dynamics in the lake, most of the water in the metalimnion and hypolimnion is eventually drawn out through the turbines. The low pH concerns that SCDHEC identified for the turbine discharges can only be addressed by nutrient management in the watershed or, possibly, by reducing internal nutrient cycling.

To prove this hypothesis, a water quality model like CE-QUAL-W2 would be needed to simulate the complex, dynamic water quality linkages and processes as they currently occur as well as how they would occur if nutrients and organic loads from the watershed were reduced. Such a model would allow a quantitative assessment of the effects of the TP loads in the Lake Murray watershed on DO in the releases from Lake Murray. It would also be needed to determine the amount

of supplemental aeration that might be needed following implementation of the full turbine venting system and nutrient controls in the watershed. It is important to consider for a situation like Lake Murray how much aeration, if any, is needed following watershed TP reductions. Also, the model would provide an assessment of the benefits of watershed TP controls to the coolwater fish species that inhabit the metalimnion. In addition, the model would allow an assessment of the potential eutrophication improvements in the upper regions of Lake Murray where SCDHEC has designated some of these areas as less than fully supporting.

The turbine discharge from Greenwood Hydro (Buzzards Roost) is now oxygenated (as of 1998), and the DO downstream from this project is plotted in Figure 30. This figure presents the results of SCDHEC grab samples for DO and shows that the DO in the discharge has generally been greater than 5 mg/l, with one exception in 1999 when a DO observation was made at 4.6 mg/L. It is interesting to note that the DO in the Greenwood releases had already improved as a result of the water quality improvements upstream from Greenwood in the 1980's.

The DO in the lower layer of water in the Little Saluda embayment tends to be less than DO in the lower layer of water in the main river channel, sometimes by as much as 5 mg/L (Figure 31.) This could be caused by lower flows in this embayment, higher internal nutrient loads within the embayment (i.e., higher rates of nutrient releases from the sediments within the embayment), and nutrients entering the embayment from the main channel or from the watershed. If these lower DO values are caused by internal nutrient cycling, this factor possibly could be reduced by dropping the pool level of the lake in the winter so as to re-suspend sediments in the embayment and redeposit them the sediments at another location down reservoir where they may not have as much impact on the lake. If these lower DO values are caused by local watershed sources of nutrients, watershed management (point and nonpoint source controls) may be needed to improve DO. If these lower DO values are attributed to nutrients entering from the channel, then nutrient reductions in Ninety-Six Creek and the Bush River may be needed to improve DO.

Tailwater Data

SCE&G started monitoring DO and temperature in the releases from The Saluda Project in 1989, and they are continuing this monitoring. The results of the DO monitoring since 1989 are presented in Figure 32, and the results of the temperature monitoring since 1996 are presented in Figure 33. Presented with the DO and temperature data are the cumulative flows through the Saluda Project starting in January and May for each year.

The most striking pattern shown in these plots is the increased DO starting in 1999 when turbine venting was implemented together with modified operations at the Saluda Project so that aeration could be maximized using the turbine venting capability currently installed. The amount of water flow that passes through the turbines affects the amount of air that can be aspirated through the turbine system—a lower amount of flow, or gate setting, allows more air to be aspirated into the turbine system which in turn allows DO to be increased to a greater extent in the turbine discharges. Figure 34 shows how much DO has increased in the tailwater since this system was implemented in 1999. The median DO has increased from about 2.7 mg/L to about 7.2 mg/L. The percentage of time that the DO is less than 5 mg/L has decreased from 88% to 12%. The percentage of time that the DO is less than 3 mg/L has decreased from about 55% to about 3%.

The current turbine venting system and modified operational scheme was developed using field studies in October 1998 and data analyses using the data obtained during these field studies (Saluda Hydroelectric Project Turbine Venting Study—1998, April 1999.) SCE&G is in the process of implementing other recommendations in the April 1999 report. They have installed hub baffles on Unit 5 and plan to install hub baffles on the other units in the near future.

One significant finding during the 1998 study was that the USGS gage in the tailrace yields lower daily average DO values. Over a period of nine days, the average daily DO as measured by the USGS gage was 0.6 lower than the average

of three other DO monitors located across a transect of the river. Instantaneous measures of DO at the USGS monitor were as much as 2.5 mg/l less than monitors located out in the river. The USGS monitor is located in an area of the streambank where it does not measure water that is representative of the river. It was placed there so that it could be maintained on a weekly basis without significantly increasing the cost. A new monitor is available from Stevens® that holds calibration for many months without significant maintenance requirements. SCE&G may want to consider replacing the current monitor with a Stevens® monitor so that it will be more representative of actual conditions.

The plots for 1999-2000 show that daily average DO dropped to less than 4 mg/l periodically. These periods were associated with days when daily turbine flows were higher as evidenced by the cumulative flows during these periods of lower DO. Units 1- 4 currently do not have hub baffles on them, so when these are installed, the daily average DO values will increase. The ultimate capability of turbine venting for adding DO to the discharges at the Saluda Project will not be known until the hub baffles and perhaps other improvements are added to the system and tested.

Part of the success of the turbine venting system can be attributed to the low flows that occurred in 1999-2001, i.e., SCE&G was able to operate the turbine venting without having to operate at higher flows as frequently as they would have to in normal and high flow years. The summertime cumulative flows in 1999-2001 were less than half of the normal cumulative flows observed in most of the other years (see the cumulative flow plots in Figure 32) for which DO data are available.

Following are some additional general observations:

- In normal and wet years, the minimum DO period (i.e., when DO is less than 2 mg/L) tends to start earlier in the year and end sooner.
- In low flow years, maximum temperature in the turbine discharges is lower.

4.0 CONCLUSIONS AND RECOMMENDATIONS

- A considerable amount of water quality data have been collected by SCDHEC and SCE&G over the last 25 years to allow an assessment of conditions on Lake Murray as well as its inflows and the Saluda Project discharges.
- SCDHEC has conducted three assessments of water quality conditions associated with Lake Murray over the last decade.
- The findings of SCDHEC's last two assessments (their 1998 report and their 303(d) list) were similar.
- From a total of twelve stations on Lake Murray (including embayments), seven stations were listed as non-supporting or only partially supporting water uses. Metal concentrations were listed as the cause for six of these stations and nutrients were listed as the cause for two stations (note: the causes for one station listed both metals and nutrients.) The locations impacted by nutrient concentrations were listed as priority 2 on the 303(d) list, but they were not designated as potential TMDL sites. The locations impacted by metals concentrations were given the lowest priority (i.e., priority 3) on the 303(d) list. SCDHEC requires considerable more effort before determining whether the metals concentrations are actually a cause for not fully supporting aquatic life on Lake Murray.
- The stations at Rocky Creek and in the Bush River arm of Lake Murray were reported to be among the most eutrophic sites on large lakes in South Carolina, and both these locations were designated as non-supporting for aquatic life uses. All the locations between Rocky Creek and the dam, including the embayment locations, were reported to be among the least eutrophic in South Carolina.
- Low DO in the tailwater was the cause for non-supporting and partially supporting ratings in the tailrace and the first station below the dam (S-149), respectively. Low pH levels were also given as a reason of non-supporting aquatic life uses in the tailrace. The 303(d) list listed these stations as priority 1, and they may become designated as TMDL sites.
- Fecal coliforms were identified as the cause for impacting recreation at six locations in 1995 and 8 locations in 1998. All of these locations were either in the inflows to Lake Murray or in the tailwater. The elevated fecal coliform designations were all attributable to point or nonpoint sources, or both. All locations in Lake Murray were reported to be fully supporting the recreational use of the lake; however, increasing trends in fecal coliforms were reported for much of the main channel of the lake, in both 1995 and 1998.

- There are a total of 51 sites listed on the 303(d) list. The most significant cause is fecal coliform, which is shown as the cause at 21 sites. Three sites have been designated as TMDLs, and six additional sites may become designated as TMDLs.
- Except for a very small wastewater discharger (i.e., Dreher Island), there are no direct dischargers to the lake.
- SCDHEC is considering a “No Discharge” designation for boats on the lake to protect water quality for the water supplies for Columbia and West Columbia as well as for recreation. A final decision was passed in 1999 approving this designation.
- Watershed management was recommended to reduce phosphorus loading to two areas of the lake: Bush River embayment and the Rocky Creek area of Lake Murray.
- The water quality in the discharges from Greenwood Dam have improved dramatically over the last 15 years. In the late 1980’s, nutrients and organic matter was reduced. In 1998, an aeration system was installed and DO in the discharges is now usually greater than 5 mg/l.
- However, the TP load to Lake Murray still remains high due to nutrient loads from Ninety-Six Creek, Bush River, Little Saluda, and Clouds Creek. These tributaries to the upper end of Lake Murray contribute an estimated 75% of the TP load to Lake Murray while their streamflow contributions only total 12%.
- Phosphorus loads have dramatically decreased in the watershed above Greenwood Reservoir and therefore in the discharges from Greenwood Dam. This reduction in pollutant loads has resulted in improved water quality in the upper areas of Lake Murray, especially upstream from Rocky Creek. Similar reductions of P loads in Ninety-Six Creek, Bush River, Little Saluda, and Clouds Creek would probably improve water quality (trophic status, water clarity, reductions in algae, DO) in the upper areas of Lake Murray (Rocky Creek and upstream). If these waterways were reduced to natural levels, the inflows to Lake Murray would be among the cleanest 10-20% of the hydropower reservoirs reported in a recent EPA study (Crossman and Ruane, 2000). DO in the reservoir as well as the releases also would likely improve.
- The concentration of TP in Lake Murray downstream from the Bush River embayment is estimated to be greater than the mean TP concentration in the Congaree River at the inflow to Lake Marion, and ranks at the 80 percentile level when compared to the other reservoirs as discussed above regarding the EPA study.

- Further study (water quality modeling and perhaps additional water quality data collection) would be required to determine how water quality might improve using more point source controls in the watershed as well as a periodic lake drawdown to reduce internal nutrient cycling.
- Considerations for internal nutrient cycling—eutrophication at Rocky Creek and low DO in the metalimnion (and subsequently in the turbine discharges) could be partly attributed to internal nutrient cycling due to it being the first main sampling station in the lake above which a lot of anoxic water forms that may be subject to upwelling due to power pulse inflows being cooler than the surface water. This upwelling could cause additional P and N (i.e., NH_3) into the surface layer. This upwelling of nutrients in combination with low NO_3 in the inflows from Greenwood, especially for the upper lake area, could cause algae to grow. Sediment management should be considered for reducing internal nutrient cycling, if it is occurring. The sediment data collected by ERC showed that the area down to Rocky Creek is depositional. This probably is still the case, but it would be good to get some data to confirm this.
- If the Little Saluda River is experiencing water quality problems (algae, anoxics, low DO), sediment management may be especially important and perhaps the only way to improve conditions due to the small watershed feeding this embayment (i.e., it's a sizeable body of water with relatively low potential for sediments to be flushed out.) Nutrients accumulate in a system like this and just cycle over and over as they are taken up by algae, the algae die and settle, and then the nutrients are cycled up into the water column again.
- The following hypothesis can be formulated based on the available data on Lake Murray, its watershed, and the Saluda Project turbine discharges:

Hypothesis: a major portion of the water with low DO that is passed through the turbines derives from low DO water in the metalimnion and much of the hypolimnion, which is low in DO due to the nutrients and organic matter in the Bush River, Ninety-Six Creek, and Little Saluda River. Sediment oxygen demand in the inflow region of Lake Murray also causes low DO in the metalimnion, but this sediment oxygen demand as well as nutrient releases from these sediments can be attributed to the impacts of these same watershed nutrient and organic sources. As illustrated using the temperature dynamics in the lake, most of the water in the metalimnion and hypolimnion is eventually drawn out through the turbines. The low pH concerns that SCDHEC identified for the turbine

discharges can only be addressed by nutrient management in the watershed or by reducing internal nutrient cycling.

To prove this hypothesis, a water quality model like CE-QUAL-W2 would be needed to simulate the complex, dynamic water quality linkages and processes as they currently occur as well as how they would occur if nutrients and organic loads from the watershed were reduced. Such a model would allow a quantitative assessment of the effects of the TP loads in the Lake Murray watershed on DO in the releases from Lake Murray. It would also be needed to determine the amount of supplemental aeration that might be needed following implementation of the full turbine venting system and nutrient controls in the watershed. It is important to consider for a situation like Lake Murray how much aeration, if any, is needed following watershed TP reductions. Also, the model would provide an assessment of the benefits of watershed TP controls to the coolwater fish species that inhabit the metalimnion. In addition, the model would allow an assessment of the potential eutrophication improvements in the upper regions of Lake Murray where SCDHEC has designated some of these areas as less than fully supporting.

- DO in the turbine discharges probably would improve if TP were reduced using point source controls in the watershed and/or by reducing internal nutrient cycling. Although the DO in the turbine discharges probably would not achieve the South Carolina DO criteria without turbine venting, it would be higher than previous (pre-1999 conditions) concentrations and would exceed previous DO levels with greater frequency of occurrence at selected DO levels, and the metalimnion may not experience DO levels as low as current conditions—this could help lake fish (i.e., DO would be higher in areas of the lake where temperature is more desirable for coolwater species of fish).
- In 1999, a turbine venting system was implemented together with modified operations at the Saluda Project so that aeration could be maximized using the turbine venting capability currently installed. The amount of water flow that passes through the turbines affects the amount of air that can be aspirated through the turbine system—a lower amount of flow, or gate setting, allows more air to be aspirated into the turbine

system which in turn allows DO to be increased to a greater extent in the turbine discharges.

- Since this system was implemented in 1999, the median DO in the Saluda Project discharges has increased from about 2.7 mg/L to about 7.2 mg/L. The percentage of time that the DO is less than 5 mg/L has decreased from 88 percent to 12 percent. The percentage of time that the DO is less than 3 mg/L has decreased from about 55 percent to about 3 percent.
- The current turbine venting system and modified operational scheme was developed using field studies in October 1998 and data analyses using the data obtained during these field studies. SCE&G is in the process of implementing other recommendations from this study. SCE&G has installed hub baffles on Unit 5 and plans to install hub baffles on the other units in the near future.
- One significant finding during the 1998 study was that the USGS gage in the tailrace yields lower daily average DO values. Over a period of nine days, the average daily DO as measured by the USGS gage was 0.6 lower than the average of three other DO monitors located across a transect of the river. Instantaneous measures of DO at the USGS monitor were as much as 2.5 mg/l less than monitors located out in the river. SCE&G may want to consider replacing the current monitor with a Stevens® monitor that can be located in a more representative area of the tailwater.
- Aeration of releases: the current turbine venting system with the addition of hub baffles would increase the achievable minimum DO, especially when turbines are operated at higher gate settings. Additional aeration beyond maximizing the turbine venting system capability might not be needed if nutrient sources in the watershed and possibly the up-reservoir sediments were reduced. Selection of the best approach for the next step of aeration, if it is needed, would depend significantly on the characteristics of the low DO in the reservoir after nutrient loads to the reservoir were reduced. A CE-QUAL-W2 model could be used for estimating the benefits of nutrient controls in the watershed, reduction of internal nutrient cycling, and how DO conditions would change in the reservoir and turbine discharges following nutrient reductions. This model could also be used to determine if and how much supplemental aeration might be needed following reductions of nutrient loads to Lake Murray.

- Fecal coliform levels were reported by SCDHEC to be acceptable in Lake Murray, but fecal coliform in inflowing streams are often above the South Carolina water quality criteria. This is typical of many large reservoirs. Unfortunately, most of the sampling stations within large lakes like Lake Murray are not in sensitive areas where fecal coliform might occasionally exceed the water quality criteria. It is especially important to consider those locations near inflow points where you might expect periodic episodes of high inflows. This concern can be addressed by adding monitoring points closer to the inflow regions (perhaps specifically for fecal coliform) and by educating the public and using warning signs near these inflow points. Special studies can be used to identify these areas and the extent of the concern for each inflow region.

5.0 LITERATURE CITED

- DHEC, 1995, "Watershed Water Quality Management Strategy—Saluda-Edisto Basin," Technical Report No. 003-95, prepared by South Carolina Department of Health and Environmental Control.
- DHEC, 1998, "Watershed Water Quality Assessment—Saluda River Basin," Technical Report No. 005-98, prepared by South Carolina Department of Health and Environmental Control, Bureau of Water, December, 1998.
- EPA, 2001, "Evaluation Of Hydropower Projects And Identification Of Opportunities For Pollutant Trading—Final Report," prepared by John Crossman and RJ Ruane, John Crossman and Associates, May 2001.
- ERC, 1975, "Environmental Inventory of Lake Murray, South Carolina—Volumes I and II," prepared for SCE&G, January 1976.
- Heiskary and Walker, 1987, "Developing Phosphorus Criteria For Minnesota Lakes," presented at Annual Symposium of the North American Lake Management Society, Orlando, FL
- Matthews, DA, SW Effler, CM Brooks-Matthews, CA Siegfried, and ME Spada, 2001, "Responses of Onondaga Lake, New York, to Early Stages of Rehabilitation: Unanticipated Ecosystem Feedbacks," *Water Environmental Research*, Vol. 73, pp. 691-703, November/December 2001.
- Ruane, RJ, and GE Hauser, 1991, "Factors Affecting Dissolved Oxygen in Hydropower Reservoirs," Proceedings of the ASCE Waterpower '91 Conference, Denver, CO.
- SCE&G 1999, "Saluda Hydroelectric Project Turbine Venting Study—1998," prepared by Kleinschmidt Associates, Reservoir Environmental Management, Inc., and TVA. April 1999.
- Williams, VP, 2001, "Effects of Point-Source Removal on Lake Water Quality: A Case History of Lake Tohopekaliga, Florida," *Lake and Reservoir Management*, Vol. 17, No. 4, December 2001.