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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
SOUTHERN NUCLEAR OPERATING CO.	)	Docket No. 52-011-ESP
	)	
(Early Site Permit for Vogtle ESP Site)	)	

NRC STAFF TESTIMONY OF DR. MICHAEL T. MASNIK, ANNE R. KUNTZLEMAN, REBEKAH H. KRIEG, DR. CHRISTOPHER B. COOK, AND LANCE W. VAIL CONCERNING ENVIRONMENTAL CONTENTION EC 1.2

Q1. Please state your names, occupations, and by whom are you employed.

A1(a). (MTM) My name is Dr. Michael T. Masnik (MTM). I am employed as a Senior Aquatic Biologist in the Division of Site and Environmental Reviews in the U.S. Nuclear Regulatory Commission's ("NRC") Office of New Reactors. I am the lead technical reviewer for the NRC on the aquatic resources issues associated with the application submitted on August 14, 2006, by Southern Nuclear Operating Company, Inc. ("Southern" or "Applicant") for an early site permit ("ESP") for a site within the existing Vogtle Electric Generating Plant ("VEGP") site near Waynesboro, Georgia. A statement of my professional qualifications is attached hereto.

A1(b). (ARK) My name is Anne "Nancy" R. Kuntzleman (ARK). I am employed as an Aquatic Biologist in the Division of Site and Environmental Reviews, Office of New Reactors, NRC. I am a technical reviewer for the NRC on aquatic and terrestrial resources issues associated with the application submitted on August 14, 2006, by Southern for an ESP for a site within the existing VEGP site near Waynesboro, GA. A statement of my professional qualifications is attached hereto.

A1(c). (RHK) My name is Rebekah H. Krieg (RHK). I am employed as a Senior Research Scientist in the Ecology Group, Environmental Sustainability Division, Energy and Environment Directorate of the Pacific Northwest National Laboratory ("PNNL"). I am a technical reviewer for PNNL's contract with the NRC on aquatic resource issues associated with the application submitted on August 14, 2006, by Southern for an ESP for a site within the existing VEGP site near Waynesboro, GA. A statement of my professional qualifications is attached hereto.

A1(d). (CBC) My name is Dr. Christopher B. Cook (CBC). I am employed as a Senior Hydrologist in the Division of Site and Environmental Reviews, Office of New Reactors (NRO), NRC. I was employed as a Senior Research Engineer at PNNL and was assigned as the lead technical reviewer on hydrology issues for PNNL's contract with the NRC when the application was submitted on August 14, 2006, by Southern for an ESP for a site within the existing VEGP site near Waynesboro, GA. While at PNNL, I assisted with the development of portions of NUREG-1872, "Draft Environmental Impact Statement for an Early Site Permit (ESP) at the Vogtle Electric Generating Plant Site," September 2007 ("DEIS"), relating to hydrological alterations, water use, and water quality issues. As part of my current employment, I was a technical reviewer for the NRC on hydrological alterations, water use, and water quality issues associated with the Vogtle ESP. A statement of my professional qualifications is attached hereto.

A1(e). (LWV) My name is Lance W. Vail (LWV). I am employed as a Senior Research Engineer in the Hydrology Group, Environmental Sustainability Division, Energy and Environment Directorate of PNNL. I am a technical reviewer for PNNL's contract with the NRC on hydrological alterations, water use, and water quality issues associated with the application submitted on August 14, 2006, by Southern for an ESP for a site within the existing VEGP site near Waynesboro, GA. A statement of my professional qualifications is attached hereto.

Q2. Please describe your current responsibilities in relation to this review.

A2(a). (MTM) As part of my official responsibilities as the senior aquatic biologist assigned to the VEGP ESP review, I provided technical oversight to the NRC and PNNL reviewers as well as performing aspects of the review related directly to a portion of the evaluation of impacts to aquatic organisms due to interactions with the proposed station intake and discharge structures. My assessment of impacts is contained, in part, in Sections 4.4, 5.4 and 7.5 of NUREG-1872, Final Environmental Impact Statement for an Early Site Permit (ESP) at the VEGP site," August 2008 ("FEIS"). I also had technical input to the descriptive information contained in Section 2.7.2 of the FEIS.

A2(b). (ARK) In my capacity as the aquatic biologist assigned to the VEGP ESP review I provided technical oversight to the PNNL reviewers during the preparation of Sections 2.7.2 (Aquatic Ecology), 4.4 (Ecological Impacts from Construction), 5.4 (Ecological Impacts from Operation), and 7.5 (Cumulative Impacts - Aquatic Ecosystem) of the FEIS.

A2(c). (RHK) In my current responsibility as the aquatic ecology technical reviewer assigned to the VEGP ESP review, I wrote the descriptive information contained in Section 2.7.2 and performed the review of the impact to aquatic organisms due to interactions with the proposed station intake and discharge structures as presented in Sections 4.4.2, 5.4, and 7.5 of the FEIS. I worked under the technical oversight of Dr. Michael T. Masnik and Ms. Nancy Kuntzleman of the NRC.

A2(d). (CBC) As part of my official responsibilities at PNNL as a hydrology technical reviewer to the VEGP ESP review, I evaluated the surface water hydrology and plant water systems documented in Chapters 2, 3, 4, 5, 7 and 9 of the DEIS. As part of my official responsibilities at the NRC as the hydrology technical reviewer assigned to the VEGP ESP review, I was responsible for reviewing the analysis prepared by Mr. Vail (LWV) related to surface water hydrology and plant systems until March 2008. Although I was not a technical reviewer on the application during completion of the FEIS, I am familiar with the Staff's analysis

and conclusions documented in Chapters 2, 3, 4, 5, 7, and 9 of the FEIS concerning surface water hydrology and plant water systems.

A2(e). (LWV) In my current responsibility as the hydrology technical reviewer assigned to the VEGP ESP review I am responsible for the analysis related to surface water and plant water systems documented in Chapters 2, 3, 4, 5, 7, and 9 of the FEIS. I assumed responsibility as the PNNL hydrology technical reviewer following publication of the NRC Staff's Draft Environmental Impact Statement ("DEIS").

Q3. What is the purpose of this testimony?

A3(a). (ALL) The purpose of this testimony is to present the NRC Staff's views with respect to Contention EC 1.2 , which challenges the adequacy of the analysis in the FEIS of cooling system-related impacts on aquatic resources.

Q4. Are you familiar with Contention 1.2?

A4. (ALL) Yes. Contention EC 1.2 submitted in this proceeding by the Center for a Sustainable Coast, Savannah Riverkeeper, Southern Alliance for Clean Energy, Atlanta Woman's Action for New Directions, and Blue Ridge Environmental Defense League (collectively, "Joint Intervenors") as restated by the Atomic Safety and Licensing Board in its Memorandum and Order of January 15, 2008, ruling on the Applicant's Motion for Summary Disposition, alleges that:

> The [Environmental Report (ER)] fails to identify and adequately consider direct, indirect, and cumulative impingement/entrainment and thermal effluent discharge impacts of the proposed cooling system intake and discharge structures on aquatic resources.

We are familiar with the contention and the bases submitted in its support presented in the Joint Intervenors' filing dated December 11, 2006, as well as with the declarations of Shawn Paul Young, Ph.D., dated December 07, 2006, November 11, 2007, and September 22, 2008, and the declaration of Barry W. Sulkin, dated November 9, 2007. It is our understanding that the contention concerns the potential operational and cumulative impacts of the proposed new

Vogtle reactors on the aquatic biota in the Savannah River. Specifically, it concerns impacts from impingement and entrainment due to operation of the new units' intake structure, as well as thermal impacts due to the operation of a new discharge structure.

The new intake and discharge structures are necessary for the operation of two additional units at the VEGP site. The Staff's assessment of the impacts to aquatic biota in the Savannah River due to impingement and entrainment and thermal effects from the operation of two additional units at the VEGP site is presented in the FEIS. Our testimony therefore focuses on the Staff analysis documented in the FEIS. However, in preparing this testimony we have also considered and referenced the following specific documents (with NRC Exhibit numbers noted) in the responses for which we are individually responsible, as indicated by our initials:

- NUREG-1872, Final Environmental Impact Statement for an early Site Permit (ESP) at the Vogtle Electric Generating Plant Site, Volumes 1 & 2 (August, 2008) combined with corrected Appendix F and the September 3, 2008 Errata. Volume 1; Volume 2; Appendix F; Errata (NRC000001).

- Academy of Natural Sciences of Philadelphia (ANSP). 2001. 2000 Savannah River Biological Surveys for Westinghouse Savannah River Company. Report No. 01-16F. Patrick Center for Environmental Research, Philadelphia, Pennsylvania. (NRC000002).

- Academy of Natural Sciences of Philadelphia (ANSP). 2003. 2001 Savannah River Biological Surveys for Westinghouse Savannah River Company. Report No. 03-08F, Patrick Center for Environmental Research, Philadelphia, Pennsylvania. (NRC000003).

- Academy of Natural Sciences of Philadelphia (ANSP). 2005. 2003 Savannah River Biological Surveys for Westinghouse Savannah River Company. Report No. F04-06, Patrick Center for Environmental Research, Philadelphia, Pennsylvania. (NRC000004).

- The Catena Group. 2007. Freshwater Mussel Surveys, The Savannah River from Augusta to Savannah: South Carolina & Georgia. The Catena Group, Hillsborough, North Carolina. (NRC000005).

- Excerpts from: Marcy Jr. B.C., D.E. Fletcher, F.D. Martin, M. Paller, and M.J.M. Reichert. 2005. Fishes of the Middle Savannah River Basin. The University of Georgia Press, Athens, Georgia. (NRC000006).

- Excerpts from: Regulatory Guide 4.2 Rev. 2, Preparation of Environmental Reports for Nuclear Power Stations (1976). (NRC000007).

- Regulatory Guide 4.7, Rev. 2, General Site Suitability Criteria for Nuclear Power Stations (1998). (NRC000008).

- NUREG-1555 Standard Review Plans for Environmental Reviews for Nuclear Power Plants ("ESRP") (2000) Sections: 2.3.1, 2.4.1; 2.4.2; 5.3.1.2; 5.3.2.2; 9.4.1 (NRC000009).

- NUREG-1555 Standard Review Plans for Environmental Reviews for Nuclear Power Plants ("ESRP") Draft Rev. 1 (2007) Sections: 4.7; 5.3.1.2; 9.4.1 (NRC000010).

- Excerpts from: Specht 1987, Comprehensive Cooling Water Study, Final Report, Volume V, Aquatic Ecology, Savannah River Plant, DP-1739-5. (NRC000011).

- Paller M.H., B.M. Saul, and D.V. Osteen. 1986. Distribution and Abundance of Ichthyoplankton in the Mid-Reaches of the Savannah River and Selected Tributaries. Primary Report No. DPST-86-798, Environmental and Chemical Sciences, Inc., Aiken, South Carolina. (NRC000012).

- Excerpts from: Bennett D.H. and R.W. McFarlane. 1983. The Fishes of the Savannah River Plant: National Environmental Research Park. SRO-NERP-12. Savannah River Ecology Laboratory, U.S. Department of Energy, Washington, D.C. (NRC000013).

- NUREG -1087 Final Environmental Statement Related to the Operation of Vogtle Electric Generating Plant, Units I and 2. Docket Nos. 50-424 and 50-425 (1985). (NRC000014).

- Hendricks A.S. 2002. The Conservation and Restoration of the Robust Redhorse, Moxostoma robustum. Vol. 3. Georgia Power Company Environmental Laboratory, Smyrna, Georgia. (NRC000015)

- Nichols M. 2003. Conservation Strategy for Robust Redhorse (Moxostoma robustum) Environmental Laboratory Georgia Power Company for Robust Redhorse Conservation Committee, Atlanta, Georgia. (NRC000016).

- Grabowski T.B. and J.J. Isely. 2006. "Seasonal and Diel Movements and Habitat Use of Robust Redhorses in the Lower Savannah River, Georgia, and South Carolina." Transactions of the American Fisheries Society 135(5):1145-1155. (NRC000017).

- Letter from United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service from Walt Wilson, Fisheries Biologist, Protected Resources Division to NRC Staff, October 24, 2006, "Endangered and Threatened Species and Critical Habitats under the Jurisdiction of the NOAA Fisheries Service." (NRC000018).

- Georgia Department of Natural Resources (GDNR). 2008. Locations of Special Concern Animals, Plants and Natural Communities in Burke County, Georgia. (NRC000019).

- E-Mail from Jennifer Price, South Carolina Department of Natural Resources, to Rebekah Krieg, Pacific Northwest National Laboratories, July 26, 2007, "Federal Threatened and Endangered Species in the Vicinity of Vogtle Electric Generating Plant." (NRC000020).

- South Carolina, Rare, Threatened ,and Endangered Species Inventory; Species Found in Barnwell County. (NRC000021).

- Collins M.R. and T.I.J. Smith. 1997. "Distributions of Shortnose and Atlantic Sturgeon in South Carolina." North American Journal of Fisheries Management, 17:995-1000. (NRC000022).

- Halverson et al. 1997, Savannah River Site Ecology Environmental Information Document. WSRC-TR-97-0223, Westinghouse Savannah River Company, Washington, D.C. (NRC000023).

- Collins M.R. and T.I.J. Smith. 1993. "Characteristics of the Adult Segment of the Savannah River Population of Shortnose Sturgeon." Proceedings of the Annual Conference of Southeastern Association of Fish and Wildlife Agencies 47:485-491. (NRC000024).

- Status Review of Atlantic Sturgeon (Acipenser oxyrinchus): Prepared by the Atlantic Sturgeon Status Review Team for the National Marine Fisheries Service National Oceanic and Atmospheric Administration February 23, 2007. Updated with corrections on July 27, 2007. (NRC000025).

- Graph Showing Waynesboro-Thurmond Discharge, Date (1.22.05 - 10.27.08). (NRC000026).

- Freeman, M.C. and P. Marcinek, 2006. "Fish Assemblage Responses to Water Withdrawals and Water Supply Reservoirs in Piedmont Streams" Envi. Management vol. 38, no. 3 pp. 435-450. (NRC000027).

- Historic Savannah Streamflow Graph from USGS gage # 02197000 at Augusta, GA (~1904-2007). (NRC000028).

- Letter from United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service from Roy E. Crabtree, Ph.D., Regional Administrator to William Burton, dated August 11, 2008, “A Biological Assessment for the Shortnose Sturgeon for the Vogtle Electric Generating Plant Early Site Permit Application.” (SNC000022).

- Southern Nuclear Operating Company, Draft Interim Report of Fish Impingement and Entrainment Assessment at the Plant Vogtle Electric Generating Plant, September 2008. (NRC000030).

- Letter from J. A. "Buzz" Miller, Senior Vice President, Nuclear Development, Southern Nuclear Operating Company, Inc. to NRC Staff dated May 27, 2008 with attached Impingement and Entrainment Monitoring Update at Plant Vogtle. (NRC000031).

- Note-to-File: Trip report of March 7-9, 2007, tour of VEGP Units 1 and 2. (NRC000032).

- Note-to-file: Trip report of October 14, 2008. (NRC000033).

- Paller M.H. 1992. The Influence of Savannah River Discharge and Changing Savannah River Site (SRS) Cooling Water Requirements on the Potential Entrainment of Ichthyoplankton at the SRS Savannah River Intakes. WSRC-RP-92-1001, Westinghouse Savannah River Co., Aiken, South Carolina. (NRC000034).

- U.S. Environmental Protection Agency "National Pollutant Discharge Elimination System: Regulations Addressing Cooling Water Intake Structures for New Facilities," 66 Fed. Reg. 65,256. (December 18, 2001). (NRCR00035).

- McFarlane R.W., R.F. Frietsche and R.D. Miracle. 1978. Impingement and Entrainment of Fishes at the Savannah River Plant. An NPDES 316b Demonstration. DP-1494, E.I. Du Pont DE Nemours and Company, Savannah River Laboratory, Aiken, South Carolina. (NRC000036).

- NUREG-1437 Vol. 1 & 2 Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Main Report, Final Report. (1996). (NRC000037).

- U.S. Army Corps of Engineers (USACE). 2006. Drought Contingency Plan Update: Savannah River Basin. Draft Environmental Assessment and Finding of No Significant Impact. Mobile/Savannah Planning Center, Savannah District, U.S. Army Corps of Engineers. (NRC000038).

- US Army Corps of Engineers, Savannah District, Draft Environmental Assessment and Finding of No Significant Impact, Temporary Deviation Drought Contingency Plan, Savannah River Basin, October 2008. (NRC000039).

- Aucott, W.R., S.R.S. Meadows, and G.G. Patterson. 1987. Regional Ground-Water Discharge to Large Streams in the Upper Coastal Plain of South Carolina and Parts of North Carolina and Georgia. Water-Resources Investigations Report 86-4332, U.S. Geological Survey, Columbia, South Carolina. (NRC000040).

- Flow Data from Thurmond Dam Discharge and USGS Gauge #021973269 Near Waynesboro, GA. (NRC000041).

- Excerpt from: Clarke, J.S. and C.T. West, USGS, Ground-Water Levels, Predevelopment Ground-Water Flow, And Stream-Aquifer Relations In The Vicinity Of The Savannah River Site, Georgia And South Carolina. 1997. (NRC000042).

- Excerpt from: US Global Change Research Program: The Potential Consequences of Climate Variability and Change (2000). (NRC000043).

- Excerpt from: Intergovernmental Panel on Climate Change: Climate Change 2007, Synthesis Report. (NRC000044).

- NUREG 1437, Supplement 34-General Environmental Impact Statement for Licenses Renewal of Nuclear Plants, Supplement 34, Regarding Vogtle Electric Generating Plant, Units I and 2. Draft Report for Comment. (NRC000045).

- AP1000 DCD Revisions 15 and 16 Values: Summary of Cooling System Flow Rate Changes. (NRC000050).

I. Description of Aquatic Species and Habitat in FEIS

Q5. Does the U.S. NRC Staff ("Staff") discuss in the FEIS the aquatic species composition and habitat in the Savannah River?

A5. (RHK) Section 2.7.2.1 of the FEIS discusses the aquatic communities on and near the VEGP site. The discussion includes the species composition of molluscs and fish in the Savannah River. It also includes a short description of the habitat types in the middle reach of the Savannah River (defined as occurring from the Fall Line at RM 220 downstream to the mouth of Brier Creek (RM 97)). The FEIS discusses the results of studies related to diatoms, aquatic insects, molluscs and fish.

The discussion of attached algae, aquatic macrophytes, diatoms and aquatic insect composition from Section 2.7.2.1 of the FEIS is based on information provided in a series of reports written by the Academy of Natural Sciences, Philadelphia ("ANSP"), which contained the results of biological and water quality studies that the ANSP conducted in the Savannah River in the vicinity of the Savannah River Site (SRS). Exhibit NRC000001 at 2-75. In particular, "2000 Savannah River Biological Surveys for Westinghouse Savannah River Company", addresses attached diatoms, algae, aquatic macrophytes, and aquatic insects. Exhibit NRC000002 at v to vii, 17 to 73, and 122 to 206. "2001 Savannah River Biological Surveys for Westinghouse Savannah River Company", addresses diatoms, attached algae, aquatic macrophytes and aquatic insects. Exhibit NRC000003 at v to x, 19 to 99, and 153 to 198. In addition, "2003 Savannah River Biological Surveys for Westinghouse Savannah River Company", addresses diatoms and aquatic insects on pages 6-12. Exhibit NRC000004 at 6 to 12. The SRS is a U.S. Department of Energy ("DOE") site located across the Savannah River from the VEGP site.

A discussion of molluscs identified in the vicinity of the VEGP site is included in Section 2.7.2.1 of the FEIS. Exhibit NRC000001 at 2-76. The ANSP studies were used as a basis for describing the changes in the mussel fauna since studies began in 1951. Exhibit NRC000002

at vi, vii, and 74 to 79, 90 to 107 and 112 to 121; Exhibit NRC000003 at vii, viii, and 99 to 104, 117 to 137 and 141 to 152. The ANSP studies were also used to identify the continued presence of state protected species in the Savannah River. Exhibit NRC000001 at 2-87 and 2-88; Exhibit NRC000002 at 94; Exhibit NRC000003 at 121. After the draft was published, the Staff became aware of a more recent survey of freshwater mussels occurring in the middle and lower Savannah River in late 2006 for the U.S. Fish and Wildlife Service ("USFWS") (The Catena Group, 2007, "Freshwater Mussel Surveys: The Savannah River from Augusta to Savannah: South Carolina and Georgia"). Exhibit NRC000005. The Staff included information from the mussel survey in the FEIS, including the number of important species identified during the survey and their locations. Exhibit NRC000001 at 2-76, 2-87 and 2-88.

The list of native, diadromous, marine and upland fish species in the Middle Savannah River, in Table 2-7 of Section 2.7.2.1 of the FEIS is based on Marcy, et al. (2005), "Fishes of the Middle Savannah River Basin." Exhibit NRC000001 at 2-77 to 2-79; Exhibit NRC000006 at 9 to 11. A list of introduced fish species was provided in Table 2.8 of Section 2.7.2.1 of the FEIS. Exhibit NRC000001 at 2-80. FEIS Section 2.7.2.1 also provides information on the latest fish surveys that were conducted on the Savannah River in the vicinity of the VEGP site by the ANSP. Exhibit NRC000001 at 2-80 and 2-81; Exhibit NRC000002 at viii to ix and 207 to 251; Exhibit NRC000003 at ix and 199 to 238. These surveys occurred between RM 122 and 161. Exhibit NRC000002 at 9 to 14; Exhibit NRC000003 at 11 to 16. For reference, the VEGP Units 3 and 4 intake site is proposed to be located at approximately RM 151. Section 2.7.2.1 of the FEIS states the number of fish species and specimens that were identified in these samples, and specifies the five taxa that composed 74-75% of the sample. Exhibit NRC000002 at 221 to 223; Exhibit NRC000003 at 214 to 216. A brief description of the ichthyoplankton studies conducted at the Savannah River site in 1984 and 1985 is also presented in Section 2.7.2.1. Exhibit NRC000011 at V-241 to V-548; Exhibit NRC000012.

Q6. What is the applicable Staff guidance for preparing its description of aquatic species and habitat in the FEIS?

A6. (ARK) The Staff reviewed the environmental report (ER) prepared by the applicant in accordance with guidance provided in Regulatory Guide 4.2, Revision 2, *Preparation of Environmental Reports for Nuclear Power Stations* (NRC 1976). Regulatory Guide 4.2 identifies the information needed by the Staff in the preparation of its assessment of the potential environmental effects of the proposed nuclear facility. Regulatory Guide 4.2, Chapter 2.2, "Ecology," states that "the applicant should describe the flora and fauna in the vicinity of the site, their habitats, and their distribution. This initial inventory will reveal certain organisms which, because of their importance to the community, should be given special attention." Exhibit NRC000007 at 2-3.

The Staff also followed guidance set forth in NUREG-1555, *Environmental Standard Review Plan,* Section 2.4.2, and "Aquatic Ecology." This section "[d]irects the staff's description of the aquatic environment and biota at and in the vicinity of the site and other areas likely to be impacted by the construction, maintenance, or operation of the proposed project." Exhibit NRC000009 at 2.4.2-1. According to the ESRP, the scope of the Staff's review "[s]hould include the spatial and temporal distribution, abundance, and other structural and functional attributes of biotic assemblages on which the proposed action could have an impact. The review should also identify any "important" or irreplaceable aquatic natural resources and the location of sanctuaries and preserves that might be impacted by the proposed actions." Exhibit NRC000009 at 2.4.2-1. The ESRP explains that "[t]he depth and extent of the input to the EIS should be governed by the kinds of aquatic ecological resources that could be affected by plant construction or operation and by the nature and magnitude of the expected impacts to these resources." Exhibit NRC000009 at 2.4.2-6.

Furthermore, the ESRP states that:

> "The input should be brief and should contain the following information: 1) The principal aquatic ecological features of the site and vicinity…with emphasis on the communities of the ecosystem that will be potentially affected by project construction, operation, or maintenance. This information should be based on an analysis of at least one full year of data to reflect seasonal variations in aquatic populations. Thus, the extent of discussion of various biotic components should be in proportion to the estimated severity of impacts and should be adequate to support the assessment of ESRP Chapters 4.0 (Environmental Impacts of Construction) and 5.0 (Environmental Impacts of Station Operation). 2) Descriptions of environmental or man-induced stresses to aquatic biota at the existing site and vicinity. 3) A discussion of 'important' aquatic species that may be affected by plant or transmission corridor construction or operation. Estimates of their abundance should be provided where appropriate. Special habitat and forage needs should be emphasized, if the proposed project would potentially disrupt these. 4) A summary of consultations with appropriate Federal, State, regional, local and affected Native American tribal agencies, including the U.S. Fish and Wildlife Service (through the regional director), and the director of the State fish and wildlife agency."

Exhibit NRC000009 at 2.4.2-6 and 2.4.2-7. A description of how the Staff followed this guidance in its review of the Vogtle ESP application is described below in response to Question 7.

Q7. How did the Staff follow that guidance in its review of the Vogtle ESP application?

A7. (ARK) The Staff followed the guidance in Regulatory Guide 4.2 and in the ESRP in several ways. The Staff characterized the kinds of aquatic ecological resources in the vicinity of the VEGP site and other areas likely to be impacted by the construction, operation, or maintenance of the proposed VEGP Units 3 and 4. In doing so, the Staff emphasized the aquatic communities of the VEGP site (e.g., onsite ponds and streams as well as the reach of the Savannah River adjacent to the VEGP site) that will be potentially affected by project construction, operation and maintenance. Then, consistent with the definitions in the ESRP and Regulatory Guide 4.2, the Staff identified the "important" aquatic species, including Federally listed threatened, endangered, or candidate species; those aquatic species listed by the States of South Carolina or Georgia as threatened, endangered, or species of concern; and commercially and recreationally important fish species that may be affected by plant

construction or operation. The determination of these species for the review of the Vogtle ESP application is discussed in more detail in my colleague's response to Question 10, below. Also, the Staff consulted with the U.S. Fish and Wildlife Service, National Marine Fisheries Service, Georgia Department of Natural Resources ("GADNR"), and the South Carolina Department of Natural Resources ("SCDNR") and requested information on listed species, the presence of any critical habitat in the vicinity of the VEGP site, and any additional information considered to be appropriate under the provisions of the Fish and Wildlife Coordination Act.

Q8. During the Staff's preparation of the FEIS, was recent sampling or monitoring data obtained by the applicant available specifically for the existing Units 1 and 2?

A8. (RHK) No, the applicant did not provide recent sampling and monitoring data that it had conducted in support of the ESP application at the time the application was submitted. However, the applicant provided sampling and survey information from that stretch of the Savannah River from other sources in support of its application. Further, shortly before the publication of the FEIS, the applicant provided initial results of impingement monitoring.

Regulatory Guide 4.2, "Preparation of Environmental Reports for Nuclear Power Stations", Rev. 2 (1976), on page ix, specifies that an applicant "should present sufficient information in the environmental report that is submitted with the application to allow staff evaluation of the potential environmental impact of constructing and operating the proposed facility." Exhibit NRC000007 at ix. Further, the guidance states that "in all cases, the site-specific environmental data presented at the time of filing for a construction permit should (1) document the critical life stages and biologically significant activities (e.g., spawning, nesting, migration) that increase the vulnerability of the potentially affected biota at the proposed site and (2) characterize the seasonal variations of biota likely to be affected by the station." *Id.* In other words, the documentation and characterization of the potentially affected biota should be aimed at those activities and life-stages that make the biota vulnerable to the operations at the site and should span multiple periods in a year.

Further, Section 2.4.2 of the ESRP 2000 states that this information "should be based on an analysis of at least one full year of data to reflect seasonal variations in aquatic populations." Exhibit NRC000009 at 2.4.2-6. As discussed later in my testimony in response to Question 9, the applicant's ER did refer to studies that were systematic and spanned multiple years and multiple periods within years and that occurred in the vicinity of the site, even though these studies were not conducted by the applicant.

Moreover, as discussed in the FEIS, the applicant initiated impingement monitoring and entrainment monitoring in March 2008 to estimate species composition and density of ichthyoplankton entrained by the cooling water withdrawals and to qualitatively identify and enumerate fish impingement rates. Exhibit NRC000001 at 2-94; Exhibit NRC000031 at 1 and 2. The Staff discussed the initial results of the impingement monitoring in Section 5.4.2.2 of the FEIS. Exhibit NRC000001 at 5-32. Furthermore, since the time the FEIS was issued, the applicant has provided additional preliminary results of these site-specific studies for both entrainment and impingement, which are discussed later in this testimony.

The Staff considered the data that was presented in the application along with other data that was available to be adequate for the Staff's review and consistent with Staff guidance.

Q9. What sources or studies did the Staff rely on for preparing its description of aquatic species and habitat in the FEIS? How did the Staff determine which sources to include?

A9. (RHK) The Staff relied on a variety of sources of information to prepare the description of the aquatic species and habitats in the FEIS. There were five major sources or groupings of sources of information that were used, as well as specific reports that addressed individual species.

First, the Staff used Marcy et al. to provide a general description of the environment, and specifically to identify the fish species that are present in the stretch of the Savannah River adjacent to the site as given in Section 2.7.2.1 of the FEIS. Exhibit NRC000006; Exhibit NRC000001 at 2-74 and 2-77 to 2-80. In the Introduction to Marcy et al., the authors explicitly

state on page 1 that “Our book comprises habitat characterizations, family descriptions, species accounts, habitat and species photographs, and a taxonomic identification key.” The data that are presented by Marcy et al. were obtained from an area from RMs 97 to 221. The VEGP site is located at RM 150 to 152, roughly the midpoint in this stretch of the river. Marcy et al. based their records of distribution in the Middle Savannah River Basin (MSRB) and species life history information on more than 120 years of data collection from the MSRB and 50 years for the Savannah River Site (SRS). Exhibit NRC000006 at 7. According to Marcy et al., the SRS, which is located directly on the other side of the Savannah River from the VEGP site, has contributed more than 500 publications to fish studies. Exhibit NRC000006 at 8. Marcy et al. also used other sources, including input from the South Carolina Department of Natural Resources. Over 33 pages of references are provided in Marcy et al., as literature sources that were cited in the development of this compendium. Exhibit NRC000006 at 419 to 452.

Marcy et al. was not developed to provide an impact assessment, although the chapter entitled “Savannah River and Swamps” and the subsection entitled “Human Influences on the Fish Fauna of the Savannah River and Associated Swamps” does describe the many sources of indirect influences on the local fish fauna including urbanization, fisheries, industrial activities, the Savannah River Site, flood/water control, channelization, sedimentation and pollution. Exhibit NRC000006 at 13 to 20 and 14 to 17. In the discussion of industrial activities, Marcy et al. indicates that historically the largest sources of entrainment in the MSRB have been the cooling water intakes for SRS and Plant Vogtle. Exhibit NRC000006 at 16. Marcy et al. does not specify water velocity across the intake screens. Marcy et al. also does not quantify or compare the magnitude of the entrainment impacts in relation to other industrial impacts or to other impact sources on this list.

Second, the Staff used a series of reports that were developed by the Academy of Natural Sciences in Philadelphia as a source of information for the FEIS to describe the aquatic species composition and habitat in the Savannah River. The three reports referred to in the

FEIS were published in 2001, 2003 and 2005 (ANSP 2001, ANSP 2003, ANSP 2005). The ANSP conducted biological and water quality studies in the Savannah River between RM 122 and RM 160 starting in 1951 for the purpose of assessing potential effects of the SRS on the aquatic communities in the Savannah River. Components of the ANSPs study included basic water chemistry, diatoms, other attached algae, aquatic macrophytes (mosses and rooted aquatic plants), protozoa, aquatic insects, non-insect macroinvertebrates and fish. Sampling stations were added at RM 151.2 and 149.8 in 1985 to assess the potential impacts of the VEGP site. Exhibit NRC000003 at ii, 2, 3 and 15-16. The ANSP conducted two types of surveys – "comprehensive surveys" and "cursory surveys", defined as surveys including "a reduced set of components, typically attached algae, insects and fish, but [that] were conducted annually with four sampling periods per year. During years with comprehensive surveys, the comprehensive surveys substituted for two of the usual cursory sampling periods. Cursory surveys occurred at the Vogtle site until 1997. Exhibit NRC000003 at ii. Beginning with data from 1997 and continuing with data collected through 2000, aspects of the Plant Vogtle surveys were combined into a single, comprehensive study, which included fish species. The last sampling at Station 2B (one of the original Vogtle stations) was conducted in 2001, but the samples were archived and not analyzed. Exhibit NRC000003 at 199 and 200.

The Staff used the ANSP studies to provide an understanding of the river ecology and the current species of fish and molluscs present in the vicinity of the VEGP site. These studies demonstrate that the Savannah River has been studied extensively upstream and downstream of the VEGP site and at different seasons throughout the year. The Staff also used the studies to provide an indication of the impacts of the SRS facilities and the existing VEGP Units 1 and 2 on the health of the Savannah River. When all SRS facilities were in operation, they withdrew considerably greater amounts of cooling water than are anticipated to be withdrawn by VEGP Units 3 and 4. The VEGP Units 1 and 2 withdraw an amount comparable to that anticipated for VEGP Units 3 and 4. The ANSP studies were "designed to assess the potential effects of

Savannah River Site (SRS) contaminants and warm-water discharges on the general health of the river and its tributaries." Exhibit NRC000003 at i. Surveys above and below the Plant Vogtle intakes were initiated in 1985 "to assess potential impacts of Georgia Power and Light's Vogtle Nuclear Power Plant so that these could be separated from potential SRS impacts" (*id.* at ii). The Staff noted in FEIS Section 2.7.2.1 that the ANSP 2001 study data (ANSP 2003) indicated that species richness for fish was significantly higher at the sampling location farther downstream than at the sampling location upstream of the SRS, and, further, that neither species diversity, nor densities of common species of fish, differed significantly between stations. Exhibit NRC000001 at 2-81; Exhibit NRC000003 at x. Moreover, in a finding the Staff did not specifically cite in the FEIS, the ANSP went further and stated that "We conclude that…results of the 2001 Savannah River biomonitoring study do not provide compelling evidence of an SRS impact on biological communities in the river." Exhibit NRC000003 at xi. The ANSP also characterized its sampling program as being "one of the most comprehensive ecological datasets available for any of the world's rivers." Exhibit NRC000003 at v.

A third source of information was two overlapping reports describing the ichthyoplankton distribution, which was discussed in FEIS Section 2.7.2.1. Exhibit NRC000001 at 2-81. Both sources were studies conducted by the Savannah River Site and reported in Specht (1987) and Paller (1986). Specht (1987), "Comprehensive Cooling Water Study Final Report," is a comprehensive review of Paller (1986), "Distribution and Abundance of Ichthyoplankton in the Mid-Reaches of the Savannah River and Selected Tributaries" and several other reports. Exhibit NRC000011 at V-241 to V-335 and V-454 to V-536; Exhibit NRC000012 at xii to xvii and 3-1 to 5-9, respectively. These studies involved the stretch of the river along the southwestern edge of the SRS, which is directly across the river from the VEGP site. Although the studies were 20 or more years old, they were included in the FEIS because they occurred at the same location and showed similar species distributions.

A fourth source of information that the Staff used became available after the Staff's Draft Environmental Impact Statement ("DEIS") was published, when the Staff received notice from the USFWS that a study had been performed for that agency by The Catena Group. The report, "Freshwater Mussel Surveys, The Savannah River from Augusta to Savannah: South Carolina & Georgia," is based on data collected in a survey of freshwater mussels in the Savannah River between RM 22.8 and RM 203, performed in late 2006. Exhibit NRC000005 at 2. This is the most recent study of the freshwater mussels in the river that has been conducted. The Staff used this study to update information in Section 2.7.2.1 of the FEIS, including the number of important species identified during the survey and their locations. Exhibit NRC000001 at 2-76, 2-87, and 2-88.

A fifth set of information was used to provide general background or used in the development of descriptions of specific species and their life histories. These include the Final Environmental Statement ("FES") for Vogtle Units 1 and 2, and comprehensive studies such as Bennett and McFarlane, 1983, "The Fishes of the Savannah River Plant: National Environmental Research Park" (written to provide background information on the Savannah River). Exhibit NRC000013, Exhibit NRC000014. Specific studies were used for developing descriptions of aquatic species and their life history, such as Hendricks, 2002, "The Conservation and Restoration of the Robust Redhorse, *Moxostoma robustum*"; Nichols, 2003, "Conservation Strategy for Robust Redhorse (*Moxostoma robustum*); and Grabowski and Isely, 2006, "Seasonal and Diel Movements and Habitat Use of Robust Redhorses in the Lower Savannah River, Georgia, and South Carolina", which are cited in the FEIS to describe the spawning locations and larval behavior of the robust redhorse. Exhibit NRC000001 at 2-88 and 2-89; Exhibit NRC000015, NRC000016, NRC000017, respectively. These sources and studies were among the most recent, reliable and authoritative studies of which the Staff was aware.

Q10. How did the Staff determine which aquatic species were to be described in detail?

A10. (RHK) The Staff's criteria for selection of "important" species is given in ESRP Section 2.4.2, "Aquatic Ecology," (ESRP 2000) and in Regulatory Guide 4.2, "Preparation of Environmental Reports for Nuclear Power Stations". ESRP Section 2.4.2 instructs the reviewer to "identify the species and habitats that will be considered 'important' ecological resources of the site, vicinity…and offsite areas for evaluation of potential impacts on them, using Table 2.4.2-1 as a reference." Exhibit NRC000009 at 2.4.2-6. ESRP Table 2.4.2-1 is titled "Important Species and Habitats," and it provides the guidance for determining species that are "important" for the Staff's review. Exhibit NRC000009 at 2.4.2-7.

Regulatory Guide 4.2's guidance for applicants defines a species to be "important" "if a specific causal link can be identified between the nuclear power station and the species and if one or more of the following criteria applies: (a) the species is commercially or recreationally valuable, (b) the species is threatened or endangered, (c) the species affects the well-being of some important species within criteria (a) or (b), or (d) the species is critical to the structure and function of the ecological systems or is a biological indicator of radionuclides in the environment." Exhibit NRC000007 at 2-3. In most cases, for facilities with closed-cycle cooling, the causal link between the nuclear power plant operations and impacts on aquatic species is rather weak (as discussed later in this testimony in response to Questions 22 and 28).

The Staff determined "important" species for the VEGP ESP review by referring to the criteria in Table 2.4.2-1 (following the guidance in ESRP Section 5.3.1.2) and comparing that guidance (along with the guidance in Regulatory Guide 4.2, which is similar) to the list of species identified in the studies discussed in the response to Question 9. In addition, the Staff contacted the appropriate Federal and state agencies. These agencies included the Southeast Regional Office of the National Marine Fisheries Service, the Coastal Georgia Suboffice of the U.S. Fish and Wildlife Service, the Georgia Department of Natural Resources, and the South Carolina Department of Natural Resources.

In a letter dated October 24, 2006, the National Marine Fisheries Service provided a listing of Federally-protected species under the jurisdiction of NMFS for the state of Georgia (NMFS 2006). Exhibit NRC000018. Of these species (as discussed in Section 2.7.2.1 and 2.7.2.2 of the FEIS), the only Federally listed threatened or endangered aquatic species known to occur in the Savannah River in the vicinity of the VEGP site was the shortnose sturgeon (*Acipenser brevirostrum*). Exhibit NRC000001 at 2-86 and 2-89. The State of Georgia lists the shortnose sturgeon (*Acipenser brevirostrum*), robust redhorse (*Moxostoma robustum*), and the Atlantic pigtoe mussel (*Fusconaia masoni*) as State-endangered. Exhibit NRC000001 at 2-85 and 2-86. The Savannah Lilliput mussel (*Toxolasma pullus)* is considered threatened in South Carolina. This information was obtained from the South Carolina Department of Natural Resources website and confirmed verbally with State staff. Exhibit NRC000021; Exhibit NRC000020. Nine mussels that were South Carolina state species of concern were identified from the South Carolina Department of Natural Resources website and confirmed through discussions with South Carolina DNR staff. In addition, the Savannah darter (*Etheostoma fricksium*) is considered a species of concern for the State of Georgia; however, it does not have a legal protected status in the State. The Staff therefore did not consider it an "important species." Exhibit NRC000001 at 2-86.

In the FEIS discussion of threatened and endangered aquatic species known to occur in the vicinity of the Vogtle site, the Staff states that the Atlantic sturgeon (*Acipenser oxyrinchus*) is considered a species of concern by the National Marine Fisheries Service. This statement was based on information provided by NMFS in its letter dated October 24, 2006 in response to NRC's letter dated October 12, 2006, requesting a list of endangered, threatened, candidate and proposed species. Exhibit NRC000018. However, the Staff subsequently discovered that the Atlantic sturgeon's Federal listing status was changed from "Species of concern" to "candidate species" in the Federal Register (71 Fed. Reg. 61022, 61023) on October 17, 2006, and thus the Atlantic sturgeon should have been included as an "important species" in the FEIS

because “candidate species” are included in the definition of “important species” provided in ESRP Section 2.4.2. Exhibit NRC000009 at 2.4.2-6 and 2.4.2-7. Listing as a candidate species, according to NMFS, “does not confer any procedural or substantive protections of the [Endangered Species Act (ESA)] on the candidate species”. 71 Fed. Reg. 61,022. However, the Staff does consider the distinction between Federal “species of concern” and “candidate species” in its environmental review guidance, including NUREG-1555, “Environmental Standard Review Plan” (2000) (“ESRP”). Exhibit NRC000009 at 2.4.2-6.

The Staff discussed commercially and recreationally important fish (referred to in ESRP 2.4.2-7 as “Commercially and recreationally valuable species”) in the vicinity of VEGP on page 2-81 and 2-83 of the FEIS. *Id.* at 2.4.2-7. These fish were identified from general statements in Marcy et al., 2005 and Halverson et al., 1997, as part of descriptions of the commercial and recreational fisheries in the area. Exhibit NRC000006 at 15; Exhibit NRC000023 at 3-45 and 3-48. In addition, the Staff consulted the SCDNR and GADNR regulations posted on those agencies’ websites for commercial and recreational fishing. The identified commercial fisheries included American shad (*Alosa sapidissima*), channel catfish (*Ictalurus punctatus*), white catfish (*Ameiurus catus*) and American eels (*Anguilla rostrata*). Recreationally important fish included striped bass (*Morone saxatilis*) and to a lesser degree, sunfish (*Lepomis* spp.) and crappie (*Pomoxis* spp).

Based on the guidance in the ESRP and the information from other agencies, the Staff determined that, with the exception of the Atlantic sturgeon, a newly identified candidate species, the Staff correctly identified the list of “important” aquatic species for its review of the application.

Q11. Why did the Staff only provide the detailed life history information for the “important species” in the FEIS?

A11. (RHK) Life history information was only provided for species that were considered “Important species” as specified by ESRP Section 2.4.2. Exhibit NRC000009.

ESRP Section 2.4.2 instructs the reviewer to provide "a discussion of 'important' aquatic species that may be affected" by plant construction or operation. *Id.* at 2.4.2-7. It states that "[s]pecial habitat and forage needs should be emphasized, if the proposed project would potentially disrupt these." *Id.* The ESRP also states that the "extent of discussion of various biotic components should be in proportion to the estimated severity of impacts and should be adequate to support the assessment of ESRP Chapters 4.0 and 5.0 [for construction and operation impacts, respectively]." *Id.* at 2.4.2-6.

Guidance for applicants is also provided in Regulatory Guide 4.2. Regulatory Guide 4.2, "Preparation of Environmental Reports for Nuclear Power Stations," states that "[s]pecial attention should be given to the relative importance of the station area to the total regional area of the living resources (potential or exploited)." Exhibit NRC000007 at 2-4. Regulatory Guide 4.7, "General Site Suitability Criteria for Nuclear Power Stations," contains guidance concerning the ecological systems and biota at potential sites and states that their environs should be sufficiently well-known to allow reasonably certain predictions that there would be no unacceptable or unnecessary deleterious impacts on populations of important species. Exhibit NRC000008 at "B. Discussion." Under Regulatory Guide 4.2, as previously discussed in my testimony in response to Question 10, a species is "important" if a specific causal link can be identified between the nuclear power station and the species and if "one or more" specified criteria applies.

Consistent with the guidance in the ESRP and Regulatory Guide 4.2, the Staff included life histories of the robust redhorse, shortnose sturgeon, American shad, American eel, and striped bass in the FEIS. Exhibit NRC000009; Exhibit NRC000007. Although the blueback herring, sunfish, crappie, and catfish were identified as recreational or commercially important fish, they were not discussed in greater detail because they either were identified as being a significantly smaller fishery and thus less valuable (catfish; blueback herring) or they were not identified as being one of the favorite recreational species in the area (crappie and sunfish).

The instructions of Regulatory Guide 4.7 and Regulatory Guide 4.2 refer to a detrimental effect and a causal link. Exhibit NRC000008; Exhibit NRC000007 at 2-3. For closed-cycle cooling systems, like that proposed for VEGP Units 3 and 4, there is no detrimental effect on species (as discussed later in this testimony in response to Questions 22 and 28); accordingly, the Staff presented detailed life history data only for "important" species.

Q12. How did the Staff decide what life history information to include for those "important species"?

A12. (RHK) According to the guidance in ESRP Section 2.4.2, the Staff should provide "the temporal and spatial (including depth) distribution and abundance of important aquatic species, especially in the discharge area and receiving water body." Exhibit NRC000009 at 2.4.2-3. Relatedly, "[s]uch critical life-support requirements as spawning areas, nursery grounds, food habits, feeding areas, wintering areas, and migration routes" are included "to the extent that power plant construction or operation is expected to affect these parameters." *Id.* The depth and extent of life history information provided in the EIS for a given species should relate directly to the nature and magnitude of the impact to that species that would result from the construction and operation of the facility. *Id.* at 2.4.2-6.

In cases where a fish species is considered to be recreationally or commercially important, but where the fishery is not significant and unique to the vicinity of the plant, and where the plant is expected to have very little impact on the species, the life history is usually not discussed in the FEIS or is only discussed briefly. For example, members of the family Ictaluridae (freshwater bullheads, catfishes and madtoms) are located near the site and have been identified as species that are commercially fished; however, the fishery is not a major one, it is not unique to this portion of the Savannah River drainage, the fish species is not managed by state or Federal agencies, and the fish is known to be found commonly along the eastern coastal states or major parts of the United States.

ESRP Section 2.4.2 specifies that the "input should be brief" for life histories. *Id.* at 2.4.2-6. The data needed to assess the impact to important aquatic species is dependent on the type and potential for impact. While there may be much data available on the life history of a particular species, much of it may not be relevant to the Staff's analysis. For example, the Staff's life history description for the sturgeon and robust redhorse contains the species' spawning locations, and the characteristics of larvae, because this provides information relative to the impact of the proposed units on these fish. However, the Staff mentioned the spawning area for the American eel only in passing since it is in the Sargasso Sea, well out of range of any impact from the VEGP site.

Q13. You stated that the Atlantic sturgeon's Federal listing status was changed from "species of concern" to "candidate species" during the Staff's review and thus should have been discussed in the FEIS as an "important species." Accordingly, please explain how the Staff would have described the life history for the Atlantic sturgeon in the FEIS.

A13. (RHK) The Staff identified the Atlantic sturgeon, *Acipenser oxyrinchus*, in FEIS Table 2-7 as being present in the Middle Savannah River Basin based on information from Marcy et al., 2005. Exhibit NRC000001 at 2-79; Exhibit NRC000006 at 10. The Staff also discussed the species in the FEIS, in relation to a previous fishery closure for harvest of Atlantic sturgeon, and with respect to its status (as understood by the Staff at that time) as a "species of concern" and its similarity to the shortnose sturgeon (Collins and Smith 1997). Exhibit NRC000001 at 2-81 and 2-89; Exhibit NRC000022. Additional information that the Staff would have included with respect to the Atlantic sturgeon's life history includes the following:

> The Atlantic sturgeon is a member of the Family Acipenseridae, a long-lived group of ancient anadromous and freshwater fishes. The Atlantic sturgeon was listed in the Federal Register on October 17, 2006 (71 FR 61,022, 61,023) as a "candidate" species. Listing as a "candidate" species does not confer any procedural or substantive protections of the Endangered Species Act (ESA) on the "candidate" species (71 FR

61,022). Thus, the Atlantic sturgeon's changed status implicates no additional statutory requirement under the ESA. However, pursuant to its guidance, the Staff does include candidate species as "important species" in its environmental reviews.

Historically, the Atlantic sturgeon was present in 38 rivers in the United States, from St. Croix Maine to the Saint Johns River in Florida. Thirty-five of the rivers were confirmed to have a historical spawning population. Currently, Atlantic sturgeon is present in 35 rivers and spawning occurs in at least 20 of them (including the Savannah River). Exhibit NRC000025 at 6.

Although the Atlantic sturgeon life history has been intensely studied since the 1970s, there are still important aspects that are unknown. Generally the Atlantic sturgeon is anadromous and spends the majority of its life in marine waters, but reproduces in a freshwater habitat. Like the shortnose sturgeon, spawning adults generally migrate upriver in the spring (February to March) in southern rivers. Atlantic sturgeon spawning is believed to occur in flowing water between the salt wedge and the fall line of large rivers. Atlantic sturgeon eggs are highly adhesive and are deposited on the bottom substrate, usually on hard surfaces. Hatching occurs in approximately 94-140 hours after egg deposition at temperatures of 20 and 18 degrees C, respectively. Larvae tend to stay near the bottom. After 8-12 days, when the yolk-sac larval stage is complete, the larvae move downstream to rearing grounds over a 6-12 day period. During the first half of their migration, movement is limited to night, and in the day they use the bottom (for example a gravel matrix) as refugia. During the last half of the migration stage, when the larvae are more fully developed, the migration occurs both day and night. Juvenile sturgeon eventually arrive in estuarine waters, where they remain for months or years. *Id.* at 3 and 4.

Further, as explained later in response to Questions 24 and 33, the Staff would have come to a conclusion, which would be similar to that for the shortnose sturgeon, that the Atlantic sturgeon would not be adversely affected by the proposed VEGP units.

Q14. How does the Staff's description of aquatic species in the FEIS account for flow-habitat relationships and the potential impacts of the project on habitat availability?

A14. (MTM) As the flow in a river is reduced, it follows that the habitat available for aquatic biota is also diminished. In a river, the relationship between flow and the habitat available to a species, depending on the species' habitat requirements, is most often not a linear relationship. Depending on the bathymetry of the river, a small change in flow could, for example, significantly reduce the amount of shallow water overbank habitat necessary for some species. However, for a deep river channel with steep banks, even experiencing a significant change in river flow could have little effect on the amount of habitat available.

The Staff examined the relationship between river flow rate and habitat availability in the Savannah River. Low river flow conditions, coupled with the consumptive loss of water from the river due to the operation of VEGP Units 3 and 4, may result in a reduction of habitat for aquatic biota, thereby affecting local or regional fish populations. However, this situation is unlikely at the VEGP site. As stated in the FEIS, at the maximum withdrawal rate of 129 cfs, the resulting decrease in river stage as a result of operating the proposed VEGP Units 3 and 4 would be approximately 2 inches at Drought Level 3 conditions (3800 cfs) and approximately 1 inch under average-daily discharge river flow (8830 cfs). Exhibit NRC000001 at 5-8. Average river depth in the vicinity of the discharge structure is slightly more than 8 feet. *Id.* at 5-17. Such reductions in river stage would not result in any measurable impact to populations of aquatic biota inhabiting the river in the vicinity of the station.

Moreover, daily fluctuations in river flow due to upstream activities have a much greater effect on river stage than would the consumptive use of water due to Units 3 and 4 operations. Although the Staff did not discuss the relative size of these fluctuations in the FEIS, such daily

fluctuations, based on flow records from the USGS gauge on the Savannah River at Waynesboro, Georgia (Waynesboro gauge) for the period January 2005 through October 2008, would have exceeded the normal consumption rate of 62 cfs for the two proposed VEGP Units 83 percent of the time. Exhibit NRC000041. Changes in flow rate of the Savannah River occur frequently, and organisms inhabiting the river currently tolerate this variation and will continue to do so whether or not the VEGP Units 3 and 4 become operational.

A recent study by Freeman and Marcinek (2006) evaluated the effects to aquatic biota from altering stream flows through water withdrawals and the use of instream reservoirs. Exhibit NRC000027. Impacts related to changes in aquatic habitat due to altered flow regimes were investigated. *Id.* at 436. Some 27 sites on six river systems, including the Savannah River system, were studied. One of the parameters Freeman and Marcinek evaluated and determined did influence the presence of fluvial fish species was a parameter they termed the withdrawal index (WI). *Id.* at 436 to 439. The WI was computed by dividing the withdrawal rate of water from the water body by the calculated 7Q10 of the watercourse. For example, in the case of VEGP Units 3 and 4, the proposed consumptive water withdrawal for the two units is 62 cfs and the calculated 7Q10 for the Savannah River in the vicinity of the VEGP site is 3828 cfs; accordingly, the computed WI for VEGP Units 3 and 4 would be 0.016. Exhibit NRC000001 at 5-9 and 2-20.

Freeman and Marcinek (2006) concluded that "…streams in the lower Piedmont [Physiographic Province] may begin to experience species losses if permitted withdrawals exceeds about 0.5 to one 7Q10-equivalent of water." Exhibit NRC000027 at 447. The lower range of the WI value of 0.5 for Freeman and Marcinek's action level is over 30 times greater than the computed WI value for the VEGP Units 3 and 4 using the combined water consumption value for both units.

Although the Staff did not discuss this study in the FEIS, I believe that the results of this study provide additional support to the Staff's conclusion that the consumptive loss of water due

to operation of two additional units, even at persistent low flow conditions, will not result in habitat changes that cause a detectable alteration of the Savannah River fishery by shifting species composition from species that require flowing water for at least part of their life-cycle (fluvial specialists) to species that are able to maintain populations in both lotic and lentic environments (habitat generalists).

Additionally, as the Staff stated in FEIS, aquatic organisms inhabiting rivers and streams flowing into the Atlantic are preadapted to tolerate large variations in water flow. Exhibit NRC000001 at E-75. Periodic droughts have historically occurred in the rivers of the southeastern United States. *Id.* Prior to the construction of the upstream impoundments on the Savannah River, flows in the Savannah River periodically dropped to as low as 1000 to 1500 cfs. Exhibit NRC000028. Despite these periodic very-low flows, aquatic organisms have persisted in the Savannah River. Since the construction of Thurmond Reservoir, completed in the mid-1950s, flows have been regulated and these exceedingly low historic flows have not re-occurred. Finally, I am unaware of any species having been extirpated from the middle Savannah River for any reason, including very-low river flows, since scientific collecting in the river began.

In the FEIS, the Staff considered the flow-habitat relationship and its potential to affect the availability of suitable habitat, specifically the potential impact to aquatic organisms due to the reduction in flow resulting from the consumptive use of the river water. The Staff determined that the reduction in river stage would be minor and there would be no detectable impact on populations. For the reasons just discussed, this conclusion is supported by the persistence of species in the Savannah River despite historic low water events and the large daily variations in Savannah River water flow that already occur without adverse impact to fish populations.

Q15. What is the Staff's basis for determining that its description in the FEIS of relevant aquatic resources is adequate in the absence of additional monitoring in the vicinity of Plant Vogtle?

A15. (RHK) The Staff determined that its description of the aquatic resources in the Savannah River in the vicinity of the VEGP site contained in Section 2.4.2 of the FEIS is adequate and systematic for three reasons: 1) it provides a sufficient description of the aquatic resources in the vicinity of the VEGP site based on data obtained in the vicinity of the VEGP site by entities other than the applicant; (2) the Staff complied with the relevant guidance in ESRP Section 2.4.2; and (3) the comments received on the draft EIS from state and Federal agencies were used to update the description of the aquatic resources in the FEIS. Exhibit NRC000009 at Section 2.4.2.

The Staff's description of aquatic resources in the vicinity of the VEGP site is sufficient for assessing impacts, even in the absence of site-specific data provided by the applicant, because the Staff relied on sources of data, some of which were recent, some of which provided data that spanned multiple periods within years, and all of which were focused on the middle stretch of the Savannah River or on the sections of the river adjacent to the VEGP site. These sources included the FEIS for operation of Units 1 and 2, Marcy et al., 2005, the SRS studies (including Paller et al. 1986 and Specht 1987), the recent survey of freshwater mussels for the USFWS (The Catena Group, 2007), and the most recent ANSP studies (ANSP 2001, ANSP 2003, ANSP 2005). Exhibit NRC000014; Exhibit NRC000006; Exhibit NRC000012; Exhibit NRC000011; Exhibit NRC000005; Exhibit NRC000002, Exhibit NRC000003; Exhibit NRC000004, respectively. The Staff primarily used Marcy et al., 2005 to develop the list of species that appears in FEIS Table 2-7. Exhibit NRC000005; Exhibit NRC000001 at 77 to 79. The Staff compared this list with the species that were identified in the SRS studies and in the ANSP studies to confirm that the Staff's list was complete. The information in Marcy et al. 2005 spanned more than 120 years of scientific data collection. Exhibit NRC000005. The SRS data

were from focused studies on the stretch of river near the VEGP site and spanned multiple periods of time during a given year. Exhibit NRC000011; Exhibit NRC000012. As discussed in more detail in response to Question 22, the SRS studies evaluated impacts from intake structures with a much larger withdrawal rate and through-screen velocity than those anticipated for VEGP Units 3 and 4.

The Staff used the ANSP studies for characterization of the environment and the relative health of the stretch of the river adjacent to the SRS, a stretch which is also adjacent to the VEGP site. Because the ANSP data were recent, the Staff used it to capture the description of the status of the relative abundance of fish from the Savannah River, as well as to characterize the environment related to diatoms, aquatic insects and molluscs.

Because neither Marcy et al. nor the ANSP study directly addressed the concentrations of fish larvae and eggs in the Savannah River, the Staff relied on the studies performed by the SRS in the mid-1980s. Exhibit NRC000011; Exhibit NRC000012. Although this data is over 20 years old, the Staff determined that, based on the similarity in the descriptions of the environment and in the distribution and abundance of fish reported in the SRS studies as compared to the ANSP studies and the Marcy et al. compendium, the SRS studies on ichthyoplankton were appropriate sources for the FEIS analysis. *Id.*

The Staff complied with the relevant guidance in ESRP Section 2.4.2 by identifying the species and habitats that would be considered “important”; consulting with local offices of appropriate Federal (including the USFWS) and National Marine Fisheries Service (NMFS)) and State agencies to verify the possible occurrence of such species; identifying the threatened or endangered species that, based on known distributions, could be represented within these areas; and listing the commercially and recreationally valuable species in consultation with State or local agencies or organizations. Exhibit NRC000009 at Section 2.4.2.

Further, the Staff provided brief input that contained the information requested by ESRP 2.4.2, including principal ecological features of the site and an emphasis on the communities

that could potentially be affected by project construction, operation or maintenance. Exhibit NRC000009 at 2.4.2-6 to 2.4.2-8. This input included descriptions of studies that provided data that spanned multiple time periods in a given year to reflect seasonal variations in aquatic populations (the ANSP comprehensive studies and the SRS ichthyoplankton studies). The FEIS also included descriptions of environmental and man-induced stresses, and a description of important aquatic species that could be affected by construction or operation.

Following publication of the DEIS, the Staff received comments from other Federal agencies that supplemented the analysis made by the Staff. This information was incorporated into the FEIS. For example, the USFWS provided a copy of a report on mussels in the Savannah River, of which the Staff had not previously been aware. Exhibit NRC000005. The information in this report was provided in the FEIS to supplement the description of the Savannah River mussel population that had been presented in the DEIS. This information did not change the Staff's conclusion with respect to impacts on aquatic resources.

As mentioned previously, the Staff also consulted with other Federal agencies such as the USFWS and the NMFS. However, the response resulting from the Staff's consultation with the NMFS regarding the shortnose sturgeon was not included in the FEIS because it was received after publication of the FEIS. The response from NMFS to the biological assessment on the shortnose sturgeon that was provided by the NRC is given as an attachment to this testimony. Exhibit SNC000022 at 4. As explained later in this testimony, the response from NMFS supports the Staff's conclusion with respect to impacts on aquatic resources.

In sum, the Staff determined that the data available was adequate to characterize the environment in the vicinity of the VEGP site and to allow the identification of important species. Moreover, subsequent to the publication of the FEIS the applicant provided additional data related to the impingement and entrainment sampling program for VEGP Units 1 and 2, and these data support the Staff's conclusion on the distribution and abundance of species in the

river. Exhibit NRC000030. These data are discussed further in the Staff's responses to Questions 22, 25, 30 and 34, below.

II. Impacts to Aquatic Resources from Impingement and Entrainment

A. Background

Q16. What does the Staff mean when it discusses impacts from "impingement" and "entrainment"?

A16. (MTM) Operation of nuclear power stations requires the withdrawal of large amounts of water, almost always from surface waterbodies, to dispose of waste heat. Water is circulated through various station components and heat exchangers. Debris and large aquatic organisms need to be removed from the water before it enters critical station components. Removal of material in the water column is typically accomplished by rotating traveling screens. The typical intake screen mesh size is 3/8 inch. Any debris and aquatic organisms that are larger than about 3/8 inch in any dimension can end up "impinged" on the intake screens. Impingement takes place when organisms are trapped against intake screens by the force of the water passing through the cooling water intake structure. The most common organisms impinged are fish, macroinvertebrates, shellfish, and aquatic macrophytes. Impinged organisms can be injured or killed due to mechanical forces, asphyxiate due to the inability to properly move their gills, or be preyed upon by larger organisms. Impingement losses are dependent on a number of factors, including the type of cooling system, whether once-through or closed-cycle; the station location; the source waterbody type; the intake structure's through-screen velocity; characteristics of the species being impinged; the condition of the organism at the time of impingement; and the amount of debris in the water column. Certain species of fish can, after impingement, be returned by a fish return system to the source waterbody and experience little or no long term effects. Others experience a high level of mortality after transiting the fish return system.

The action of withdrawing organisms small enough to pass through the intake screens along with the cooling water into the plant is termed “entrainment.” Organisms that typically become entrained are relatively small benthic, planktonic, and nektonic organisms, including the early life stages of fish and shellfish. Once entrained into the station, these organisms are subjected to mechanical, thermal, hydrostatic, and sheer stresses, as well as chemical toxemia induced by a variety of chemicals introduced into the cooling system. As with impingement, entrainment losses are dependent on a number of factors as well, such as type of cooling system, whether once-through or closed-cycle; the station location; intake design; the source waterbody type; the presence and density of ichthyoplankton; the motility of the entrainable organisms; and other characteristics of the species being impinged. Due to the recirculation nature of the cooling systems proposed for new facilities, the mortality sustained by entrained organisms is generally accepted to be 100 percent. Exhibit NRC000010 at 5.3.1.2-8.

Q17. What is the difference between closed-cycle and once-through cooling? Why is the distinction significant with respect to the water withdrawal rate at the Vogtle site?

A17. (MTM) A closed-cycle cooling system is designed to transfer most of the waste heat from the reactor to the atmosphere by evaporation. Water is routed to the station to support contact and/or non-contact cooling uses and then cycled to a cooling canal, lake, pond, or tower to allow waste heat to be dissipated to the atmosphere mostly through the process of evaporation. The water is then returned to the station for reuse. A portion of the water flow is discharged from the system (blowdown) to maintain water quality, and water is added (makeup) from the water source to replace water lost due to drift, evaporation, blowdown and any other losses from the system. The cooling system proposed for VEGP Units 3 and 4 is a closed-cycle cooling system. Exhibit NRC000001 at 3-5.

(LWV, CBC) In contrast, a once-through cooling water system utilizes a cooling strategy not proposed for VEGP Units 3 and 4. A once-through system relies on the withdrawal of water from a waterbody, using it at the facility to support contact and/or non-contact cooling uses, and

then discharging the heated water to a waterbody without recirculation. Hypothetically, if two units similar to those planned for VEGP Units 3 and 4 were designed to utilize once-through cooling, approximately 1.5 E^{10} BTUs of heat would be transferred to the cooling water. Almost all of that heat would ultimately be transferred to the receiving waters. With a source waterbody inlet temperature of 80 degrees Fahrenheit, the two hypothetical once-through cooling system units would require approximately 5844 cfs of cooling water to maintain a discharge temperature of 91.5 degrees Fahrenheit. The hypothetical two unit plant would discharge the 5844 cfs of heated water into the receiving waters downstream of the intake structure.

(LWV, CBC) The applicant's proposed closed-cycle cooling system, employing cooling towers for both units, would result in approximately 4.26 E^{8} BTU/hr of heat discharged to the receiving waterbody through a normal discharge flow of 21 cfs (9608 gpm as given in the FEIS) and the makeup flow to the cooling system of approximately 83 cfs. Exhibit NRC000001 at 3-9. Employing a closed-cycle cooling system for the two new units at the VEGP site results in only about 3 percent of the waste heat discharged to the receiving waters and 1.4 percent of the water withdrawal from the source waterbody when compared to the same station design utilizing once-through cooling system.

(MTM) For reasons described further in the FEIS and in the remainder of my testimony, these significant reductions in cooling water withdrawals and thermal discharges compared to a once-through cooling system, would result in no detectable impact to populations of aquatic organisms inhabiting the Savannah River due to impingement or entrainment or thermal discharges at the river stages evaluated by the Staff.

Q18. Did the Staff evaluate in the FEIS the impacts to aquatic resources in terms of impingement and entrainment from proposed Units 3 and 4 operations?

A18. (MTM) Yes. In Section 5.4.2.2 of the FEIS, the Staff evaluated the impacts to aquatic resources from impingement and entrainment from the proposed Units 3 and 4 operations. Exhibit NRC000001 at 5-29 to 5-33. As described in the testimony below, the Staff

determined that impingement caused by operation of the proposed VEGP Units 3 and 4 would have no detectable impact on fish populations inhabiting the Savannah River.

B. Impingement

Q19. What conclusion did the Staff reach as to impacts on fish populations in the Savannah River due to impingement losses due to the operation of VEGP Units 3 and 4?

A19. (MTM) The Staff concluded in Section 5.4.2.9 of the FEIS that impacts due to impingement on the intake screens to fish and shellfish populations in the vicinity of the site would be minor. Exhibit NRC000001 at 5-38. The Staff based that conclusion on a) the planned low through-screen intake velocity of less than 0.5 feet per second at the minimum river water level of 78 feet, b) the applicant's use of closed-cycle cooling, which reduced river water withdrawal substantially, c) a calculated intake canal flow velocity towards the intake screens of about 0.1 feet per second, d) an evaluation of life history, distribution, and abundance data of aquatic species, including "important species" inhabiting the middle Savannah River, e) the past absence of significant impingement episodes at the existing intake of Units 1 and 2 and information collected during NRC site visits, and f) the results of the SRS impingement study.

Q20. What is the Staff's guidance for reaching a determination of impacts from impingement?

A20. (MTM) The Staff's analysis and assessment of potential plant intake system impacts, including impingement, on aquatic organisms is directed by guidance found in NUREG–1555, the NRC's Environmental Standard Review Plan (ESRP). Exhibit NRC000009; Exhibit NRC000010. ESRP Section 5.3.1.2, Aquatic Ecosystems, states that the scope of the review should include an analysis of the effects of impingement in sufficient detail to allow the reviewer to predict potential impacts on "important species" and to evaluate the potential significance of such impacts. Exhibit NRC000010 at 5.3.1.2-1.

The reviewer is to determine the susceptibility of "important species" to impingement. This determination involves the evaluation both of station-related factors that influence

impingement loss rates as well as of life history data that influence the susceptibility to impingement for the various species present. The reviewer is to determine, based on the cooling system (closed-cycle or once-through), intake design and the life history data, if the effects of impingement on "important species" would be destabilizing or noticeably alter population levels. *Id*. at 5.3.1.2-7. The ESRP directs that the reviewer also draw on the experience of comparable, currently operating power stations to assist in the prediction of impact. *Id.* The ESRP further states that "in the most practical terms, the reviewer's final evaluation is determined through professional judgment based on the pertinent data and analysis." *Id.* If the reviewer determines that the effects of impingement would not be detectable or noticeably alter population levels, then the reviewer is to state that conclusion and the review is completed.

Q21. How did the Staff use the guidance identified in Answer 20 above to determine the impacts presented in the Vogtle FEIS?

A21. (MTM) The Staff became familiar with the proposed station design, including such aspects as the type of cooling system employed, the location and the dimensions of the intake structure and intake channel, the proposed vertical traveling screen system, and pertinent operating parameters such as flow rates and flow velocities. The Staff then reviewed the list of "important species" identified in Section 2.7.2 of the FEIS. Exhibit NRC000001 at 2-72 to 2-95. Additionally, the Staff reviewed the list of species of fish known to occur in the middle Savannah River to see if any species were unusually susceptible to impingement. The Staff also considered life history data for each important species. I conducted two site visits (identified in my response to Question 22) during which I examined the debris in the screen wash basket. Exhibit NRC000032; Exhibit NRC000033. I also considered the results of impingement sampling at the nearby Savannah River Site (Exhibit NRC000011 at V-305 to V-317) and I relied on my own personal experience related to impingement losses at closed-cycle nuclear power generating facilities located on 7 other run of the river sites in addition to the VEGP site

[Callaway, Grand Gulf, Hatch, Columbia, River Bend, Limerick, and Three Mile Island Unit 1]. I also considered, for both the existing VEGP Units 1 and 2 and the proposed Units 3 and 4, the physical characteristics and location of the intake, including such factors as the low through-screen velocities, the low approach velocities in the intake canal, and the use of a closed-cycle cooling system. I concluded that impingement losses from the intake structure for VEGP Units 3 and 4 would be similar to those of the intake structure for VEGP Units 1 and 2. Based on the above, I assessed that the effects of impingement from the operation of VEGP Units 3 and 4 on the populations of each of the important species would be minor, undetectable and SMALL.

Q22. On what data did the Staff base its conclusions with respect to impingement?

A22. (MTM) At the time of preparation of the FEIS, no record of a systematic impingement sampling study at the VEGP site was available to the Staff to consider when developing its conclusions of potential impact. Therefore, in reaching my conclusions, I relied on the station design information, the use of a closed-cycle cooling system for the planned Units 3 and 4, intake-related flow rates, and life history data for "important species." I also relied on my professional experience from conducting initial licensing reviews, other early site permit reviews, license renewal reviews, and endangered species assessments of other closed-cycle and once-through power stations located throughout the U.S. on other various watercourses.

Additionally, prior to publication of the FEIS, I was able to obtain qualitative information during two VEGP site visits in March of 2007 and March 2008. Exhibit NRC000032. Based on interviews with Units 1 and 2 screen wash operators, and a detailed examination of the cumulative screen wash debris that represented a composite sample spanning several weeks to several months, I was convinced that impingement events involving large numbers of fish had not occurred at the VEGP Units 1 and 2 intake during this time period.

My knowledge of swim speed data for species that inhabit the Savannah River that would be susceptible to impingement and the preliminary results of Southern's impingement monitoring study for Units 1 and 2 provide additional support for the conclusions in the FEIS

with respect to impingement mortality rates. Adult fishes inhabiting the Savannah River in good condition are capable of avoiding the 0.5 ft/sec through-screen intake flow velocity limit planned for VEGP Units 3 and 4. In May 2008, Southern informed the Staff that, in early March 2008, it had started a quantitative, biweekly, 24-hour impingement sampling program sampling debris and fish and shellfish collected on the screens of Units 1 and 2. Exhibit NRC000031; Exhibit NRC000001 at 5-32. I had the opportunity to examine the proposed study plan and sampling gear during a site visit on March 18, 2008. On August 13, 2008, just prior to issuance of the FEIS, I witnessed the results of one of these impingement sampling events and observed that a total of 3 fish from 3 taxa were collected from the Units 1 and 2 screen wash discharge over a twenty-four hour period. Exhibit NRC000033.

The data collected during this sampling event are summarized in a September 2008 report from Southern received by the Staff on the 7th of October 2008 containing the preliminary results of the first 6 months of impingement sampling. Exhibit NRC000030. According to the report, a total of 65 organisms from 18 taxa were collected during the six month period. Sixteen species of fish and two species of crustaceans have been reported. Although this report presents only 6 months of data and the study is planned for one year, in my opinion the preliminary results confirm the Staff's assessment provided in the FEIS. Extrapolation of these biweekly losses from operation of VEGP Units 1 and 2 to daily losses for the entire 6 month period from March to September 2008 would result in losses that would not detectably alter population levels in the Savannah River. Due to the similarity in intake design between the intakes for VEGP Units 1 and 2 and the planned Units 3 and 4, the Staff concludes that the impingement losses at the planned VEGP Units 3 and 4 will be similar to those observed at the Units 1 and 2 intake structure and also result in a SMALL impact.

In the FEIS, the Staff considered the US EPA requirements implementing section 316(b) of the Federal Water Pollution Control Act, 33 USC 1251, et seq., that were contained in the December 18, 2001 rulemaking (66 Fed. Reg. 65,256). Exhibit NRC000001 at 5-30 and 5-31;

Exhibit NRCR00035. The final rule establishes national technology-based performance requirements applicable to the location, design, construction, and capacity of cooling water intake structures at new steam electric generating facilities. The EPA established national intake capacity and velocity requirements as well as location- and capacity-based requirements to reduce intake flows below certain proportions of a variety of waterbody types – called proportional-flow requirements. Implementation of these national standards for new facilities is expected to help preserve aquatic organisms and the ecosystems they inhabit. This would be accomplished by significantly decreasing the expected mortality and/or morbidity from entrainment into cooling water systems or impingement against screens or other devices at the entrance of cooling water intake structures. New facilities with a design intake flow equal to or greater than 10 million gallons per day must meet the following requirements: 1) cooling water intake flow must be at a level commensurate with that achievable with a closed-cycle, recirculating cooling system, 2) through-screen water intake velocities must be less than or equal to 0.5 ft/sec, 3) for fresh water rivers or streams, intake flow must be less than or equal to 5 percent of the annual mean flow, and 4) additional design and construction technologies must be selected if certain other conditions exist. Exhibit NRCR00035 at 65,259 to 65,260. The EPA requirements apply to the proposed VEGP Units 3 and 4, which have a normal water withdrawal rate of 84 cfs, which is approximately 54 million gallons per day. Exhibit NRC000001 at 5-6.

Based on a review of VEGP Units 3 and 4 and the associated intake structure, I believe that the facility will meet the EPA capacity and intake velocity requirements as well as the location- and capacity- based requirements to reduce intake flows below the 5 percent standard required by 40 CFR 125.84(b)(3)(i). Exhibit NRCR00035 at 65,256 and 65,340. A key parameter affecting impingement losses is the through-screen intake velocities. The design through-screen velocity for VEGP Units 3 and 4 is less than 0.5 feet/sec. The EPA determined that the 0.5 ft/sec. requirement is scientifically based, and is protective of aquatic resources, with a reasonable margin of safety. *Id*. at 65,256 and 65,303. The design, location, and

proposed operation of the intake structures for the proposed new Vogtle units is consistent with EPA's technology-based performance standards and as such support the conclusion that impingement-related effects on aquatic biota will be SMALL.

The results of an impingement study conducted at the nearby Savannah River Site support the Staff's conclusion that impingement losses due to the operation of VEGP Units 3 and 4 will be minor. Exhibit NRC000001 at 7-22. The Comprehensive Cooling Water Study for the Savannah River Site reported the results of an impingement sampling study conducted between 1983 and 1985. Exhibit NRC000011 at V-305 to V-317. Daily impingement samples were collected at three separate intakes located on the Savannah River upstream of the VEGP site. *Id.* at V-305. Sampling was conducted on random days for a total of 204 samples over the sampling period. *Id.* at V-305 and V-311. Specht (1987) reported that the number of fish impinged daily ranged from 0 to 190 over the first year of sampling with an average of 18 fish per day. *Id.* The first year of the sampling program reported a total of 1,938 fish from 50 taxa. *Id.* at V-305. The majority of fish impinged on the screens were Centrarchids, the bass and sunfish family (46.4 percent). *Id.* The most numerous species was the threadfin shad (*Dorosoma petenense*) comprising 12.2 percent of the total number of fish taken. *Id.* at V-305. During the second year of sampling, the number of fish impinged ranged from 0 to 99 per day with a total of 745 fish for the year from 33 taxa. *Id.* at V-311. The majority of fish collected were Clupeids, the shad and herring family (53.7 percent). *Id.* Again the most abundant species collected was threadfin shad. *Id.* During the time of the impingement study, the amount of water withdrawn from the Savannah River required for full power operation of either the K or L reactor was greater than three times the anticipated rate for the combined VEGP Units 3 and 4. Exhibit NRC000034 at 5. Additionally, the velocity in front of the intake screens at the Savannah River Site intake structures was calculated to be about 2.5 times greater than that anticipated for VEGP Units 3 and 4. Exhibit NRC000036 at 28. The low impingement rates reported from the Savannah River Site, despite higher withdrawal rates and through-screen

velocities than those planned for VEGP Units 3 and 4, support the conclusion that impingement rates at the new intake will not result in a detectable impact to the Savannah River fishery.

Finally, while it is not specifically referenced in the ESRP guidance, I considered the NRC's generic environmental review developed in connection with the license renewal of existing operating facilities to be pertinent to the Staff's evaluation of the Vogtle ESP application. Specifically, it provides guidance related to impacts from the type of cooling design planned for VEGP Units 3 and 4. In NUREG-1437, Generic Environmental Impact Statement for License Renewal of Nuclear Plants (May 1996) ("GEIS"), the Staff evaluated generically the potential for impingement-related impacts to fish and shellfish populations at nuclear power facilities using wet-tower closed-cycle cooling. Exhibit NRC000037. Of the 104 operating nuclear power stations in the U.S., 38 units at 27 separate sites utilize closed-cycle cooling. After examining data from a variety of closed-cycle cooling stations on different types of waterbodies, reviewing literature and operation monitoring reports, consultations with utilities and regulatory agencies, and comments on the draft GEIS NUREG-1437, the Staff concluded in the final GEIS for License Renewal that the potential effect of impingement has been insignificant and not been shown to cause reductions in the aquatic populations near any existing operating nuclear power plant with closed-cycle cooling. Exhibit NRC000037 at 33 and 34. This generic conclusion has been successfully applied to the license renewal reviews of 11 closed-cycle units located on a variety of waterbodies in the US. Although it does not constitute review guidance for the evaluation of new facilities, I believe the results of this generic study are consistent with the Staff's analysis at the VEGP site and with the U.S. EPA's conclusions related to the impact of closed-cycle cooling on aquatic organisms.

Q23. Do the data used by the Staff account for variations in impingement rates that might occur in species composition at different times of the year, or for those species' vulnerability at different life stages?

A23. (MTM) Impingement rates at water intakes vary on a seasonal basis. In my experience, high impingement losses are typically confined to one or two species during certain times of the year at stations that use once-through and not closed-cycle cooling. Typically, however, large numbers of impinged fish are, with the occasional exception of some species of Clupeids (shad and herrings), unusual at riverine intakes. Riverine fishes are preadapted to tolerate and even thrive in an environment of wide variations in water velocities. Seasonal variation of impingement mortality in riverine environments such as that of the Savannah River at the VEGP site is generally less than in lakes, reservoirs, and estuary environments primarily because of the lack of large schooling populations of fish.

However, certain Clupeid species (such as threadfin shad (*Dorosoma petenense*) and the Alewife (*Alosa pseudoharengus*)) have unusual physiological characteristics that make them periodically susceptible to impingement. Additionally, Clupeids are a schooling fish and fragile, which increases their likelihood to experience impingement mortality and morbidity. Nevertheless, while some seasonal variation in impingement rates would be expected at the VEGP Unit 3 and 4 intake, the monthly variation would not be large because few fish are expected to be taken.

While preparing the FEIS I was aware of the results of impingement studies conducted over a two-year period at the Savannah River Site in the early 1980s. As reported in the Comprehensive Cooling Water Study Final Report for the Savannah River Site, Specht, (1987) found variation in impingement rates in both years of sampling, with peaks in November through December and April through May of 1983-84 and January through February and in July in 1984-85. Exhibit NRC000011 at V-308 and V-314. Specht believed that, at least in the 1983-84 sampling period, the variation may have been partially related to river flow. *Id.* at V-305. In any case, the daily variation in fish impingement for the 24-hour sampling program was not great, ranging from zero to 190 fish in a 24-hour period. *Id*. Considering the large withdrawal rates due to two unit operation at SRS operation (837cfs) (Paller 1992) and the intake velocities at the

SRS intake structures (about 1.25 ft/sec) (McFarlane et al. 1978) compared to the normal and maximum withdrawal rates for VEGP Units 3 and 4 of 83 and 129 cfs, respectively, and a through-screen intake velocity of less than 0.5 ft/sec, impingement rates at VEGP Units 3 and 4 should be exceedingly low, and the resulting impact minor, as the Staff concluded in the FEIS. Exhibit NRC000034 at 5; Exhibit NRC000036 at 28; Exhibit NRC000001 at 5-33. Preliminary impingement data collected since March 2008 from Units 1 and 2 support this conclusion due to the low number of organisms impinged. Exhibit NRC000030. The Staff expects that annual variation in impingement rates and species composition would occur at the VEGP Units 3 and 4 intake. After completion of the full year of impingement sampling at the VEGP Units 1 and 2 intake structure, Southern and the Staff will have a better understanding of annual variation in impingement losses. However, for the reasons just stated, the Staff does not expect that variation to be significant and expects that the impingement rate for all species would be small.

There would also be variation in susceptibility to impingement of different life stages for certain species. Juvenile fish, as well as post-larval fish, large enough to prevent entrainment, are more susceptible to impingement than sub-adults or adults. Preliminary impingement data from Units 1 and 2 support this conclusion), as Southern concluded that except for the gizzard shad, *Dorosoma cepedianum*, black crappie, *Pomoxis nigromaculatus*, and taillight shiner, *Notropis maculatus*, (each represented by a single specimen), primarily young of the year and juveniles were impinged at VEGP Units 1 and 2. *Id.*

Therefore, the Staff concludes that there will be daily and seasonal variation in impingement losses and that different life stages of organisms will experience varying susceptibility to being impinged. Nevertheless, for the reasons stated above, such losses will not result in detectable changes in the Savannah River fishery.

Q24. What is the basis for the Staff's conclusion that "important species" will be able to evade impingement? And how does the Staff use this information in evaluating the impingement impacts?

A24. (MTM) The Staff considered the intake design and location, the anticipated volume of water to be withdrawn from the river by the closed-cycle cooling system, the very low anticipated approach velocities (about 0.1 ft/sec) in the proposed intake canal, a designed through-screen intake velocity of less than 0.5 ft/sec, and pertinent life history data. Exhibit NRC000001 at 5-30 and 5-31. Adults of any of the "important species" that inhabit the Savannah River in the vicinity of VEGP Units 3 and 4 that are in good condition have a burst swim speed in excess of 0.5 ft/sec and should be able to avoid impingement. In my opinion, impingement losses will primarily be confined to small fish that inadvertently get too close to the surface of the screens or become entangled in floating debris, disoriented and then pinned to the screens, and fish in poor condition or already moribund. Larger fish in good condition such as the juvenile, sub-adult or adult robust redhorse (*Moxostoma robustum*) and shortnose sturgeon (*Acipenser brevirostrum*) would only be susceptible to impingement if moribund or already expired. Relatedly, although it was not specifically discussed in the FEIS, the Staff concludes that it is highly unlikely that a juvenile or adult Atlantic sturgeon (*A. oxyrinchus*) in good condition would end up impinged on the intake screens of VEGP Units 3 and 4. The Staff is unaware of any documented case of Atlantic sturgeon in good condition being impinged at any nuclear power station, including once-through stations, along the Atlantic coast.

Based on these factors, the Staff concluded that impingement of important species at a rate that might affect Savannah River populations is highly unlikely. This prediction is supported by the results of the impingement studies conducted at the SRS in the early 1980s, swim speed data for "important species" inhabiting the Savannah River, the preliminary results of the VEGP Units 1 and 2 impingement sampling study, information on the design, location and planned operation of the station intake, and the anecdotal information I collected at the intake structure during my visits to the site. Although some individuals of each species determined to be important may be impinged and experience mortality, the overall effect on the Savannah River fish populations would be undetectable.

Q25. Is impingement associated with the proposed new Vogtle units a threat to fish populations in the Savannah River?

A25. (MTM) Impingement at the proposed VEGP units 3 and 4 is not a threat to fish populations in the Savannah River. Impingement would result in some loss of individuals from the population. Individuals in poor condition would be more susceptible to impingement. These individuals are of less value to sustaining the river fishery. Although the details were not discussed in the FEIS, Specht 1987 found that impingement losses at the SRS over a two year sampling period during 1983 to 1985 ranged from zero to 190 fish/day with a mean of 18 fish per day the first year of study and 7.7 fish per day the second year. Exhibit NRC000011 at V-305 and V-311. As stated in response to Question 22, during the time of the impingement study, the amount of water withdrawn from the Savannah River required for full power operation of either the K or L reactor (Paller, 1992) was greater than three times the anticipated rate for the combined VEGP Units 3 and 4. Exhibit NRC000034 at 5. Additionally, the velocity in front of the intake screens at the SRS intake structures (McFarlane et al. 1978) was calculated to be about 2.5 times greater than that anticipated for VEGP Units 3 and 4. Furthermore, preliminary results of Southern's impingement study of VEGP Units 1 and 2 are consistent with the data collected by Specht (1987), indicating very low impingement rates in 2008. Exhibit NRC000036 at 28; Exhibit NRC000030; Exhibit NRC000011. Accordingly, the Staff does not expect that the very low impingement rates as a result of Units 3 and 4 operations would have a detectable or destabilizing effect on those same aquatic populations. As discussed in more detail in section F of this testimony, the Staff also evaluated the potential cumulative impact of impingement from VEGP Units 1 through 4 and determined that the losses are unlikely to adversely affect Savannah River fish populations. Exhibit NRC000001 at 7-22.

C. Entrainment

Q26. What conclusion did the Staff reach in the FEIS as to the impacts of entrainment from operations of the proposed Units 3 and 4?

A26. (RHK) The Staff concluded in Section 5.4.2.2 of the FEIS that the impacts to the fish populations of the Savannah River from entrainment due to the operation of the proposed VEGP Units 3 and 4 would be minor. Exhibit NRC000001 at 5-32. The analysis in the FEIS was based on several factors, including the small percentage of total river flow that would be withdrawn by the closed-cycle cooling system employed by the new units as well as the design and location of the cooling intake canal and structure, including the use of a weir wall at the mouth of the intake. That design is shown in Figures 3-4 and 3-5 of the FEIS. *Id.* at 3-10 and 3-11. These factors are associated with the applicant's use of a closed-cycle cooling system (FEIS pages 5-30 and 5-31). Other factors include the lower larval densities in the run-of-the-river sampling performed by Specht 1987, when compared to the oxbows; the typically high fecundity of most species inhabiting rivers, the high natural mortality rates of eggs and larvae, and the results of sampling related to SRS operations. Exhibit NRC000011 at V-478.

Following the publication of the FEIS, the Staff's conclusion has been further supported by the preliminary results of Southern's entrainment sampling program near the Units 1 and 2 intake, as I explain below. Exhibit NRC000030 at 1-16, 18-25, 27-35 and Appendix D.

Q27. What is the Staff's guidance for reaching a determination of impacts from entrainment?

A27. (RHK) The Staff's analysis and assessment of potential plant intake system impacts, including entrainment, on aquatic organisms is directed by guidance in NUREG-1555, the U.S. Nuclear Regulatory Commission's Environmental Standard Review Plan (ESRP) (Rev. 1, July 2007), Section 5.3.1.2, "Aquatic Ecosystems." Exhibit NRC000010 at Section 5.3.1.2.

The ESRP states that the scope of the review "should include an analysis of the effects of… entrainment in sufficient detail to allow the reviewer to predict potential impacts on "important" species and their habitats and to evaluate the potential significance of such impacts" (ESRP 2007 at 5.3.1.2-1). *Id.* at 5.3.1.2-1. The ESRP 2007 states that

> "However, compliance with environmental quality standards and requirements of the Clean Water Act is not a substitute for and does not negate the requirement for NRC to weigh the environmental impacts of the proposed action…If an environmental assessment of aquatic impacts is available from the permitting authority, the NRC will consider the assessment in its determination of the magnitude of the environmental impacts in striking an overall benefit-cost balance. When no such assessment of aquatic impacts is available from the permitting authority the NRC…will conduct its own assessment."

Id. at 5.3.1.2-6. Further, the ESRP states that "in the most practical terms, the reviewer's final evaluation is determined through professional judgment based on the pertinent data and analyses. The reviewer may refer to earlier NRC environmental reviews in which evaluation of intake system operational impacts has been important." *Id.*

The ESRP states that the reviewer is to first determine if the facility "is being located at a site close to an existing nuclear facility." *Id.* If it is, then the ESRP specifies that the reviewer should "determine whether the applicant has a current National Pollutant Discharge Elimination System (NPDES) permit with a Clean Water Act Section 316(b) determination, if appropriate, or equivalent State permits and supporting documentation." *Id.* If no 316(b) determination is available, the ESRP instructs the reviewer to "identify the "important" aquatic organisms and their life stages susceptible to…entrainment" by coordinating with the reviewer of ESRP 2.4.2. *Id.* at 5.3.1.2-7. Following the determination that "important" aquatic species are present and susceptible to entrainment, the reviewer is instructed to "estimate the levels of susceptibility in either qualitative or quantitative terms, or both." *Id.* It also instructs the reviewer to "estimate survival rates for those species entrapped, impinged or entrained by relying on experience at other stations." *Id.* It further instructs the reviewer to "assume 100% mortality for all entrained biota." *Id.* at 5.3.1.2-8.

The "potential for altered hydrodynamic characteristics" and the "potential for recirculation of heated effluent from the plant discharge system" are also to be considered. *Id.* Finally, the Staff is directed to "estimate the magnitude of the potential…entrainment impacts on the species population and aquatic ecosystem." This is accomplished by using the estimate provided above and considering cropping rates (loss of individuals due to entrainment in relation to the population) in relation to natural mortality rates, reproductive rates and standing stock estimates and by considering other existing stresses to fragile species (such as nearby electrical generating stations). *Id.* at 5.3.1.2-7 and 5.3.1.2-8.

Q28. How did the Staff follow this guidance in determining the impacts of entrainment for the Vogtle FEIS?

A28. (ARK,RHK) The proposed Vogtle Units 3 and 4 are adjacent to the existing Units 1 and 2. Exhibit NRC000001 at 2-1. The VEGP Units 1 and 2 are closed-cycle cooling systems and have an NPDES permit. However, they do not have a Clean Water Act Section 316(b) determination. Because there was no specific entrainment data available from the adjacent VEGP Units 1 and 2 at the time of preparation of the FEIS and because those Units did not have a 316(b) determination, the ESRP directs the Staff to estimate the levels of susceptibility to entrainment. Exhibit NRC000010 at 5.3.1.2-7. In doing so, first, the Staff identified that there were "important" species present that would be susceptible to entrainment. As a result, the Staff continued to follow ESRP Section 5.3.1.2 by considering in the FEIS the intake design, including the percentage of water from the river that would be withdrawn and the orientation of the design relative to the habitat ("intake canal would be built so that the river flow is almost perpendicular to the intake canal flow," with a weir wall that would extend upward approximately 1 ft from the bottom of the intake canal near its entrance), as well as the flow velocity along the intake canal (at the minimum river operating level of 78 ft above mean sea level, the flow velocity along the intake canal would be about 0.1 fps, based on the site maximum make-up water demand of 129 cfs). *Id.*; Exhibit NRC000001 at 5-30 and 5-31.

The Staff also considered how the amount of water withdrawn from the source waterbody greatly influences the degree to which entrainment affects the aquatic biota. The U.S. Environmental Protection Agency ("EPA"), in its Phase I final regulations for new facilities that withdraw water from waterbodies for cooling purposes, established proportional flow requirements for new facility cooling water intake structures (see response above to Question 22). Exhibit NRCR00035 at 65,256. EPA based these requirements on a similar assumption – that a facility withdrawing 5 percent of the water from a freshwater river or stream would thereby entrain approximately 5 percent of the river or stream's entrainable organisms. *Id.* at 65,256 and 65,277. EPA stated that "[e]ntrainment impacts of cooling water intake structures are closely linked to the amount of water passing through the intake structure, because the eggs and larvae of some aquatic species are free-floating and may be drawn with the flow of cooling water into an intake structure." *Id.*

Since a closed-cycle wet cooling tower system would be used for VEGP Units 3 and 4, at a normal withdrawal rate of 83 cfs, the two new VEGP units would withdraw between 0.9 and 2.2 percent of the total flow of the Savannah River depending on the river stage (average-daily discharge and Drought Level 3, respectively) in the Savannah River. Exhibit NRC000001 at 5-8 and 5-30. And as discussed in the response to Question 43, the normal withdrawal rate of 83 cfs represents 1.2 percent of the annual mean flow of 6991 cfs from the Waynesboro gauge. The percentage of river flow withdrawn through the intake structure provides an estimate of the impact of the entrainment from the river because, all other factors being equal, the higher the withdrawal rate, the greater the impact of entrainment.

Consistent with ESRP guidance at 5.3.1.2-8, the Staff assumed 100% mortality of the entrained biota. Exhibit NRC000001 at 5-32. The ESRP indicates that the Staff should evaluate the "potential for altered hydrodynamic characteristics" and the "potential for recirculation of heated effluent from the plant discharge system." Exhibit NRC000010 at 5.3.1.2-8. However, these factors were not directly discussed in the FEIS, because the design of the

intake canal, the location of the discharge and the velocity of the water in the Savannah River was such that the potential for altered hydrodynamic characteristics and recirculation of heated effluent were not realistic considerations. The potential for recirculation and altered hydrodynamic characteristics is important to consider in reservoirs and ponds, rather than in free-flowing rivers such as the segment of the Savannah River that flows past the VEGP site.

Additionally, in order to estimate the magnitude of the potential entrainment impacts, as specified in the ESRP, the Staff looked at the losses from entrainment of species based on the amount of water entrained by the facility. As described in the ESRP, "the reviewer may refer to earlier environmental reviews in which evaluation of intake system operational impacts has been important." *Id.* at 5.3.1.2-6. As discussed previously, the Staff, in the FEIS, did refer to the analysis in the 1985 FES for Units 1 and 2, which "assumed a uniform distribution of drift organisms". Exhibit NRC000001 at 5-31; Exhibit NRC000014 at 5-17. The Staff discusses this assumption later in this testimony. The Staff made a similar estimate of losses from entrainment by Vogtle Units 3 and 4 based on 0.9 and 2.2 percent removal depending on the flow conditions and assuming a normal withdrawal rate.

The Staff also looked at historic entrainment rates for reactor facilities at the Savannah River Site. Exhibit NRC000001 at 5-32. This consideration of the SRS rates was performed as a bounding comparison, since, as discussed in the FEIS, the volume of water withdrawn into each of the K-reactor or L-reactor intakes at full power is about 3 times the maximum withdrawal rate of the VEGP Units 3 and 4 (129 cfs) or a little more than four times the normal withdrawal rate of 83 cfs. Exhibit NRC000034 at 5. The intake velocity was about 2.5 times as great as that for the proposed VEGP Units 3 and 4. Exhibit NRC000036 at 28.

Finally, the Staff, using the professional judgment as specified by the ESRP, also considered the guidance in NUREG-1437, "Generic Environmental Impact Statement for License Renewal of Nuclear Plants" (GEIS). Exhibit NRC000010 at 5.3.1.2-6; Exhibit NRC000037. The GEIS states that "[s]tudies of intake and discharge effects of closed-cycle

cooling systems have generally judged the impacts to be insignificant (NUREG/0720; NUREG/CR-2337). None of the resource agencies consulted for this GEIS (Appendix F) [in Volume 2] expressed concerns about the impacts of closed-cycle cooling towers on aquatic resources." Exhibit NRC000037 at 4-33. Appendix F, page F-3 of the GEIS states that the Staff contacted resource agencies "with responsibility either for regulating the construction and operation of [sic] protection and maintenance of aquatic resources in the vicinity of the power plants." Responses were received from 17 Federal agency regions and 55 state agencies. *Id.* at F-5.

However, the GEIS also states that "even low rates of entrainment and impingement at a closed-cycle cooling system can be a concern when an unusually important resource is affected. Such aquatic resources would include threatened or endangered species or anadromous fish that are undergoing restoration." *Id.* at 4-33. For that reason, the Staff focused its attention strongly on the "important species." Therefore, consistent with ESRP guidance, the Staff specifically discussed the potential entrainment of important species, including the robust redhorse and the shortnose sturgeon, based on the life history data the Staff had obtained for these species as well as on the design of the Vogtle Units 3 and 4 intake structure. Exhibit NRC000010 at 5.3.1.2-7 and 5.3.1.2-8; Exhibit NRC000001 at 5-36, 5-37, 5-41 and 5-42. As explained further in response to Question 33, the Staff found that for all important species the potential for entrainment was minor.

Q29. On what data did the Staff base its conclusions with respect to entrainment?

A29. (RHK) As the ESRP states, because the existing VEGP units do not have a 316(b) determination, the Staff needed to estimate the magnitude of the potential entrainment impacts by examining the intake design and the life history data to determine if the impacts to "important species" would be detectable or noticeable. The Staff considered two sources of data: first, the information that was presented in the ER related to the design and placement of the intake structure and canal, and second, life history of "important" species. In addition, the

Staff compared the analysis of these data to the entrainment studies performed at the SRS between 1982 and 1985. Exhibit NRC000011 at V-1 to V15 and V-321 to V548.

The data from the ER included information related to the design and placement of the intake structure and canal. That information is presented in Section 3.2.2.2 of the FEIS. Exhibit NRC000001 at 3-8 to 3-14. The cooling system proposed for Units 3 and 4 is a closed-cycle system with a through-screen velocity of less than 0.5 ft/second and a normal withdrawal rate of 83 cfs. A surface skimmer wall would be present to keep floating debris from entering the intake canal. The weir wall, extending upward approximately 1 ft from the bottom of the intake canal near the entrance of the canal would, along with the skimmer wall, serve to reduce entrainment mortality, especially of eggs, which as discussed in the FEIS and shown by the SRS data tend to have higher densities near the bottom of the river. Exhibit NRC000001 at 2-81; Exhibit NRC000012 at xv and 3-36 to 3-39.

As explained in response to Question 28, because entrainment data was not available from the existing VEGP units, the Staff considered and compared the available site-specific entrainment data from the SRS. The SRS studies conducted in the vicinity of the VEGP site conducted between 1982 and 1985 measured entrainment rates of once-through cooling system intakes, which had four times the anticipated water withdrawal rate of the proposed VEGP Units 3 and 4 (at normal consumption) and an intake velocity of about 2.5 times as great as for the proposed VEGP Units 3 and 4. Exhibit NRC000001 at 5-32. The operation of the intakes at the SRS involved withdrawals much greater than those anticipated from VEGP Units 3 and 4. According to Specht 1987, “[w]hile a substantial fraction of the Savannah River ichthyoplankton are entrained at the SRP cooling water intake structures, there appears to be no effect on the fishery of the river.” Exhibit NRC000011 at V-13.

Furthermore, preliminary data collected by Southern (2008) during entrainment studies at Units 1 and 2 support the Staff’s conclusions in the FEIS by showing lower larval densities in the intake canal as compared to the densities in the river. Exhibit NRC000030 at 30.

Q30. You stated that in assessing entrainment, the Staff assumed uniform distribution of drift organisms in the water column. What do you mean by "uniform distribution," and why is it an appropriate assumption for this analysis?

A30. (RHK) Uniform distribution is a conceptual term meaning that the organisms would be distributed uniformly or evenly throughout the water column. Thus, there would be equal spacing between all organisms, and the same number of organisms would be selected in any given volume of water regardless of where within the particular waterbody that volume of water was obtained. This is an artificial construct because in reality organisms do not distribute uniformly. However, the Staff considered the uniform distribution of drift to be an appropriate assumption for two reasons. First, the ESRP suggests that the Staff should rely on earlier environmental reviews when assessing environmental impacts associated with intake structures and the assumption of uniform distribution was made in the original FES (NRC 1985) for Units 1 and 2. Exhibit NRC000010 at 5.3.1.2-6; Exhibit NRC000014 at 5-17. And second, it is a conservative estimate of the ichthyoplankton that will be entrained.

Some aquatic species (including fish and molluscs) release their eggs into the water column, where the eggs hatch into larvae. Others deposit their eggs on, or near, the bottom and are considered demersal spawners. The robust redhorse is one example. The robust redhorses lay their eggs in gravel bars, where the eggs hatch into larvae. Exhibit NRC000001 at 2-88; 17 at 1152. The shortnose sturgeon and the Atlantic sturgeon, as two more examples of demersal spawners, also have eggs that sink quickly and adhere to sticks, stones, gravel and rubble shortly after fertilization. Exhibit NRC000001 at 2-90; Exhibit NRC000046 at 172. The assumption of uniform distribution for species such as the shortnose sturgeon and the robust redhorse is not realistic, since their eggs and larvae are found primarily in and on the substrate at the bottom of the river; thus, assuming a uniform distribution for entrainment of these species will greatly bias the entrainment losses higher than what would occur in actuality.

Other species of fish spawn their eggs in the water column, where the larvae are hatched. The eggs and larvae that are suspended in the water column are termed "ichthyoplankton drift." The distribution of eggs and larvae in the drift will vary depending on the density of the eggs and the ability of the larvae to swim and the water currents. American shad and striped bass are two of the "important" species for which the eggs and larvae tend to be carried in the water column, and would be considered to be part of the ichthyoplankton drift. As a result, the assumption of uniform distribution is somewhat more realistic for the striped bass and the American shad, which have eggs that are pelagic or semipelagic. Exhibit NRC000006 at 292, 294 and 104. These species have a relatively high fecundity rate relative to demersal spawners; nevertheless, the distribution is not really uniform, with clouds of eggs and larvae moving through the river as a result of spawning patterns and river flow. However, as explained below, the Staff believes that the uniform distribution assumption is an appropriate method for determining environmental impacts.

Overall, the actual volume of water being moved into the intake will result in lower numbers of fish eggs and larvae entrained than would be anticipated based on the uniform distribution assumption for the following reasons. First, as described in the FEIS, data from the SRS studies shows that egg densities exhibit significant differences between the top and bottom of the river column at over half of the transects in the sampling sites examined. Exhibit NRC000001 at 2-81; Exhibit NRC000012 at 3-37 and 3-39. In all of these cases, the densities were higher near the bottom than near the surface. *Id.*

Second, as discussed in the FEIS, the proposed VEGP Units 3 and 4 will not draw water directly from the bottom of the water column, due to the presence of a weir wall projecting up from the river bottom at the entrance of the intake canal. Exhibit NRC000001 at 5-31. Additionally, the applicant plans to install a surface skimming wall primarily to restrict floating debris from entering the canal. This surface curtain skimmer, along with the bottom weir wall, would result in water from the middle of the river water column preferentially entering the canal.

For these reasons, the assumption made in the FES for Units 1 and 2 of a uniform distribution of eggs and larvae results in an overestimation of the entrainment losses of eggs and larvae entrained, which is why the Staff considered it to be a conservative approach for its analysis of Units 3 and 4. Exhibit NRC000014 at 5-17.

Furthermore, the preliminary results of Southern's entrainment sampling program for Units 1 and 2 support the Staff's position that the uniform distribution assumption represents a conservative estimate because these results show that the concentration of eggs and larvae in the water column in the intake canal are significantly lower than the concentration reported from the river. Exhibit NRC000030 at 30.

Q31. How does the Staff's FEIS analysis account for the mobility of the eggs and larvae of aquatic species?

A31. (RHK) The Staff did not assume mobility of eggs or larvae in the water column. The Staff assumed that, from the standpoint of avoidance of entrainment, once an egg or larvae is in the hydraulic zone of influence it will be entrained. The Staff did not assume that eggs or larvae will preferentially move towards or away from the hydraulic zone of influence or seek out the middle of the water column. Instead, the Staff made the assumption that entrainment impacts are closely linked to the amount of water passing through the intake. Thus, if 0.9% of the river is withdrawn by the intake structure under normal withdrawal and average flow conditions, then 0.9% of the eggs and larvae in the river are assumed to be entrained. Inherent in this is the further assumption that the eggs and larvae are incapable of avoiding entrainment if they are in the zone of hydraulic influence of the intake structure.

This assumption of uniform distribution of eggs and larvae in the water column is also an assumption that is made by the EPA in its Phase I Final regulations for new facilities that withdraw water for cooling purposes (also see my colleague's response above to Question 22). Exhibit NRCR00035 at 65,256, 65,277 and 65,340. The EPA states in those regulations that "Entrainment impacts of cooling water intake structures are closely linked to the amount of water

passing through the intake structure, because the eggs and larvae of some aquatic species are free floating and may be drawn with the flow of cooling water into an intake structure." *Id.* For these reasons, the Staff considered this assumption of entrainment being generally proportional to water withdrawal to be appropriate in the FEIS analysis.

Q32. Do the data used by the Staff in its entrainment analysis account for variations that might occur in species composition at different times of the year (or for those species' vulnerabilities at different life stages)?

A32. (RHK) The Staff's analyses did not directly take into account the variations that might occur at different times of the year, or those species' vulnerability at different life stages. Instead, as discussed in the previous response, the Staff assumed that the entrainment impacts are closely linked to the amount of water being withdrawn by the intake. However, the Staff recognizes that there are differences in river flows during the year and likewise there are differences in ichthyoplankton densities throughout the year, with the higher densities corresponding to periods of higher flow in the March to June time frame. Exhibit NRC000011 at V-454 and V-456 to V-461. These differences would result in a lower percentage of the ichthyoplankton being entrained (since the plant is pulling in a smaller percentage of the water flowing down the river) than was assumed by the Staff. Accordingly, this too results in a conservative estimate.

Q33. What is the basis for the Staff's conclusion that populations of important aquatic species will not be adversely affected by entrainment?

A33. (RHK) The Staff reached the conclusion in the FEIS that populations of important species will not be adversely affected by entrainment from proposed Units 3 and 4. Exhibit NRC000001 at 5-32. For fish that spawn pelagically, such as the striped bass or American shad, this conclusion is based on the anticipated small percentage of water the new units would withdraw and the resulting small percentage of ichthyoplankton lost using the conservative assumption that the amount of water pulled through the intake is closely linked to

the amount of ichthyoplankton entrained. This assumption is even more conservative when one takes into account the design of cooling intake canal and structure, which selects water from the middle of the water column and reduces the overall percentage of ichthyoplankton entrained from the water column. *Id.* at 5-31 to 5-32. This reasoning is supported by the finding from the SRS studies that egg densities are higher at the bottom of the water column than at the top, which would further reduce the significance of the entrainment-related losses. Exhibit NRC000012 at 3-37 and 3-39.

The Staff's conclusion that there will be a lack of impact to fish such as striped bass or American shad is also supported by the typically high fecundity of these species that spawn pelagically in rivers such as the Savannah River, where there is a high natural mortality rate for eggs and larvae of these important species. The timing of the spawning of these species relates to seasonal periods of naturally higher river flow, when the fraction of the water removed by the proposed units (and the subsequent fraction of eggs and larvae entrained) is smaller. Exhibit NRC000006 at 104, 292, and 294.

With respect to the robust redhorse, the Staff's conclusion was supported by the life history of the fish including the placement and development of robust redhorse eggs in gravel. Exhibit NRC000001 at 2-88, 2-89 and 5-36. In addition, the location of the nearest known spawning area is 25 river miles upstream of the VEGP site, further reducing the likelihood of entrainment of redhorse eggs or larvae at VEGP. Exhibit NRC000017 at 1152 and 1148.

The Staff's conclusion in the FEIS, that the shortnose sturgeon will not be adversely affected by entrainment from Units 3 and 4 is also based on the shortnose sturgeon's life history data, which shows that the sturgeon eggs are demersal and adhere to hard substrate and are thus less likely to be entrained into the cooling water system than eggs of other species. Exhibit NRC000001 at 2-89 to 2-93, 5-41 and 5-42. In addition, the embryos (age 1-8 days old) tend to stay near the bottom and seek cover and young juveniles (greater than 40 days old) spend most of the time swimming on the bottom. Exhibit NRC000046 at 172, 179 and 180. In addition,

shortnose sturgeon larvae collected in rivers (as are Atlantic sturgeon larvae) were found in the deepest water, usually within the channel rather than in the area near the intake where they would be more susceptible to entrainment. *Id.* at 180. Further, the identified spawning grounds for the shortnose sturgeon are located downstream of the site at RM 111 to 118 and upstream at RM 171-172. Exhibit NRC000047 at 695. Collins and Smith (1993) reported a probable spawning site between RM 111 and 142. Exhibit NRC000024 at 485. In comparison, the VEGP units 3 and 4 intake structure is approximately at RM 151.

Because Atlantic sturgeon eggs are also highly adhesive and deposited on the bottom substrate and larvae tend to stay near the bottom (see response to Question 13) the Staff also concludes that the eggs and larvae of the Atlantic sturgeon would not be adversely affected by entrainment.

The Atlantic pigtoe mussel, another species identified in the FEIS as an "important species," has only been tentatively identified in the Savannah River, and only at a considerable distance from the VEGP site (52 river miles upstream) and thus the Staff concluded, in the FEIS, that it would not be adversely affected by entrainment. Exhibit NRC000005 at 4, 5, 6 and 18; Exhibit NRC000001 at 5-37.

The nine South Carolina mussel species identified in the FEIS could be entrained, however, the glochidia (larval stage) of most freshwater mussels are obligate parasites of fish and once they attach to the gills or fins of a fish they are less susceptible to the impacts of entrainment. Exhibit NRC000001 at 5-37.

As a result, after examining the specific life-history characteristics of each of the important species, the Staff concluded that the impact to the important species in the Savannah River from the proposed new Units 3 and 4 would be minor or SMALL. *Id.* at 5-37 and 5-42.

In addition, as I explain in more detail below, the Staff's conclusion with respect to the impact of entrainment of important species is supported by the preliminary results of Southern's entrainment monitoring program for VEGP Units 1 and 2. Exhibit NRC000030.

Q34. Is the Staff aware of additional information pertinent to the Staff's conclusions in the FEIS that projected impacts from entrainment will be minor?

A34. (RHK) Yes. Since the issuance of the FEIS, the Staff has become aware of two sources of new information relevant to the Staff's conclusions with respect to entrainment. The Staff has also revisited some information previously supplied by the applicant that was not cited in the FEIS. The Staff has determined that these three sources of information support the Staff's conclusions in the FEIS.

First, by letter dated August 11, 2008, the U.S. National Marine Fisheries Service (NMFS) responded to the Staff's January 2008 Biological Assessment. Exhibit SNC000022. The NMFS concurred with the Staff's conclusions and concluded that "this proposed action is not likely to adversely affect shortnose sturgeon[.]" *Id*. at 4.

Second, as discussed in FEIS Section 5.4.2.2, entrainment monitoring was initiated by Southern in March 2008 at the VEGP Units 1 and 2 intake structure to estimate the species composition and density of ichthyoplankton in the Savannah River and entrained in the cooling water withdrawals. An interim report provided by Southern dated September 2008 states that fish eggs and larvae in samples taken from the Savannah River were approximately 36.4 times more numerous than in samples taken in the intake canal collected at approximately the same period of time. Exhibit NRC000030 at 30. The majority (52%) of entrainment sample organisms were collected during March through July. Although eggs were the most abundant life stage collected in the Savannah River (accounting for 61.8 percent of the total sample), no eggs were encountered in entrainment samples, possibly indicating they may have settled out of the water column at the entrance to the canal where the water velocities are the lowest. Annualized extrapolation of sample data by the applicant resulted in an entrainment rate of 1302 organisms (eggs and larvae) per day. *Id.* This rate of 1302 organisms per day is minor when compared to the estimates by Specht of 23.4 million eggs and larvae entrained/year (64,000 per day) in 1984 and 25.9 million entrained per year (71,000 per day) in 1985. Exhibit NRC000011 at V-13.

The entrainment from the VEGP Units 1 and 2 (and by extension from Units 3 and 4) would be a small percentage (less than 1%) of the entrainment experienced in 1984 and 1985 at the SRS, when three nuclear reactors (K, L, and P) and a coal-fired power plant were operating. The Staff believes these data support its conclusions in the FEIS that the impacts of entrainment would be minor, as discussed in the response to Question 29. The impacts of entrainment at the SRS did not appear to have an effect on the fishery of the river, even though they were much higher entrainment rates than would occur at VEGP.

The Staff is also aware of a May 7, 2008, study by Southern to conduct a hydraulic zone of influence survey at the VEGP Units 1 and 2 intake structure. Exhibit NRC000031 at 2, 4. While this study was not discussed in the FEIS, the Staff has determined that it provides additional insight into the assessment of impacts that the VEGP Units 3 and 4 will potentially have on the aquatic biota in the vicinity of the site. The purpose of this study was to determine what fraction of the Savannah River that flows past the VEGP site is drawn into the Unit 1 and 2 intake canal by the operation of the pumps. The Savannah River flow at the time of the survey was 4,482 cfs. The water withdrawal rate was 110 cfs, compared to a normal withdrawal rate for VEGP Units 1 and 2 of 90 cfs. Exhibit NRC000001 at 7-4.

The results of the hydraulic zone of influence determination showed that, under approximately the same low flow conditions but with slightly greater withdrawal rates, the Units 1 and 2 intake structure had an area of hydraulic influence of 0.14 acres and extended about $1/6^{th}$ of the way across the river in the vicinity of the VEGP site. In the vicinity of the intake and discharge, under Drought Level 3 conditions, the river is over 300 feet wide. Therefore, the vast majority of ichthyoplankton drifting down the river would be unaffected by the water withdrawal of the intake structure for Units 3 and 4, since they are designed similar to Units 1 and 2. The Staff believes that this information provides additional support for its conclusions in the FEIS, because it demonstrates that only a fraction of the Savannah River is influenced by the kinds of water withdrawals associated with closed-cycle cooling system for Units 1 and 2. By extension,

the Staff believes influence on the river from the Units 3 and 4 intake structure would affect only a fraction of the river, comparable to that of Units 1 and 2; thus, most species that are moving up or down the river would not be adversely affected by the influence of the intake structures.

D. General River Flow Considerations

Q35. In evaluating impacts to aquatic resources, how did the Staff determine what river flow values to consider?

A35. (LWV, CBC) As discussed in the FEIS, the Staff considered a representative range of river flows, including seasonal variability, based on data from the USGS stream gauging network. Additionally, due to public concern with low-flow conditions resulting from the ongoing drought, the Staff augmented its analysis with consideration of some exceptionally low-flow conditions. This approach was consistent with guidance in the ESRP that directs the Staff to look at a range of flow conditions. Exhibit NRC000009 at 2.3.1-2.

As discussed in the FEIS, the U.S. Army Corps of Engineers ("Corps") released a draft Drought Contingency Plan in 2006. Exhibit NRC000038. The draft plan proposed release rates from upstream reservoirs under four drought levels. The draft Drought Contingency Plan, defines the drought levels by the elevations of the pool in the Thurmond and Hartwell storage reservoirs. Exhibit NRC000001 at 2-20. As the pools in the reservoirs drop, the drought levels increase from 1 to 4. As the drought level increases, the maximum release from Thurmond reservoir is decreased in an attempt to preserve the conservation pools in the reservoirs thus reducing the streamflow downstream. These reductions in releases are balanced against the need to maintain instream flow for aquatic habitat downstream from the Thurmond Dam.

The Drought Contingency Plan was not finalized at the time the FEIS was written. Exhibit NRC000001 at 2-20. However, in the FEIS, the Staff presented the reservoir release policies described in the draft Drought Contingency Plan, because it represented the most current understanding of future operations and releases by the Corps. The Staff used these published proposed minimum releases at Thurmond reservoir to represent streamflows

downstream at the VEGP site during drought periods when the Drought Contingency Plan would be in effect. We discuss this methodology and its relevance for the Staff's impact analysis later in this testimony.

As stated in the FEIS, the Savannah River Basin is currently in a severe and multiple-year drought. As a result, the Corps is presently operating in a manner similar to the draft Drought Contingency Plan, except that the Thurmond Dam discharge has been at 3600 cfs and not the 3800 cfs minimum currently prescribed in the draft plan. Exhibit NRC000038 at 1. Based on the draft plan, at the time that the FEIS was prepared, the Savannah River Basin was at Drought Level 2 and had never reached Drought Level 3 or 4. Exhibit NRC000001 at 5-7. However, the Corps had stated that without a reprieve in the drought, Drought Level 3 would be likely during the summer of 2008. *Id.* at 5-8. This did occur and, as of the date of this testimony, the Savannah River hydrosystem is in Drought Level 3 for the first time. This development is discussed in a Draft Environmental Assessment and Finding of No Significant Impact published by the Corps in October 2008 concerning a "Temporary Deviation Drought Contingency Plan" for the Savannah River Basin. Exhibit NRC000039 at 1. At the time the FEIS was written, the Staff was additionally advised that the Corps was considering revising the minimum releases in the December to April period downward to 3100 cfs. Exhibit NRC000001 at E-44. This change has also now been proposed in the Corps' Temporary Deviation Drought Contingency Plan. Exhibit NRC000039 at 1.

The Staff explained in the FEIS that the implementation of Drought Level 4 in the draft Drought Contingency Plan did not provide the explicit flows that would be needed for an impact analysis. Exhibit NRC000001 at E-44. The Corps, the State of Georgia and the State of South Carolina are presently clarifying the operational implementation of Drought Level 4. Without explicit flow levels (and given the likelihood that any such flow levels would likely change based on the ongoing development of the Draft Drought Contingency Plan) and because a Drought Level 4 would be an extremely rare event, the Staff determined that it was still conservative to

base its low-flow analysis in the FEIS on Drought Level 3 flows (3800 cfs). Exhibit NRC000001 at E-44.

However, in part because of the ongoing drought conditions and the reservoir-release changes contemplated by the Corps, the Staff did include calculated values in the FEIS in order to disclose potential fractional withdrawals and consumptive water use at flow rates of 3000 and 2000 cfs, in addition to the 3800 cfs minimum for Drought Level 1, 2, and 3 from the current draft Drought Contingency Plan. Exhibit NRC000001 at 5-9 to 5-10. While, as we have just mentioned, the Corps is proposing a further seasonal drop in releases from Thurman reservoir down to 3100 cfs, this value is still bounded by the 3000 cfs the Staff already considered in the FEIS. The 3000 and 2000 cfs values are not specifically Drought Level 4 flow rates but instead were the Staff's attempt to provide additional conservative context for its analysis. The Staff expects that the occurrence of these flows would be extremely rare and of only temporary duration.

Q36. In light of these recent developments concerning both the declared Drought Level and the Corps' proposed temporary deviation plan, do you believe the Staff's analysis in the FEIS of Drought Level 3 flows of 3800 cfs and of very-low flows of 3000 cfs and 2000 cfs remains appropriate?

A36. (LWV, CBC) Yes. Particularly when considering factors such as river flow, it is important in a NEPA review of a plant with a 40 plus year operating life not to bias the description of a site and the associated assessment of environmental impacts based on the limited context of current conditions. The current drought has provided a new drought of record. This occurrence increases the overall probability of a future occurrence of a similar event. However, this does not mean that the current state of flows in the river has become the new norm. As stated in the FEIS in response to comments on the DEIS, and as we will discuss later in our testimony, we do not believe that the current drought conditions represent a new baseline condition for the Savannah River Basin. Furthermore, as the Staff stated in the FEIS in

response to public comments on the DEIS, if flows decline to a level that the consumptive use of water by the plant's cooling system or the discharge of blowdown to the Savannah River represent a significant impact, the plant may be required by appropriate State water permitting authorities (e.g., GADNR) to derate or stop operation. Exhibit NRC000001 at E-44.

Q37. Why is it appropriate to use Thurmond Dam releases as the basis for the Staff's analysis of impacts at the site, given the withdrawals and releases upstream between Thurmond Dam and the Vogtle site? Why did the Staff not use flows from any USGS gauge closer to the site?

A37. (LWV, CBC) In the FEIS, in response to public comments on the DEIS, the Staff explained that between the Thurmond Dam and the VEGP site, discharges to the river and withdrawals from the river will change the flows reaching the VEGP site. Exhibit NRC000001 at E-45. The two largest water withdrawals upstream of the VEGP site are Urquhart Station at RM 195, which withdraws 3.61 m^3/s (127.5 cfs) and the D-Area Powerhouse, which withdraws 1.94 m^3/s (68.4 cfs). Both facilities are operated by South Carolina Electric and Gas. Upstream of the VEGP site, primary discharges of groundwater and surface water (including from Butler Creek, Spirit Creek, Hollow Creek, McBean Creek, Upper Three Runs Creek, Four Mile Branch, and Pen Branch) into the river increase the streamflow. Exhibit NRC000001 at E-45. A map showing these tributaries is attached as Exhibit NRC000042 at 8. The U.S. Geological Survey (USGS) estimated groundwater discharge over the reach of the river from just below Thurmond Dam to just above the VEGP site to be approximately 223 cfs during low flow conditions (i.e., river flow of 3800 cfs). Exhibit NRC000001 at 2-35; Exhibit NRC000040. Furthermore, the Staff stated in the FEIS that groundwater discharges to the river would likely increase at extremely low stream flows, while the withdrawals would not. Exhibit NRC000001 at E-45.

For these reasons, the Staff considers it likely that the groundwater discharges to the river are approximately equivalent to the consumptive loss from the upstream users (even under lower flow conditions). In any event, whatever the potential difference between the upstream

withdrawals and discharges, that difference would be very small compared to the total river flow. The Staff also found that the Jackson gauge, which is closer to the VEGP site than Thurmond Dam, was taken out of service in 2002 and is not available to measure streamflow near the VEGP site. Exhibit NRC000001 at 2-32. Moreover, the Staff notes that the accuracy of the Savannah River stream gauges ranges from 5 to 10 percent of true. *Id.* Accordingly, given the likelihood that upstream withdrawals from and discharges to the Savannah River are approximately equivalent, and considering the reliability of the flow estimates at the Thurmond Dam release point, the Staff considered it appropriate to base its FEIS analysis of the flow past the VEGP site on the Thurmond Dam estimated releases.

Since the issuance of the FEIS, the Staff also has considered additional recent data from the Waynesboro gauge. Exhibit NRC000041. The USGS operation and maintenance of this real-time stream gauge is funded in cooperation with Southern Nuclear under FERC licensing regulations. While the gauge is located near the VEGP site, it has only been in operation since January 2005 and, therefore, the Staff considered it to be of too limited a period of record to be the basis of the Staff's assessment in the FEIS.

However, the record of data from this new gauge does show flows in excess of the releases from Thurmond Dam and shows some periods of flow significantly above the Thurmond Dam releases, consistent with the unregulated surface water flow that, as we have just discussed, would enter the Savannah River from tributaries (Exhibit NRC000042) below Thurmond Dam. Therefore, this supports the Staff's view that the flow at the VEGP site will exceed the release at Thurmond reservoir, as long as the inflow from tributaries and groundwater exceed the consumptive water losses by users between Thurmond reservoir and the VEGP site (an assumption the support for which we have already explained). In general, the limited data shows greater flows at the Waynesboro gauge than at Thurmond reservoir. Therefore, in our opinion, this data from the Waynesboro gauge provides further support for the Staff's determination that the use of the Thurmond Dam flow releases represents a reasonable

and conservative assumption for evaluating river flows at the ESP site. Exhibit NRC000041. (The Waynesboro gauge data is available at http://waterdata.usgs.gov/nwis/uv?021973269.)

Q38. How does the Staff's analysis of impacts to aquatic resources account for monthly or annual ranges and averages of Savannah River flows?

A38. (MTM) The Staff based its analysis of operational impacts in FEIS Chapter 5 on the maximum withdrawal rate for the proposed VEGP Units 3 and 4. The Staff considers use of this rate to be a conservative assumption since the withdrawals at this maximum rate would occur infrequently and only for short periods of time. For river flows, the Staff used the average-daily river discharge of 8830 cfs and the Drought Level 3 river discharge rate of 3800 cfs. Exhibit NRC000001 at 5-29. Because the releases at Thurmond Dam are controlled, particularly at low flow levels, the Staff considers the use of these values to be reasonable. During low flow conditions, variation in releases at Thurmond Dam is minimal; nevertheless, the range in flows at the VEGP site, even on a daily basis, is often greater than the normal and maximum withdrawal rates for the planned VEGP Units 3 and 4. Such daily fluctuations, based on the flow records from the Waynesboro gauge for the period January 2005 through October 2008 would have exceeded the normal planned water withdrawal rate for Units 3 and 4 of 83 cfs 79 percent of the time. Exhibit NRC000041.

Withdrawals from the Savannah River by VEGP Units 3 and 4 will be relatively constant. Superimposed on this constant withdrawal rate will be the daily fluctuations in river flow. As stated above, river flows fluctuate at the site despite the fairly constant releases from Thurmond Dam. Variation in river flow rates is considered normal and beneficial to riverine systems. Often resource agencies insist on more normative flows downstream of impoundments by requiring variations in flow, both seasonally and in some cases more frequently, to maintain a balanced indigenous system.

Hypothetically, at very low river flows (less than 2000 cfs) that persist over a long period of time, the VEGP water withdrawals could have an adverse impact on the Savannah River

fishery with respect to impingement and entrainment losses. However, these very low-flows are not expected, and if they did occur they are unlikely to persist over a long period of time. Should very-low flows occur the Staff believes that the impacts related to operation of two additional units at the VEGP site on the fishery at these very low flow levels would be temporary, reversible, and confined to a stretch of river that is not biologically unique. Historically, even since the construction of the upstream impoundments, higher river flows occur in the spring and early summer, which is typically when most fish spawning occurs. Exhibit NRC000001 at 2-19. However, while the Staff recognized that this was the case, as an additional conservatism the Staff did not factor these historically higher flows into its FEIS assessment. Instead, the Staff relied on the average-daily discharge flow and the Drought Level 3 flows in performing its assessment. The Staff used these two flow values and the assumption of maximum withdrawal rate for the two units to conservatively assess the impact related to the water withdrawals.

E. Flow Considerations for Impingement and Entrainment

Q39. Did the Staff consider how the proposed cooling system for Units 3 and 4 would alter the flow in the Savannah River?

A39. (LWV, CBC) In the FEIS, the Staff acknowledges that operation of the proposed VEGP Units 3 and 4 will result in a small reduction in the amount of water downstream of the VEGP site. Exhibit NRC000001 at 5-7 to 5-10. This reduction in downstream flow is primarily the result of the evaporation of water to transfer reject heat from the plant into the atmosphere. At the daily-average river discharge flow of 8830 cfs, the normal consumptive use of water by VEGP Units 3 and 4 would be about 0.7 percent. The reduction in downstream flow will be proportionately greater during periods of drought, such as the one the Savannah River Basin is currently experiencing.

The flow in the Savannah River at the VEGP site is highly regulated by a series of dams upstream of the VEGP site. However, the Corps manages the reservoirs in an attempt to

balance multiple objectives of the Savannah River, including flood control, municipal needs, industrial needs, recreation, navigation, and the aquatic ecosystem. Due to the small amount of water consumed by VEGP Units 3 and 4, the Staff does not believe that any significant alteration in the Corps' reservoir management policies would be made in response to operation of the additional units.

Q40. In your opinion, does the current regional drought and the lower flows in the Savannah River associated with it suggest a need to reconsider long-term "normal" flows in analyzing impacts at the ESP site, or is this an extremely rare event?

A40. (LWV, CBC) Since early in 2006, the Savannah River Basin has been experiencing a drought. The drought has persisted to the time that this testimony is being prepared and currently represents the drought of record for the Savannah River Basin. Exhibit NRC000039 at 3. The U.S. Army Corps of Engineers operates three large multipurpose reservoirs that regulate the flow of water in the Savannah River at the VEGP site. In normal years, even with this large capacity to regulate flows, the flow in the Savannah River varies considerably both annually and seasonally. This flow variability is a result of the limited ability of the Corps reservoirs to reshape the flows entering and leaving the reservoir system in normal flow years. In low flow years, while the releases from Thurmond Dam remain rather constant, the unregulated inflows from tributaries to the Savannah River downstream of Thurmond Dam and above the VEGP site also contribute to the annual and seasonal variability.

However, the recent drought has forced the Corps to release a nearly steady minimum low flow from these reservoirs in order to maintain instream flows while still protecting the conservation pools of the reservoirs. While these low flows have persisted since 2006, that persistence does not suggest that these low flows represent a trend that will continue indefinitely. While the occurrence of drought periods such as the recent drought will increase the presumed probability of a subsequent drought, this does not mean that using the current historical record as the basis for this environmental impact assessment is inappropriate.

Another possible cause of a severe and systematic change in streamflows that might bring into question the validity of using the current historical record as a basis for this assessment is climate change. In preparing the FEIS, the Staff did consider the potential impact of climate change on streamflows. As described in response to public comments (Exhibit NRC000001 at App. E), the Staff considered both the United States Global Climate Change Research Program National Assessment and the Intergovernmental Panel on Climate Change AR4 Synthesis Report. Exhibit NRC000043; Exhibit NRC000044. Both studies agree on predicted increases in temperature. However, precipitation estimates in the climate models suggest either a regional increase in precipitation or precipitation remaining about the same as present. While there is general agreement in the scientific community that some change in climate is occurring, considerable uncertainty remains with respect to the magnitude and direction of some of the changes. Therefore the staff considers the historical record to be the most appropriate basis for analysis available at this time.

Another possible reason for a severe and systematic change in streamflows that might bring into question the validity of using the current historical streamflow record as a basis for this analysis would be a bias in the current record associated with a persistent climate pattern such as El Niño or La Niña. However, while there is some evidence to suggest a weak correlation between La Niña conditions and winter droughts in the Southeast, given the long duration of the flow record and the relatively short persistence of a La Niña event, the Staff believes it is unlikely that the historical streamflow recorded in the VEGP site vicinity and used in the FEIS analysis is significantly biased. While the 20th century has been a relatively moist period in the Southeast compared to earlier centuries, the 20th century is the longest period with relatively reliable streamflow records. The Staff identified no other patterns of climate variability to suggest that the historical streamflow record was an unsuitable basis for this NEPA assessment.

Moreover, with respect to recent flow rates, the Waynesboro gauge shows that despite the lingering drought, the streamflow past the VEGP site has only been recorded below 3800 cfs on two days in the period of 3.75 years from January 22, 2005 through October 27, 2008. Exhibit NRC000041. These data also indicate that the river flow past the site has only been recorded below 4000 cfs on 49 days during this same period. *Id*. In addition, the day-to-day fluctuation in the streamflow in the Savannah River has been greater than 173 cfs (equivalent to the normal withdrawal of all four units) two-thirds of the time. *Id.* Thus, these data confirm the Staff's determination in the FEIS that a flowrate of 2000 cfs would be an infrequent occurrence.

Q41. Earlier in your testimony, you discussed the Staff's evaluation of impacts to aquatic resources from impingement and entrainment. What river flow conditions did the Staff assume as part of that evaluation?

A41. (RHK) The Staff evaluated the impacts to aquatic resources in Chapter 5 of the FEIS under average daily flow conditions (8830 cfs) and Drought Level 3 conditions (3800 cfs). Exhibit NRC000001 at 5-30. Later in the FEIS, the Staff also considered the impacts to aquatic biota at river flow rates of 3000 cfs and 2000 cfs. Exhibit NRC000001 at 5-38.

Q42. Did the Staff determine in the FEIS what percentage of the river flow would be withdrawn (or consumptively used) by the proposed new units?

A42. (LWV, CBC) The Staff determined that, at normal withdrawal and average daily river flow conditions, 0.9 percent of the water in the river would be withdrawn for Units 3 and 4. Exhibit NRC000001 at 5-8, Table 5-1. At maximum withdrawal rates and Drought Level 3 flow conditions, this percentage increases to 3.4 % of the Savannah River flow. The percentage of water withdrawn at the maximum withdrawal rate from the Savannah River due to operation of VEGP units 3 and 4 assuming river flows of 3000 cfs is 4.3%. Assuming river flows of 2000 cfs this rises to 6.5%. Exhibit NRC000001 at 7-6.

Only a fraction of the water withdrawn by the proposed intake at the VEGP site would be subsequently returned to the river. The difference between the water withdrawn from the river

and the water returned to the river is called the consumptive use. Most of this water is discharged into the environment as water vapor from the cooling towers. The consumptive use values are shown in Table 5-2 of the FEIS. Exhibit NRC000001 at 5-9. For normal consumptive use and average river flow conditions, the percentage of the river water consumed by Units 3 and 4 is 0.7%. For maximum consumptive use and Drought Level 3 conditions the percentage of the river water consumed by the VEGP Units 3 and 4 is 1.7%. The Staff also analyzed the consumptive use under river flows of 3000 cfs and 2000 cfs. Exhibit NRC000001 at 5-10. Maximum surface water consumptive use would increase from 2.1% to 2.3% and from 3.2% to 3.4% respectively. This would constitute a 0.2 percent increase in the percent of consumptive water use.

Q43. Is the percentage of water withdrawn (or consumptively used) relevant to the Staff's impact conclusions for impingement and entrainment? If so, why?

A43. (RHK) Yes, the Staff based its analysis of impingement and entrainment impacts, in part, on the percentage of water withdrawn from the Savannah River, although the percentage of water withdrawn from the river is of greater significance for the assessment of impact from entrainment than it is for the assessment of impact from impingement. However, as we explained earlier in our testimony, the Staff's conclusions in the FEIS also considered other factors --the life history data of important aquatic species (see testimony at Question 28, above) and most importantly, the smaller amounts of water that are withdrawn by a closed-cycle cooling system (see testimony at Question 17, above).

Within the range of river flows anticipated at the VEGP site, the Staff does not anticipate variations in impingement losses directly related to river stage that could result in impacts to fish populations inhabiting the Savannah River. However, at very low flows, some increase in impingement may occur (see response to Question 45, below). The type of cooling system, the intake design and location, species composition, type of watercourse, and life history data all

have a greater potential for affecting impingement rates than do the kinds of flow variation expected in the Savannah River at the VEGP site.

The Staff is aware of the U.S. EPA's "Phase I Final regulations for new facilities that withdraw water from waterbodies for cooling purposes," and that it established proportional flow requirements for new facility cooling water intake structures requiring that the total design intake flow from all cooling water intake structures at a facility withdrawing from a freshwater river or stream be no greater than 5 percent of the source water body annual mean flow (also see my colleague's response to Question 22, above). Exhibit NRC000001 at 5-30. According to the U.S. EPA, "[t]he 5 percent value for rivers and streams reflects an estimate that this would entrain approximately 5 percent of the river or stream's entrainable organisms." Exhibit NRCR00035 at 65277, 65340. The EPA stated that "[p]roportional flow limitations are one way to provide protection for aquatic life and enhancement of commercial and recreational uses of source waters. Larger proportionate withdrawals of water may result in commensurately greater levels of entrainment. Entrainment impacts of cooling water intake structures are closely linked to the amount of water passing through the intake structure, because the eggs and larvae of some aquatic species are free floating and may be drawn with the flow of cooling water into an intake structure." *Id.*

The FEIS considered the percentage of water withdrawn during normal operations for the proposed VEGP Units 3 and 4 from the Savannah River at the average daily discharge and Drought Level 3 river flow levels. At normal withdrawal rates the proposed VEGP Units 3 and 4 would withdraw between 0.9 and 2.2 percent, respectively, of the river flow at these flow rates. Exhibit NRC000001 at 5-30. The staff has also subsequently considered the withdrawal rate at the annual mean flow for the Savannah River. The annual mean flow value for the Savannah River was determined for both the USGS Augusta and Waynesboro gauges. The staff conservatively used the calculated annual mean flow value for the Waynesboro gauge which was determined to be 6991 cfs. Because of the much shorter period of record and the influence

of the recent drought, on the average the Waynesboro flow rate value is significantly less than the annual mean flow value for the Augusta gauge. The combined normal withdrawal rate of 83 cfs for both VEGP Units 3 and 4 represents 1.2 percent of the Waynesboro annual mean flow value. This is significantly less than the USEPA national performance requirement of 5 percent for a cooling water intake structure located in a freshwater river or stream.

Q44. How did those calculated percentages affect the Staff's conclusions in the FEIS with regard to impingement and entrainment?

A44. (MTM, RHK) Although the Staff relied on the fact that only a small percentage of water is projected to be withdrawn from the river by the closed-cycle cooling system in its assessment of impacts related to impingement and entrainment on the aquatic organisms in the Savannah River, other factors and data were considered in the evaluation as well. The Staff discussed these factors earlier in this testimony. Based on the use of closed-cycle cooling, the design, location and planned operation of the intake structure, the life history data for species inhabiting the Savannah River, the results of studies conducted at the nearby Savannah River Site, the preliminary results of systematic sampling in the vicinity of the VEGP Units 1 and 2 intake, several site visits, as well as river stage and withdrawal rates, it is the Staff's professional judgment that the impacts of impingement and entrainment on aquatic resources would be minor.

Q45. What did the Staff conclude with regard to impingement and entrainment impacts to aquatic resources from Units 3 and 4 normal and maximum withdrawals under very-low-flow conditions? What was the basis for that conclusion?

A45. (MTM/RHK) The Staff determined that the impact of two additional units at the VEGP site to fish populations and particularly to the "important species" in the Savannah River due to impingement and entrainment at very-low flows would result in entrainment of a greater proportion of the ichthyoplankton in the Savannah River water column, and possibly a slight increase in impingement mortality rates. However, the Staff determined that any losses from

entrainment and impingement are unlikely to have any persistent long term impacts on populations of aquatic organisms in the river. Exhibit NRC000001 at 5-38.

It is postulated that at the very-low flows of 3000 and 2000 cfs, aquatic biota in the river would be concentrated and the through-screen velocities at the intake would increase slightly. These effects would potentially increase the rate of impingement, particularly of small and juvenile fish and fish in poor condition. However, it would likely result in only a minimal increase in impingement rates, if the rates were to increase at all. As explained earlier in this testimony, factors other than river flow (such as station water withdrawal rate, species present, and intake location) play a more significant role than low flows in influencing the magnitude of impingement losses.

The Staff determined in the FEIS that the impact of two additional units at the VEGP site due to entrainment at very-low flows would result in a proportionate increase in entrainment. The Staff evaluated the impacts to aquatic biota from entrainment at river flows of 3000 cfs and 2000 cfs in Section 5.4.2.9 of the FEIS. Exhibit NRC000001 at 5-38. The Staff concluded that at river flows of 3000 and 2000 cfs, the river stage and available habitat for aquatic organisms would be reduced, resulting in an increased fraction of water flowing past the site being drawn into the cooling system. Accordingly, entrainment would increase proportionately for both the 3000 and 2000 cfs river flow cases. However, the Staff concluded that both the increased percentage of organisms entrained and the possible increase in impingement mortality are unlikely to have any persistent long term impacts on populations in the river. The Staff reached that conclusion because the low flow conditions would likely be temporary (as discussed above in response to Question 35) and the characteristics of the Savannah River in the vicinity of the VEGP site are not biologically unique; in other words, the analysis in the FEIS does not demonstrate that there are features in the vicinity of the site that are not present in other parts of the river.

F. Cumulative Impingement and Entrainment Impacts

Q46. Did the Staff determine in the FEIS what percentage of the river flow would be cumulatively withdrawn and consumptively used by Units 1, 2, 3, and 4 at various flow levels?

A46. (LWV, CBC) Yes, the Staff's analysis in Section 7.3 determined the percentage of the river flow that would be cumulatively withdrawn by all four units. At the four flow rates considered (8830 cfs, 3800 cfs, 3000 cfs, and 2000 cfs), the fractional withdrawal of the Savannah River for normal withdrawals are 2.0 percent, 4.6 percent, 5.9 percent, and 8.8 percent, respectively. Exhibit NRC000001 at 7-4, 7-6. For maximum withdrawals at those flow rates, the fractional withdrawal would be 2.5 percent, 5.8 percent, 7.3 percent, and 11.0 percent, respectively.

The Staff's analysis also determined the cumulative consumptive use percentages for all four units. The fractional consumptive use of the Savannah River at the four flow rates mentioned above for normal consumption rates would be 1.5 percent, 3.4 percent, 4.3 percent, and 6.5 percent, respectively. Exhibit NRC000001 at 7-5, 7-6. For maximum consumption rates by all four units, the consumptive use percentages would be 1.5 percent, 3.4 percent, 4.4 percent, and 6.6 percent, respectively.

Prior to publishing the FEIS, Southern informed the Staff that a revision to the proposed plant design would increase the cumulative needs by 3 cfs. The Staff evaluated the effect of this change and determined that it would result in an increase in the normal water consumptive use to approximately 3.5 percent (an increase of only 0.1 percent) of the Drought Level 3 river flow (3800 cfs). Even with the 3 cfs cumulative increase identified by Southern, the Staff determined that the consumptive use rate for very-low river flows of 3000 cfs and 2000 cfs would be 4.4 percent and 6.6 percent, respectively. *Id.* at 7-6.

Q47. Did the Staff evaluate in the FEIS the cumulative impacts to aquatic resources from impingement and entrainment from existing Units 1 and 2 in combination with Units 3 and 4?

A47. (MTM,RHK) Yes. The Staff's review is in Section 7.5.2 of the FEIS. *Id.* at 7-21.

Q48. For flows down to Drought Level 3, what was the Staff's conclusion with respect to cumulative impingement and entrainment impacts, and how did the calculated water withdrawal percentages affect the Staff's conclusions in the FEIS regarding those impacts?

A48. (MTM,RHK) The Staff assessed cumulative impacts to fish and shellfish due to impingement and entrainment losses at VEGP Units 3 and 4 at average-daily and Drought Level 3 flows of 8830 and 3800 cfs, respectively. The Staff did not rely solely on the percent water withdrawal values to assess the cumulative impacts associated with impingement and entrainment. As explained earlier in our testimony concerning impingement, the Staff's evaluation of the location, design, and planned operation of the intake and cooling system, the life history characteristics of the "important" species, conformance with U.S. EPA national requirements (see response to Question 22, above) for intake design, and the characteristics of the watercourse in the immediate vicinity of the intake location led to the Staff's conclusion that the resulting impact to Savannah River aquatic populations would be SMALL.

Based on the Staff's analysis, there is no indication that the Savannah River fishery would be destabilized as a result of the additional small and undetectable impact related to impingement losses from proposed VEGP Units 3 and 4 at river flow levels down to Drought Level 3.

The Staff's assessment of losses due to entrainment, however, relied more heavily on the percent water withdrawal values to assess the cumulative impacts. The Staff determined in the FEIS that the impact of two additional units at the VEGP site due to entrainment at low flows would result in a proportionate increase in entrainment. Exhibit NRC000001 at 7-22. The anticipated total entrainment percentage would be as much as 4.6 percent under combined withdrawals by Units 1 through 4 at Drought Level 3 (3800 cfs) flows. *Id.* at Table 7-1, page 7-4.

The Staff concluded that the impacts of entrainment would be minor even from the cumulative withdrawals for all four units. As stated in Chapters 2 and 5 of the FEIS and further

explained earlier in our testimony, this conclusion is based on a number of factors. These factors include the use of closed-cycle cooling; the design, location and planned operation of the proposed intake, including conformance with US EPA National standards for intake design (see response to Question 16 above); the characteristics of the watercourse in the immediate vicinity of the intake location; the distribution, abundance, and life history data of species inhabiting the Savannah River near VEGP; the results of the SRS studies of impingement and entrainment completed in the 1980s; and the preliminary results of the impingement and entrainment sampling program for VEGP Units 1 and 2. Also, the percentage withdrawal of the flow for all four units combined would be under the EPA's 5% threshold for riverine system withdrawals (40 CFR 125.84(b)(3)(i)) at the annual mean flow rate of the Savannah River, 6991 cfs (see response to Question 43) .

These are all additional reasons why the Staff believes that the impact to fish and shellfish populations in the Savannah River due to impingement and entrainment losses as a result of the operation of two additional units at the VEGP site would not be detectable or noticeably alter or destabilize the population.

Q49. Did the Staff also evaluate cumulative impacts from impingement and entrainment under very-low-flow conditions?

A49. (MTM, RHK) Yes. The analysis is presented on FEIS page 7-24.

Q50. What did the Staff conclude, and what was the basis for that conclusion?

A50. (MTM, RHK) In FEIS Section 7.5.2, the Staff assessed cumulative impacts to fish and shellfish due to impingement and entrainment losses at VEGP Units 3 and 4 at very-low flows down to 3000 and 2000 cfs. Exhibit NRC000001 at 7-23, 7-24. At the normal withdrawal rates for all four 4 VEGP Units, the percentage of water withdrawn from the river would be 5.8 percent at 3000 cfs and 8.7 percent at 2000 cfs. *Id*.

However, the Staff did not rely solely on the percent water withdrawal values to assess the cumulative impacts associated with impingement and entrainment at these very-low flows.

For impingement, the Staff's evaluation considered the use of closed-cycle cooling, the location, design, and planned operation of the intake structure, the life history characteristics of the "important" species, conformance with US EPA national performance requirements for intake structures (see response to Question 22 above), and the characteristics of the watercourse in the immediate vicinity of the intake location. These factors led to the Staff's conclusion that the resulting impact to Savannah River populations would be small even though a small increase in impingement mortality might occur as a result of the very-low flow conditions. This conclusion factored in the likelihood that the low flow conditions would be temporary and that the characteristics of the river in the vicinity of the site are not biologically unique.

At very-low flows of 3000 and 2000 cfs, the river stage and available habitat for aquatic organisms would be reduced, which would concentrate aquatic biota populations, and through-screen velocities at the intake would likely increase slightly. These effects could result in a slight increase in impingement. However, in the FEIS the Staff emphasized that the additional reduction in river flows would be temporary and that the Staff considered it likely that, within the range of very-low flows considered, there would be no detrimental effect on the Savannah River fishery. Exhibit NRC000001 at 7-24. The Staff reached this conclusion because many of the factors controlling impingement losses, such as behavior or physiology, are relatively unaffected by the very-low flows considered. Furthermore, healthy, adult fish inhabiting the Savannah River are capable of swim speeds in excess of any likely increase in through-screen velocities and should be able to escape impingement. Moreover, should very-low flow conditions occur and impingement rates increase, Southern could be directed by the State resource agencies to reduce power or cease power operations, which would reduce water withdrawals significantly and thereby mitigate or eliminate the increased impingement.

Similarly, entrainment would increase according to the percentage of water that would be withdrawn under the very-low river flow cases. The water withdrawal percentages are 5.8% for 3000 cfs and 8.7% for 2000 cfs. However, as discussed above and as stated in the FEIS,

such very-low flows are expected to be temporary, on the order of days or weeks, rather than months. *Id.* at 7-24. Accordingly the staff did not consider it appropriate to heavily weight these percentage withdrawals under very low flow conditions in its analysis. Also in comparison to the water withdrawal rates, the entrainment losses of ichthyoplankton from the SRS site occurred under withdrawals estimated at 8.3 and 12.3 percent of the Savannah River flow, which is a greater percentage than that evaluated by the Staff for all 4 VEGP units under those very-low flow conditions. Exhibit NRC000001 at 7-24; Exhibit NRC000012 at 3-143. Specht 1987 states that "[w]hile a substantial fraction of the Savannah River ichthyoplankton are entrained at the SRP cooling water intake structures there appears to be no effect on the fishery of the river". Exhibit NRC000011 at V-13.

Again, at very-low flow conditions Southern could be directed by the State resource agencies to reduce power or cease power operations (actions which would reduce water withdrawals significantly) for several reasons. These reasons might include if it proved necessary to protect aquatic biota during, for example, a critical spawning period for an important species when fish eggs and larvae would be present.

Q51. Why did Staff use normal rather than maximum withdrawal rates in evaluating cumulative impacts (both generally and with regard to impingement and entrainment)?

A51. (LWV, CBC) Normal withdrawals are most representative of the combined flows of all four units operating. Because maximum withdrawal are rare, it is unlikely that maximum withdrawal rates would occur for more than one unit at any time. Maximum withdrawals (and maximum blowdowns) are primarily associated with activities to control the water chemistry in the cooling tower and are not associated with changes in consumptive water use. Furthermore, such periods are partially offset by periods when one of the units is experiencing an outage.

In addition, all four Vogtle units would be using closed-cycle cooling. As opposed to once-through systems, which regularly vary flows to maintain discharge temperatures below some temperature limit, closed–cycle wet cooling towers rely nearly exclusively on the latent

heat of vaporization of water. Therefore, closed-cycle wet cooling towers like those at Vogtle are able to operate at very stable flow rates. Accordingly normal withdrawal rates are the most appropriate for evaluating cumulative impacts for all four units.

III. Thermal Impacts

Q52. Did the Staff evaluate in the FEIS the thermal impacts to aquatic resources from operation of proposed Units 3 and 4?

A52. (ARK) Yes. The Staff's analysis is provided in Sections 5.4.2.3 (Aquatic Thermal Impacts) and 5.4.2.9 (Summary of Aquatic Impacts) of the FEIS. Exhibit NRC000001.

Q53. Please summarize the Staff's conclusion relative to the impact of thermal discharges on aquatic organisms.

A53. (ARK) As stated in the FEIS, the Staff has determined, based on the results of the CORMIX assessment (discussed in more detail in the response to Questions 55 through 57), that the size of the thermal plume from the proposed effluent discharge would be small in comparison to the width of the Savannah River at the VEGP site. Exhibit NRC000001 at 5-33. The Staff also determined that the location and design of the discharge structure would not impede fish passage up and down the river. *Id.* at 5-33. Furthermore, the Staff found that fish and other organisms in the river would likely avoid the elevated temperatures within the plume. *Id*. Likewise, the fish and other organisms could move through this part of the river unencumbered by any structures or physical features that would retain them in the plume. *Id*.

In the FEIS, the Staff also analyzed potential impacts from cold shock, another factor related to thermal discharges that may affect aquatic biota. Cold shock occurs when aquatic organisms that have been acclimated to warm water are exposed to a sudden temperature decrease. Typically this is a potential problem at stations that employ once-through cooling systems and that discharge to a confined body of water, such as a small lake or reservoir. Cold shock sometimes occurs when single-unit power plants shut down suddenly in winter; however, since the VEGP site will consist of multiple units, the temperature decrease from shutting down

one unit would be moderated by the heated discharge from the units that continue to operate. Moreover, cold shock is less of a factor when the discharge is to a river where the volume of the discharge in comparison to the flow of the river is very small, as is the case at the VEGP site. Therefore, the Staff determined that cold shock would not be a concern.

Heat shock occurs when fish are confined to an area in which the temperature of the water rises quickly. The rapid rise in temperature causes the fish to become disoriented and eventually succumb. As with cold shock, this is typically a potential problem at stations that employ once through cooling that discharge into a confined body of water, such as a small lake or reservoir. These conditions do not exist at the Vogtle site; therefore, the Staff determined that heat shock is not a concern.

The Staff also considered the potential impacts from the thermal plume with respect to invasive or nuisance organisms. Neither Asiatic clams (*Corbicula fluminea*), nor any other invasive species has been observed to have increased in numbers in the vicinity of the thermal plume operated by VEGP Units 1 and 2. Therefore, no large growths of invasive or nuisance organisms are anticipated from the thermal plume for the proposed units.

Based on its analysis of these factors, the Staff concluded in the FEIS that the impacts to aquatic organisms from thermal discharges from the proposed VEGP Units 3 and 4 would be minor.

Q54. What is the Staff guidance for reaching a determination of impacts on thermal discharges? How did the Staff follow that guidance?

A54. (ARK) The Staff followed guidance set forth in ESRP Section 5.3.2.2 “Aquatic Ecosystems” (2000). Exhibit NRC000009. This ESRP includes guidance that directs “the Staff’s description, quantification, and assessment of potential thermal…stresses to aquatic organisms that may occur as a result of plant cooling system discharges to receiving water bodies.” *Id.* at 5.3.2.2-1.

The ESRP instructs that the Staff's review "should include the analysis of alterations to the receiving water body resulting from plant thermal…discharges in sufficient detail to predict and determine the nature and extent of potential impacts on aquatic ecosystems." *Id.* at 5.3.2.2-1.

Furthermore, the ESRP states that "[t]he Staff's analysis may be provided by referencing the aquatic biota descriptions of ESRP 2.4.2 and describing in brief detail the effects on biota that are 'important' and susceptible to thermal…impact." *Id.* at 5.3.2.2-10. In FEIS Section 2.7.2, the Staff described the aquatic environment and biota, including the types, life stages, and relative abundance of important biota in the vicinity of the VEGP site and described thermal effects on important aquatic biota. Exhibit NRC000001 at 5-36, 5-37, 5-41. In addition, a Biological Assessment describing the Staff's findings was prepared and sent to the National Oceanic and Atmospheric Administration under Section 7 of the Endangered Species Act. *Id.* at 5-41.

Following the ESRP, the Staff "considered species in the vicinity of the station" (VEGP site) "and their susceptibility to thermal effects." Exhibit NRC000009 at 5.3.2.2-7. As part of the evaluation process, the Staff considered several factors. First, the Staff considered the physical and thermal characteristics of the plume in relation to the receiving water body. At the location of the discharge outfall, at a Drought Level 3 flow rate, the Savannah River is approximately 312 feet wide, and, assuming conservative river conditions (e.g., minimum river temperatures, maximum discharge temperatures), the maximum width of the 5^0F thermal plume would be 15 feet while the length would be would be 97 feet downstream of the outfall pipe. Exhibit NRC000001 at 5-33. Based on these calculations, the Staff determined that the size of the thermal plume would be small in comparison to the width of the Savannah River at the VEGP site and therefore would not impede fish passage up and down the river. In addition, the Staff concluded that fish and other organisms would likely avoid the elevated temperatures and would

be able to move through this part of the river unencumbered by any structures or physical features that would retain them in the plume. *Id.*

Second, the Staff also considered the potential for cold shock. Cold shock occurs when aquatic organisms that have been acclimated to warm water, such as fish in a power plant's discharge canal, are exposed to a sudden temperature decrease. The Staff concluded that cold shock would be less likely to occur at the VEGP site since the VEGP site would consist of multiple units, which would not be likely to all shut down simultaneously, and the plume discharge volume would be very small in comparison with the river flow. *Id.*

Third, the Staff analyzed the interaction between the plume and the habitat and life history of important species. As stated above, the size of the thermal plume is small in comparison to the width of the Savannah River at the VEGP site; therefore, the Staff concluded that impacts to the South Carolina mussel species of concern would be minor. *Id.* at 5-37. In addition, the Staff determined that the thermal plume would not create a barrier to the up- or down-stream migration of the important fish species of concern known to occur in the vicinity of the VEGP site, including the robust redhorse and the shortnose sturgeon. *Id.* at 5-36, 5-42. Although not discussed in the FEIS, the Staff has concluded that the thermal plume likewise would not create a barrier to the up- or downstream migration of the Atlantic sturgeon, as described in my colleague's testimony in response to Question 59.

Fourth, the Staff evaluated the potential for any adverse impacts. The Staff concluded that impacts to aquatic organisms from thermal discharges would be minor. *Id.* at 5-34.

Finally, the Staff also considered the direct and indirect effects of the plume on nuisance, invasive, and introduced species. The Staff anticipates no large growths of invasive or nuisance organisms from the thermal plume for the proposed units. *Id.*

Q55. On what information did the Staff base its conclusion with respect to thermal impacts?

A55. (RHK) The Staff based its conclusions related to thermal impacts on the discharge temperature, the plume size as estimated by using the CORMIX code, the design and the location of the discharge structure, and the width of the river at the location of the VEGP site, as based on the bathymetry of the river. *Id.* at 5-33. The plume size was compared to the width of the river to provide an estimate of how much of the river was actually involved in the 5 degree Fahrenheit plume.

Q56. Why was data on thermal tolerance and species' varying tolerances by life stage not included in the analysis of the impact to aquatic species from the thermal plume?

A56. (RHK) ESRP 5.3.2.2 states that the reviewer should consider the effects of the thermal plume on biota that are important and susceptible to thermal impact, as well as the areal extent of the plume from the point of discharge and the percent of unaffected area (in other words the percentage of the river that is not affected by the thermal plume). Exhibit NRC000009 at 5.3.2.2-7, 5.3.2.2-8. The results of the CORMIX assessment presented in Section 5.3.3.1 of the FEIS described the areal extent of the heat plume from the point of discharge, and the anticipated temperature of the plume as it extends downstream. Exhibit NRC000001 at 5-18, 5-19. Because the discharge is located in a river, and the plume was so small compared to the width of the river at the VEGP site, even under Drought Level 3 conditions it was apparent that there was no thermal blockage to movement of aquatic biota and that adult fish could easily avoid the plume. *Id*. at 5-33. The Staff acknowledges that there may be some mortality of eggs and larvae as they pass through the plume; however, this would be a very small fraction of the eggs and larvae in the river. Based on the short duration of plume transit, and the small area that it encompasses, the Staff concludes that the impact to the aquatic biota of the river would be minimal.

Based on the above reasons and the ESRP guidance, the Staff determined that thermal tolerance data on varying species and life stages was not necessary to predict impacts.

Q57. How did the Staff determine the extent of the thermal plume? Does the analysis account for the cumulative effects of all four units?

A57. (LWV, CBC) The Staff's assessment of the cumulative water temperature impacts considered discharges of heated water from all four units. The analyses considered the combined impacts by assigning the total effluent discharge for all four units to a single outfall pipe. Staff considered this scenario to produce the maximum single thermal plume. The CORMIX code was used to compute the extent of the thermal plume. CORMIX is a U. S. EPA-supported mixing zone decision support system for environmental impact assessment of regulatory mixing zones resulting from continuous point source discharges. The CORMIX methodology contains representations of single-port, multiport diffuser discharges and surface discharge sources. It considers the hydrodynamics of the system to be one dimensional and at steady state. CORMIX is an industry standard for such assessments and is commonly employed by the U.S. EPA.

Effluent from the proposed new facility will be discharged directly into the Savannah River through a new discharge structure. The new discharge structure will be 2,500 feet downstream of the intake. It will discharge the cooling water through a single port two feet in diameter. The port will be located 3 ft above the river bottom.

For a bounding analysis with the largest mixing zone, the Staff employed conservative inputs for the key parameters for the CORMIX assessment. The Staff considered the lowest ambient stream temperature (5 ºC) because it provides the largest difference between the temperature of the water coming out the discharge pipe and the water flowing down the river. The Staff also considered the highest combined (Units 1, 2, 3, and 4) discharge (90.5 cfs) because it provides the largest volume of heated water being released to the river at a single discharge point. Finally, the Staff considered the Drought Level 3 flows of 3800 cfs As stated in the FEIS, the resulting plume length and width were 97 ft and 15 ft, respectively. *Id*. at 5-18.

Q58. Does the Staff's analysis of the thermal plume account for varying river flow conditions?

A58. (LWV, CBC) Yes. In addition to the flow rates discussed above, the Staff also considered the impacts to water quality in the Savannah River at river flow rates below Drought Level 3. For additional conservatism, the Staff considered thermal impacts under flows of 3000 and 2000 cfs and analyzed how the thermal plume and associated impacts would change under such very-low flows. Exhibit NRC000001 at Errata 7. Low flow conditions result in the greatest plume size and greatest impact. As stated in the FEIS, the plume at 2000 cfs would be approximately twice the areal extent of the plume at 3800 cfs. *Id.* However, as discussed previously, the 3000 and 2000 cfs values were the Staff's attempt to provide additional conservative context for its analysis. The Staff expects that the occurrence of these flows would be extremely rare and of only temporary duration.

Q59. What was the basis for the Staff's determination that Units 3 and 4 operations at river flow levels down to 3800 cfs would result in only SMALL thermal impacts to aquatic resources?

A59. (LWV) In Section 5.4.2.3 of the FEIS, the Staff referred to the Staff's thermal plume analysis, which determined the size of the plume under maximum two-unit blowdown rate, Drought Level 3 river flows, and the conservative approach of combining the discharge from both VEGP Units 1 and 2 with Units 3 and 4. Exhibit NRC000001 at 5-19. Even under these conditions, the Staff determined in the FEIS that the maximum width of the plume, as defined by the 5 degree Fahrenheit isotherm, is about 15 feet wide and less than 100 feet in length. At the point of discharge, the river is approximately 312 feet wide. Therefore, the 5 degree Fahrenheit isotherm would occupy about 5 % of the river cross section.

(MTM) The Staff determined in the FEIS that this plume would not result in a thermal blockage and would not impede upstream or downstream movement of fish. Fish actively avoid areas of unhealthy water temperatures, provided there is an escape route. The remainder of

the cross section of the river would provide such an alternative escape route for fish. No important species of Unionid mussel are known from the river in the vicinity of the VEGP site and immediately downstream of the planned discharge structure. Therefore, it is unlikely that the thermal discharge would affect any protected mussel species. There would likely be some bottom scouring in the vicinity of the discharge location. However, the area affected would be confined to a small portion of river bottom. Typically the warm discharge water rapidly rises to the surface of the river. River turbulence would further mix and dissipate the heated water. Only a small area of river bottom would be exposed to elevated water temperatures.

(MTM) Due to the small area of the plume and the fact that a fish would have to actively swim to maintain its position in the plume, it is unlikely that a fish would become acclimated to the higher station discharge temperature. However, even assuming that fish did become acclimated to a higher water temperature than ambient, the chances of cold shock as a result of Units 3 and 4 simultaneously going offline quickly and resulting in a significant fish kill is exceedingly small because of the presence of VEGP Units 1 and 2 and the small size of the plume. There may be some loss of eggs and larvae as they pass through the plume; however, this would be only a small percentage of the total number of organisms passing the site, resulting in minor and undetectable impact to fish populations. Additionally, due to the short duration of plume transit, there would be some survival of the eggs and larvae that did experience elevated temperatures. This latent survival would further reduce any impact.

Q60. Did the Staff assess thermal impacts to aquatic resources from Units 3 and 4 operations under very-low-flow conditions? If so, what was the basis for that conclusion?

A60. (MTM) Yes, the Staff did assess the thermal impacts to aquatic resources from Unit 3 and 4 operations under very-low (less than 3800 cfs) river flows, namely down to 2000 cfs. The Staff determined that the velocity and depth of the river will decrease with lower flows and the fraction of the discharge of the blowdown to the streamflow will increase. The net impact will be a larger mixing zone defined by the five degree Fahrenheit isotherm.

At a very-low river flow of 2000 cfs, the mixing zone plume would approximately double in areal extent, as discussed in my colleague's response to Q58. Given the small size of the plume in the baseline assessment as discussed in my response to Question 59 above, the Staff determined that even a doubling in its area would not represent a significant impact to water quality in the river. Exhibit NRC000001 at Errata 7. Additionally, because the Staff believes that such very-low flow conditions would be rare and of only temporary duration, the Staff does not consider the impacts under these conditions to be significantly different from the impacts analyzed for flows down to Drought Level 3 levels.

Although the lower flows would reduce the river stage, the lateral extent of the plume relative to river width at these flow rates would still be small, and would not result in a river-wide thermal blockage since the size of the plume would be approximately double the size of the plume under Drought Level 3 conditions. Again, very-low flow conditions are expected to be temporary and, based on the historical record of flows since the construction of the upstream impoundments, would be more unlikely during the spring and early summer spawning period when most river-running species are moving up and down river. Exhibit NRC000001 at 2-19. Additionally, should the low river flow rates result in an unacceptable thermal impact or the applicant exceed its mixing zone requirements, Southern could be directed by the State resource agencies to reduce power or cease power operations. Such actions would reduce the size of the thermal plume and thus mitigate the associated thermal impacts to aquatic biota.

Q61. What is the basis for the Staff's conclusion that projected impacts will be minor if there has not been any monitoring of the current impacts of the existing units on thermal discharges in the vicinity of VEGP Site?

A61. (LWV, CBC) Section 5.3.3.1 of the FEIS describes the Staff's analysis of the size and location of the thermal plume. As explained in FEIS Section 5.3.3.1, for the VEGP ESP review, the Staff conservatively combined the discharge from both Units 1 and 2 with the discharge of Units 3 and 4 and performed the analysis for a variety of low river flows. Exhibit

NRC000001 at 5-18; Errata 7. The Staff also assumed maximum plant flows, maximum discharge temperatures, and minimum ambient river temperature to maximize the size of the plume. The conservative assumptions described earlier in this testimony predicted a small plume relative to the river width and with a downstream extent of less than 100 feet. Given the small size of the plume relative to the river, for such a conservative bounding assessment, the Staff determined that stream temperature measurements downstream of the plume were not required to make a reliable impact determination.

(MTM) All discharges of regulated non-radiological constituents, including thermal discharges, from VEGP Units 1 and 2 are addressed in NPDES permit GA0026786 issued by the State of Georgia Department of Natural Resources. Exhibit NRC000045 at 2-31. Except for occasional minor exceedances, or possible exceedances of permit standards (six since 2002, none resulting in impacts to the Savannah River or enforcement action) the existing Unit 1 and 2 discharge complies with Georgia State water-quality standards, and the Staff anticipates that Units 3 and 4 will also comply with State requirements.

(MTM) Based on the use of closed-cycle cooling for all four units and the fact that the thermal plume was calculated to be of small size even under a number of conservative assumptions such as low flows in the Savannah River and combining the discharge from all four units, the Staff did not believe additional empirical data was necessary to reach a conclusion on the potential for thermal impact to aquatic biota. Additionally, there have been no fish kills related to the thermal discharge reported from the site. Exhibit NRC000001 at 2-93.

Q62. Following publication of the draft EIS, Southern advised Staff that based on changes between Revision 15 and 16 of the AP1000 DCD, some of the cooling water demand values would change. Please describe the magnitude of these changes and how they would affect normal and cumulative impacts associated with impingement, entrainment, and thermal effects under average-daily, Drought Level 3 and very-low flow conditions.

A62. (LWV, MTM) Following publication of the draft EIS, Southern advised the Staff that flows related to cooling system operation would differ based on changes between Revision 15 and Revision 16 of the AP1000 DCD. The relevant flows consistent with DCD Revisions 15 and 16 are summarized in the attached table. Exhibit NRC000050.

The heat rejected per unit would increase by 8.0E+07 BTU/hr or 1.1 percent. The normal combined (Units 3 and 4) circulating water system makeup flow would increase by 3.57 cfs (1601 gpm) or 4.3 percent, whereas the maximum combined circulating water system makeup flow would increase by 7.49 cfs (3361 gpm) or 5.8 percent. The normal combined circulating water system consumptive use would increase by 2.68 cfs (1201 gpm) or 4.3 percent, whereas the maximum combined circulating water system consumptive use would increase by 3.75 cfs (1681 gpm) or 5.8 percent. The normal combined plant discharge would not change, whereas the maximum combined plant discharge would increase by 2.08 cfs (934 gpm) or 3.0 percent.

In order to determine how the impacts evaluated for Revision 15 would be affected, the Staff identified the increase in fractional withdrawal of the Savannah River associated with the change between Revision 15 and Revision 16 at the four flow rates considered – normal flows of 8830 cfs, Drought Level 3 flows of 3800 cfs, and also the very-low flows of 3000 cfs and 2000 cfs. For normal withdrawals by the proposed Units 3 and 4, the increase would be 0.04 percent, 0.1 percent, 0.1 percent, and 0.2 percent, respectively. For normal withdrawals by all four units, the increase would be 0.04 percent, 0.1 percent, 0.1 percent, and 0.2 percent, respectively.

For maximum withdrawals by the proposed Units 3 and 4, the increase associated with the change between Revision 15 and Revision 16 would be 0.1 percent, 0.2 percent, 0.2 percent, and 0.4 percent, respectively. For maximum withdrawals by all four units, the increase would be 0.1 percent, 0.2 percent, 0.2 percent, and 0.4 percent, respectively.

The Staff also identified the increase in fractional consumptive use of the Savannah River associated with the change between Revision 15 and Revision 16 at the four flow rates

considered (8830 cfs, 3800 cfs, 3000 cfs, and 2000 cfs). For normal consumptive rates by the proposed Units 3 and 4, the increase would be 0.03 percent, 0.1 percent, 0.1 percent, and 0.1 percent, respectively. For normal consumptive rates by all four units, the increase would be 0.03 percent, 0.1 percent, 0.1 percent, and 0.1 percent, respectively.

For maximum consumptive rates by the proposed Units 3 and 4, the increases associated with the change between Revision 15 and Revision 16 would be of 0.04 percent, 0.1 percent, 0.1 percent, and 0.2 percent, respectively. For maximum consumptive rates by all four units, the increases would be of 0.04 percent, 0.1 percent, 0.1 percent, and 0.2 percent, respectively.

As discussed above in response to Question 38, the range in flows at the VEGP site, even on a daily basis, is often greater than the normal and maximum withdrawal rates for the proposed VEGP Units 3 and 4. Accordingly, relative to the natural variability of the Savannah River, all of these percentage increases in water use associated with the change between Revision 15 and Revision 16 are exceedingly small. There was no change in the blowdown flow rate associated with the change between Revision 15 and Revision 16; therefore, there would be no change in the thermal plume analysis or its impact under all flow conditions considered. The effects on aquatic biota of the slight increase in normal and maximum withdrawal rates associated with Revision 16 would be undetectable and not result in a change in the impact level associated with impingement or entrainment. The Staff believes that would be the case under average-daily, Drought Level 3, or very-low flows when assessing both normal and cumulative impacts of operation of VEGP Units 3 and 4.

Q63. Does this conclude your testimony?

A63. (All) Yes.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
SOUTHERN NUCLEAR OPERATING CO.	)	Docket No. 52-011-ESP
	)	
(Early Site Permit for Vogtle ESP Site)	)	

AFFIDAVIT OF ANNE R. KUNTZLEMAN CONCERNING
PREFILED TESTIMONY ON ENVIRONMENTAL CONTENTIONS 1.2 AND 6.0

I, Anne R. Kuntzleman, do declare under penalty of perjury that my statements in *NRC Staff Testimony of Dr. Michael T. Masnik, Anne R. Kuntzleman, Rebekah H. Krieg, Jill S. Caverly, and Lance W. Vail Concerning Environmental Contention EC 1.2*, and in *NRC Staff Testimony of Mark D. Notich, Anne R. Kuntzleman, Rebekah H. Krieg, Jill S. Caverly, and Lance W. Vail Concerning Environmental Contention EC 6.0,* as well as in my attached statement of professional qualifications are true and correct to the best of my knowledge, information, and belief.

Executed in Accord with
10 C.F.R. § 2.304(d)

_____
Anne R. Kuntzleman

Executed at Rockville, Maryland
This 9th day of January, 2009

Anne "Nancy" R. Kuntzleman
STATEMENT OF PROFESSIONAL QUALIFICATIONS
UNITED STATES NUCLEAR REGULATORY COMMISSION
Washington, D.C.

I am currently employed as an aquatic biologist in the Office of New Reactors, Division of Site and Environmental Reviews, Environmental Technical Support Branch, U.S. Nuclear Regulatory Commission. As an NRC staff member, I am responsible for conducting the aquatic and terrestrial technical reviews associated with the preparation of an environmental impact statement (EIS) for siting, construction, and operation new nuclear power plants.

I hold a Bachelor of Science in Biology from the Pennsylvania State University (1975), a Master of Science in Education from Temple University (1981), and a Master of Science in Biology from the University of Michigan (1982). I have also pursued graduate studies in biology at the University of Maryland (1980) and the University of Pennsylvania (1985).

From July 1975 through August 1986, I was an aquatic ecologist for two environmental consulting firms (Ichthyological Associates and Radiation Management Corporation, respectively) under contract to Philadelphia Electric Company. I assisted in all phases (field work, data processing, data analyses, report writing) of both aquatic and terrestrial preoperational studies at the Limerick Generating Station (LGS), Limerick Township, PA. My duties during this time included assisting in the age and growth survey of redbreast sunfish (*Lepomis auritus*), green sunfish (*Lepomis cyanellus*), and white sucker (*Catostomus commersonii*) from the East Branch Perkiomen Creek and the Schuylkill River in the vicinity of LGS by participating in field sampling with a small stream shocker and performing fish scale removal, pressing, and reading. I also participated in field work to conduct fish population estimates along the Schuylkill River via electrofishing, fish community characterizations via seine in the Perkiomen Creek, and angler surveys along the East Branch Perkiomen Creek and Schuylkill River in conjunction with the pre-operational monitoring program at LGS. Assisted in writing the procedures for collecting plant, mammal, sediment, and fish samples in conjunction with the Radiological Environmental Monitoring Program (REMP) at LGS and was responsible for coordinating the collection of the REMP sediment, vegetation, and fish samples.

In addition, from August 1975 through December 1976, I supervised two fishery biologists and two fishery technicians during the field work performed for two Clean Water Act (CWA) Section 316(a) thermal plume investigations on the Schuylkill River: Schuylkill Generating Station (SGS), Philadelphia, PA, and Cromby Generating Station (CGS), Phoenixville, PA, respectively. Field work included electrofishing, larval fish tows, Ponar grabs for benthic macroinvertebrates, plankton sampling, thermal plume mapping, and collection of physical chemistry data. I sorted, identified, measured, and processed both adult and larval fish collections. I assisted in report writing, data coding, and editing. I conducted a thorough non-parametric statistical analysis of both the catch per effort and larval fish data for SGS. Our electrofishing efforts at the base of Fairmount Dam in Philadelphia documented the presence of American shad (*Alosa sapidissima*). This finding assisted the Pennsylvania Fish Commission in justifying construction of the Fairmount Dam Fish ladder in 1979.

During the late 1970's I was also a field biologist for CWA Section 316(b) cooling water intake studies (impingement of fish and macroinvertebrates and entrainment of plankton, macroinvertebrates, and larval fish) at four freshwater and seven estuarine steam electric power stations on the Schuylkill and Delaware Rivers, respectively. I sorted, identified, measured, and processed the impingement and larval fish collections. I assisted in the preparation of the 316(b) evaluations for CGS and SGS located on the Schuylkill River and the Eddystone Generating Station and Edge Moor Power Station on the Delaware River.

Later as an environmental educator, I developed and presented aquatic ecology and fish identification in-service training programs for elementary and secondary schoolteachers within the Philadelphia Electric service area. I also presented lectures to community groups, environmental organizations, and students explaining the environmental preoperational studies and monitoring requirements for LGS.

From September 1986 until September 1987 I taught life science and physical science at Northeast Junior High School, Reading, PA.

From October 1987 until June 2006, I was a senior biologist with the Department of the Navy, Engineering Field Activity Northeast (EFANE), a component of the Naval Facilities Engineering Command, Atlantic Division. For almost 18 years, I served as the sole professional/technical authority for EFANE in the preparation and coordination of all Department of the Army permit applications, Coast Guard permits, state wetland permits, and water quality certificates for activities in waters of the United States (U.S.) and navigable waters of the U.S. within the regulatory authority of Sections 401 and 404 of the Clean Water Act (CWA), Sections 9 and 10 of the Rivers and Harbors Act of 1899, and Section 103 of the Marine Protection, Research, and Sanctuaries Act of 1972. In addition, I also prepared federal consistency determinations pursuant to Section 307 of the Coastal Zone Management Act and Volume 15 of the Code of Federal Regulations, Part 930, Federal Consistency.

During my tenure at EFANE, I had signatory authority for permit applications and attendant issues involving some of the Navy's most complex, controversial, and environmentally sensitive projects in the northeastern U.S.: dredging and dredged material disposal, waterfront construction, and new construction in or adjacent to wetlands.

Concomitant with regulatory requirements, I prepared or evaluated environmental documentation or analyses (prepared by Navy contractors) conducted under the National Environmental Policy Act (NEPA), Section 7 of the Endangered Species Act (ESA), the Magnuson-Stevens Fishery Conservation and Management Act (Essential Fish Habitat Assessment), Marine Mammal Protection Act, Fish and Wildlife Coordination Act, Executive Order 11988 (Floodplain Management), Executive Order 11990 (Protection of Wetlands), and Executive Order 13112 (Invasive Species).

As the Navy technical representative, I developed scopes of work, prepared independent cost estimates, analyzed contractor proposals, participated in negotiations, and developed contract execution schedules for Navy contractors. I provided technical oversight of contractor's work, monitored work in progress, and evaluated contractor's performance. I reviewed technical

submissions for accuracy and interpreted biological, chemical, and other environmental test results during contractor preparation of a variety of environmental documents including: NEPA environmental assessments and EISs, essential fish habitat assessments, coastal zone consistency determinations, 401 water quality certification applications, sediment sampling and testing plans for dredging projects, wetland delineations, wetland restoration plans, CERCLA remedial action plans, and integrated natural resources management plans.

In June 2006, I joined the Nuclear Regulatory Commission as an aquatic biologist. I serve as a technical specialist whose primary responsibility is that of independently assessing the environmental impacts of siting, construction, and operation of new nuclear power plants and related facilities on the aquatic environment. This involves reviewing and evaluating specific aspects of Environmental Reports submitted to the NRC by applicants and licensees and then assisting in the preparation an EIS. My duties also include updating the NRC environmental standard review plans for aquatic ecology contained in NUREG-1555, preparing biological assessments for Federal threatened and endangered species, and coordinating with federal and/or state agencies pursuant to NEPA, ESA, Sections 401 and 404 of the CWA, Section 10 of the Rivers and Harbors Act of 1899, Magnuson-Stevens Fishery Conservation and Management Act (Essential Fish Habitat Assessment), Marine Mammal Protection Act, and Fish and Wildlife Coordination Act.

Thus far I have participated in pre-application activities for the Bell Bend, North Anna, Shearon Harris, William States Lee, Vogtle, River Bend, South Texas Project, Comanche Peak, and Callaway combined license (COL) applications. I have conducted the aquatic and terrestrial acceptance reviews for the Shearon Harris, William States Lee, and Callaway COL applications. In addition, I have participated in site audits and alternative site visits for the Vogtle Early Site Permit (ESP) as well as the William States Lee and Shearon Harris COL applications. I have provided technical oversight for the aquatic and terrestrial sections of the Vogtle ESP draft and final EISs.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
SOUTHERN NUCLEAR OPERATING CO.	)	Docket No. 52-011-ESP
	)	
(Early Site Permit for Vogtle ESP Site)	)	

AFFIDAVIT OF LANCE W. VAIL CONCERNING
PREFILED TESTIMONY ON ENVIRONMENTAL CONTENTIONS 1.2, 1.3 AND 6.0

I, Lance W. Vail, do declare under penalty of perjury that my statements in *NRC Staff Testimony of Dr. Michael T. Masnik, Anne R. Kuntzleman, Rebekah H. Krieg, Jill S. Caverly, and Lance W. Vail Concerning Environmental Contention EC 1.2*, in *NRC Staff Testimony of Dr. Michael T. Masnik, Rebekah H. Krieg, Jill S. Caverly, and Lance W. Vail Concerning Environmental Contention EC 1.3*, and in *NRC Staff Testimony of Mark D. Notich, Anne R. Kuntzleman, Rebekah H. Krieg, Jill S. Caverly, and Lance W. Vail Concerning Environmental Contention EC 6.0,* as well as in my attached statement of professional qualifications are true and correct to the best of my knowledge, information, and belief.

Executed in Accord with
10 C.F.R. § 2.304(d)

_____
Lance W. Vail

Executed at Richland, Washington
This 9th day of January, 2009

STATEMENT OF PROFESSIONAL QUALIFICATIONS OF LANCE W. VAIL

CURRENT POSITION

Senior Research Engineer II
Environmental Technology Division
Battelle, Pacific Northwest Division
Pacific Northwest National Laboratory

Since joining Battelle in 1981, Mr. Vail has been involved in projects covering a diverse set of water related issues. His professional experience includes basic and applied research, and regulatory compliance assessments. His areas of expertise cover a broad spectrum of areas related to water resources.

RESEARCH INTERESTS

Water resource management
Multiple objective tradeoff analysis in water resources
Uncertainty analysis in water resources
Advanced hydrologic process modeling
Impacts of climate on water resources
Neural networks, fuzzy logic, and genetic algorithms applied to water resource issues
Linking simulation models with optimization methods to water resource problems
Linkage of physical and biological models in fisheries management

EDUCATION

B.S.	Humboldt State University, environmental resources engineering	1979
M.S.	Montana State University, civil engineering	1982

PROFESSIONAL AFFILIATIONS

American Geophysical Union
American Society of Civil Engineers
American Water Resources Association

CURRENT PROJECTS

Hydrologic Site Safety Reviews for Early Site Permits. Principal Investigator and Project Manager. Three applications for an Early Site Permit (ESP) have been submitted to the Nuclear Regulatory Commission. This project provides an independent assessment of hydrologic suitability of the proposed sites. Assessments include a broad range of considerations such as flooding, low water conditions, ice impacts, seiches, storm surge, and tsunamis.

Water-related Environmental Reviews for Early Site Permits. Task Manager. Three applications for an Early Site Permit (ESP) have been submitted to the Nuclear Regulatory Commission. This task provides an independent assessment of the proposed sites' environmental suitability. Assessments include a broad range of considerations such as water-use conflicts and changes in water quality.

Snohomish Basin Characterization. Technical Lead. Advanced distributed watershed models were applied to provide the Tulalip Tribes of Western Washington state a thorough understanding of the impacts of logging, development, and climate on the Snohomish River Basin.

Acid Rain TMDL. Principal Investigator and Technical Project Manager. The objective of this work assignment for Region II of the U.S. Environmental Protection Agency is to develop a preliminary assessment approach for TMDLs

for pH impaired waters listed on the New York State Section 303(d) list. The intent is to enhance and further develop TMDL program capabilities by providing expertise in both acid deposition and TMDL development. The development of such an assessment approach requires that available models and data resources be reviewed. Systems engineering methods will be used in developing a conceptual model to ensure the relationships between models and data are fully understood. The assessment approach will be tested on one or more representative watersheds to be determined in close coordination with EPA, NYSDEC and Battelle. http://acidraintmdl.pnl.gov

PAST PROJECTS

Environmental Impact of License Renewal of Commercial Nuclear Power Plants. Contributor. Mr. Vail assesses the water use, water quality, and hydrologic impacts of license renewal for the Nuclear Regulatory Commission's NEPA process. He has performed this function for the following commercial nuclear plants: Calvert Cliffs, Oconee, Arkansas Nuclear One, Hatch, McGuire, Catawba, North Anna, Robinson, Ginna, and St. Lucie.

Chehalis Basin Characterization. Principal Investigator and Project Manager. Advanced numerical modeling and GIS methods were applied to assist the Corps of Engineers in characterizing the Chehalis Basin in Western Washington State. The Chehalis Basin is subject to frequent flooding. The native populations of anadramous fish have been stressed to adverse changes in habitat resulting from development and logging.

Generic Environmental Impact Statement (GEIS) for Decommissioning Commercial Nuclear Power Plants. Contributor. Mr. Vail is providing expertise in the development of a GEIS for decommissioning of nuclear plants. He provides expertise on water use, water quality, and hydrologic impacts for the Nuclear Regulatory Commission.

Impact of Climate on the Lower Yakima Basin. Principal Investigator and Project Manager. The objective of this three-year EPA STAR Grant Project was to develop and demonstrate an integrated assessment of the impact of climate variability and climate change on a diverse set of interests in the Lower Yakima Valley in Central Washington State. Interests considered include: surface and groundwater supply, surface and groundwater quality, air quality, public health, farm and regional economics, and fisheries. The project considered the effectiveness of changes in land management (crop selection) and water management (reservoir operation) in adapting to an uncertain future climate. A diverse set of models was linked with an optimization procedure to ensure that the tradeoffs between various resource management objectives are clearly articulated. http://projects.battelle.org/yakima/

Use of NOAA's Seasonal Climate Forecast for Water Resource Management. Task Manager of Reservoir Optimization Task. The objective of this NOAA funded project was to show the potential value of improved climate forecasts in managing surface water reservoirs for multiple objectives. Using a pareto genetic algorithm, the reservoir operating rules were optimized to define the tradeoff curves for hydropower, flood control, and instream flow requirements in the Tennessee River basin. Changes in forecast reliability result in changes to these tradeoffs and thereby express the value of such improved forecasts.

Accelerated Climate Prediction Initiative. Task Manager of Water Resources and Habitat Task. This project will provided a limited, systematic assessment of the potential effects of anthropogenic climate change over the next half-century on water resources in the western United States. This objective was accomplished by "downscaling" the results of the global-scale simulations described above to the spatial and temporal resolution needed to drive impact assessment models. Downscaling is particularly important for the West, where topography is a dominant climate driver. An important aspect of the hydrology of almost all western rivers is water management. Other than a few headwater streams, the hydrology of most rivers in the west is strongly affected by water use and artificial storage. Water management models were

used to study the effect of reservoir operations and understand the implications of climate variability and change on the water resources of the west. http://acpiwater.pnl.gov

Linking Physical and Biological Models. Principal Investigator and Project Manager. The objective of this three-year Laboratory Directed Research and Development project is to develop and demonstrate an integrated natural resource analysis framework. This framework: dramatically improves the ability to integrate physical and biological models, thereby encouraging the utilization of advanced process models; allows utilization of large, sparse, and distributed data sets (including model output); communicates high-level tradeoffs and their respective uncertainties; and assesses, communicates, and minimizes scales issues. During the first year, the fundamental structural differences between such models was identified as a significant obstacle to successful linking of physical and biological models. The pervasive vagueness of rules and the multivaluedness associated with temporal/spatial upscaling suggested an approach using "fuzzy methods". The second year of this project utilized a variety of fuzzy methods including: fuzzy arithmetic, fuzzy logic, fuzzy clustering, and adaptive neural fuzzy inference systems (ANFIS). A series of rules and a database from the Multispecies Framework Process were employed to test the various fuzzy methods. These rules and data are used to define aquatic habitat diversity in the Pacific Northwest. A tool called FuzzyHab was developed to estimate habitat diversity from a set of categorical statements about the environment. Each of these categorical statements is vaguely defined. Estimates for each categorical statement are derived from physical process models.

Integrated Natural Resource Data System. Contributor. This project is to demonstrate INRDS. INRDS is an advanced, web-based environmental information system that will promote public understanding of natural resource management issues and assist planners and decision makers in accessing the most relevant information and analytical tools and evaluating the tradeoffs of alternate actions. http://inrds.pnl.gov

Early Warning of El Ni o Southern Oscillation (ENSO) Events for Regional Agriculture. Task Manager of Reservoir Optimization Task. This project is investigating the current predictability of interannual variability in climate conditions in the Pacific Northwest to determine whether and how early warning and seasonal climate forecasts by the Climate Prediction Center (CPC) of the National Oceanic and Atmospheric Administration (NOAA) forecasts can be used to reduce the vulnerability of irrigated agriculture to low water-availability conditions. The study is funded by a grant from the economics and Human Dimensions Program of the NOAA Office of Global Programs. The Economics and Human Dimensions program aims to improve our understanding of how social and economic systems are currently influenced by fluctuations in short-term climate (seasons to years), and how human behavior can be (or why it may not be) affected based on information about variability in the climate system. http://elrino-northwest.labworks.org

Impact of Reservoir Operating Strategies on Resident Fish - Mr. Vail has employed several models to assess the impact on resident fish species of a variety of reservoir operating strategies. This study was undertaken as part of the Columbia Basin System Operation Review process. Mr. Vail helped define the values and value measures of the Resident Fish Work Group.

Multiobjective Optimization - Mr. Vail is the project manager of an effort to assess the multiobjective optimization needs of Bonneville Power Administration. Objectives include: hydropower, resident fish, anadramous fish, irrigation, flood control, wildlife, and navigation. Mr. Vail is developing definitions of the canonical mathematical form of each of these objectives. The resulting multiobjective statement will be used to define the required optimization tools.

Integrated Environmental Monitoring Initiative - Mr. Vail is a co-principal investigator for the Integrated Environmental Monitoring Initiative. The objective of this initiative is to develop and demonstrate a comprehensive interdisciplinary methodology targeted to improve the effectiveness of environmental monitoring and restoration activities. This objective required comprehensive integration of monitoring regimes, analytical practices, design methodologies, and compliance needs.

Coupled Simulation/Optimization of Ground Water Remediation - Mr. Vail developed a computer code that coupled a ground water flow model with an optimization procedure. The code was able to provide estimates of the pumping/injection rates that would mitigate or remove a plume at minimal cost.

Simulation of Watershed Hydrologic Responses to Alternative Climates - Mr. Vail is the principal investigator of a project studying the impacts of global climate change on the hydrologic response of a watershed. The results of hydrologic simulations using distributed snowmelt and soil moisture accounting algorithms were graphically compared via video displays of daily simulated snow water equivalent, soil moisture, and runoff for the American River, Washington, which drains 204 square kilometers of the east slopes of the Cascade Mountains, Washington. Snow water equivalents and snowmelt were simulated using a simplified distributed temperature-index model augmented with seasonally estimated net solar radiation. A classification scheme was used to partition the empirical cumulative probability distributions of precipitation (rain plus melt) and a topographic index over the basin into groups of near-equal membership. Topographically-based soil moisture capacities were assumed for each class and were estimated via automated calibration methods using historical data. The simulated soil moisture and snow water accumulations for each class were geographically mapped for visualization. Test of the effect of alternative, warmer climates on snow accumulation, the seasonal distribution of soil moisture, and runoff were conducted by adjusting historical (daily) temperature and precipitation and repeating the analysis.

Pacific Northwest Climate Change Case Study - Water Resource Impacts - Mr. Vail is investigating the effects of global climate change on water resources of the Pacific Northwest. Spatially distributed snowmelt, soil moisture, and runoff models have been combined with a graphics visualization package to understand the changes in snowpack, soil moisture, and evapotranspiration over time. A weather classification scheme has been developed which estimates point precipitation as a function of large-scale atmospheric variables. This allows the synthesis of point precipitation given large-scale meteorological information as might be produced by GCM simulations. Orographic effects also have a significant role in defining climate at the watershed scale. Efforts are under way to develop a scientific basis to extend the sparse meteorological measurements basis to extend the sparse meteorological measurements available for any watershed to estimate the spatial distribution of precipitation, temperature, and wind speed within the watershed. A reservoir network model for the Columbia River Basin has been aggregated to fourteen nodes. This network model of the Columbia River Basin has been aggregated to fourteen nodes. This network model will be driven by a collection of index watersheds. A daily hydroclimatological data set has been developed to aid in the selection of index watersheds.

Acid Rain Watershed Modeling Project - Mr. Vail directed the hydrologic part of a study to evaluate and apply several coupled hydrology/geochemical codes that were developed to model the impact of acid rain on surface water chemistry. The project involved extensive behavior and sensitivity analyses of three coupled geochemical/hydrological simulation codes.

Incineration at Sea - The objective of this project was to assess the impact of incinerating toxic waste at sea on the aquatic environment. Mr. Vail developed a model on an IBM-PC to estimate the concentration of contaminant in the ocean.

Aquifer Thermal Energy Storage - The objective of this project was to develop and apply computer codes that would simulate the trade-offs between different management policies of an Aquifer Thermal Energy Storage system. Mr. Vail independently developed, validated, and applied several computer codes for this purpose.

Flow and Fractured Media - The objective of this study is to develop a state-of-the-art predictive capability for flow and transport in saturated fractured media. Mr. Vail was responsible for implementing, modifying, and testing a computer code that models steady flow in permeable media with discrete fractures. Mr. Vail has also developed a computer code that models steady flow through fractures in an impermeable rock mass. The fractures can either be specified or generated via Monte Carlo Methods. This code was applied in an investigation of the potential impact of a nuclear meltdown on groundwater.

Modeling Flow With Certainty in Hydraulic Parameters - The objective of this study is to develop a methodology to analyze the uncertainty in predicting piezometric surfaces caused by uncertainty in groundwater flow parameters. Mr. Vail developed a computer code that couples perturbation and finite-element techniques to estimate the mean and variance of the piezometric surface.

Stripa Mine Hydrogeologic Characterization - The objective of this study was to perform three-dimensional simulations with the CFEST code for ground water flow at the Stripa Mine in Sweden. Mr. Vail was the Battelle project manager of this effort.

PUBLICATIONS

Coleman A, LW Vail, and A Savery. 2005. "Landscape Classification for Assessment of Impacts of Landuse and Climate on Water Resources." Presented by Andre M Coleman (Invited Speaker) at 25th Annual Environmental Systems Research Institute International User Conference, San Diego, CA on July 25, 2005. PNWD-SA-7118.

Prasad R, LW Vail, CB Cook, and G Bagchi. 2005. "Establishment of Safety-Related Site Characteristics Based on Consideration of External Sources of Flooding at Nuclear Power Plant Sites in the United States of America." Presented by Rajiv Prasad (Invited Speaker) at IAEA-India External Flooding Hazards Workshop , Kalpakkan, Tamil Nadu on August 29, 2005. PNNL-SA-46005.

Scott MJ, LW Vail, CO Stockle, A Kemanian, KM Branch, R Prasad, MS Wigmosta, and JA Jaksch**.** 2005. "Benefits and Costs of Options to Mitigate the Uncertain Effects of Climate Change on Irrigated Agriculture in the Yakima Basin. What Matters? What Doesn't?" Presented by Michael J. Scott (Invited Speaker) at 39th Annual Pacific Northwest Regional Economic Conference, Bellingham, WA on May 20, 2005. PNWD-SA-6980.

Scott MJ, LW Vail, and R Prasad. 2005. "Managing Water for Irrigated Agriculture Under Extended Climate-Related Drought." Presented by Micahel J. Scott at American Water Resources Association 2005 Annual.

Scott MJ, LW Vail, CO Stockle, A Kemanian, KM Branch, R Prasad, MS Wigmosta, and JA Jaksch. 2005. "Benefits and Costs of Options to Mitigate the Uncertain Effects of Climate Change on Irrigated Agriculture in the Yakima Basin. What Matters? What Doesn't?" Presented by Michael J. Scott (Invited Speaker) at Pacific Northwest Regional Economic Conference, Bellingham, WA on May 20, 2005. PNWD-SA-6902.

Vail LW**.** 2005. "Adaptive Management of Water Resources in the Puget Sound." Presented by Lance W. Vail (Invited Speaker) at Puget Sound Georgia Basin Research Conference, Seattle, WA on March 29, 2005. PNNL-SA-44581.

Scott MJ, LW Vail, CO Stockle, A Kemanian, KM Branch, R Prasad, MS Wigmosta, and JA Jaksch. 2005. "Adapting Irrigated Agriculture to Climate Variability and Change." Presented by Michael J. Scott (Invited Speaker) at 2005 Annual Meeting, American Association for the Advancement of Science, Washington, DC on February 20, 2005. PNWD-SA-6848.

Scott MJ, LW Vail, CO Stockle, A Kemanian, KM Branch, R Prasad, MS Wigmosta, and JA Jaksch. 2005. "Adapting Irrigated Agriculture to Climate Variability and Change." Presented by Michael J. Scott (Invited Speaker) at 2005 Annual Meeting, American Association for the Advancement of Science, Washington, DC on February 20, 2005. PNWD-SA-6743.

Scott MJ, LW Vail, and R Prasad. 2005. "Managing Water for Irrigated Agriculture Under Extended Climate-Related Drought." Presented by Michael J. Scott (Invited Speaker) at American Water Resources Association 2005 Annual Conference, Seattle, WA on November 8, 2005. PNNL-SA-47342.

Scott MJ, LW Vail, CO Stockle, and A Kemanian. 2005. "Impacts of Water Availability on Washington Agriculture in a Changing Climate." Presented by Michael J. Scott (Invited Speaker) at 2005 Fall Climate Change Conference, Seattle, WA on October 27, 2005. PNNL-SA-47128.

Meza EP, and LW Vail. 2005. Real-time Harvesting of Distributed Environmental Data for Improved Management of Complex Distributed Water and Power Management Systems . PNNL-15333, Pacific Northwest National Laboratory, Richland, WA.

Prasad R, LW Vail, CB Cook, and G Bagchi**.** 2005. "Establishment of Safety-Related Site Characteristics Based on Consideration of External Sources of Flooding at Nuclear Power Plant Sites in the United States of America". In Proceedings of International Workshop on External Flooding Hazards at Nuclear Power Plant Sites (tentative; title yet to be finalized by IAEA). PNNL-SA-46268, Pacific Northwest National Laboratory, Richland, WA.

Coleman A, LW Vail, and A Savery. 2005. "Landscape Classification for Assessment of Impacts of Landuse and Climate on Water Resources." PNWD-SA-7118, Battelle—Pacific Northwest Division, Richland, WA.

Prasad R, LW Vail, CB Cook, and G Bagchi. 2005. "Establishment of Safety-Related Site Characteristics Based on Consideration of External Sources of Flooding at Nuclear Power Plant Sites in the United States of America." PNNL-SA-46005, Pacific Northwest National Laboratory, Richland, WA.

Scott MJ, LW Vail, CO Stockle, A Kemanian, KM Branch, R Prasad, MS Wigmosta, and JA Jaksch**.** 2005. "Benefits and Costs of Options to Mitigate the Uncertain Effects of Climate Change on Irrigated Agriculture in the Yakima Basin. What Matters? What Doesn't?" PNWD-SA-6902, Battelle—Pacific Northwest Division, Richland, WA.

Scott MJ, LW Vail, CO Stockle, A Kemanian, KM Branch, R Prasad, MS Wigmosta, and JA Jaksch. 2005. "Benefits and Costs of Options to Mitigate the Uncertain Effects of Climate Change on Irrigated Agriculture in the Yakima Basin. What Matters? What Doesn't?" PNWD-SA-6980, Battelle—Pacific Northwest Division, Richland, WA.

Scott MJ, LW Vail, and R Prasad**.** 2005. "Managing Water for Irrigated Agriculture Under Extended Climate-Related Drought." PNWD-SA-6946, Battelle—Pacific Northwest Division, Richland, WA.

Vail LW. 2005. "Adaptive Management of Water Resources in the Puget Sound." PNNL-SA-44581, Pacific Northwest National Laboratory, Richland, WA.

Scott MJ, LW Vail, CO Stockle, A Kemanian, KM Branch, R Prasad, MS Wigmosta, and JA Jaksch. 2005. "Adapting Irrigated Agriculture to Climate Variability and Change." PNWD-SA-6848, Battelle—Pacific Northwest Division, Richland, WA.

Scott MJ, LW Vail, CO Stockle, and A Kemanian**.** 2005. "Climate Change and Adaptation in Irrigated Case Study of the Yakima River ." American Association for the Advancement of Science, Portland, OR.

Cook, CB, LW Vail, and DL Ward. 2005. "North Anna Early Site Permit Water Budget Model (LakeWBT) for Lake Anna". PNNL-14944, Pacific Northwest National Laboratory, Richland, WA.

Pennell WT, LR Leung, MS Wigmosta, and LW Vail. 2004. "Prospects for Adapting to Near-Term Climate Change: The Yakima River Example ." Presented by William T. Pennell (Invited Speaker) at American Water Resource Association's annual state conference, Seattle, WA on October 28, 2004. PNNL-SA-43189.

Scott MJ, JA Jaksch, and LW Vail. 2004. "Water Exchanges: Tools to Beat Climate Variability*."* Journal of the American Water Resources Association 40(1):15-31.

Scott MJ, LW Vail, R Prasad, and JA Jaksch. 2004. "Can WE Use Long-Lead Climate Forecasts to Operate the Pacific Northwest Rivers Better?" PNWD-SA-6512, Battelle – Pacific Northwest Division, Richland, WA.

RL Skaggs, LW Vail, and SA Shankle. 2003. "Operationalizing Adaptive Management for Water Supply Planning: Sustaining Mexico City's Water Supply." In Urban Water Supply Infrastructure Management Handbook. J. Wiley. New York, NY.

Burke JS, GR Danielson, DA Schulz, and LW Vail. 2002. "Parallel computing for automated model calibration." vol. XVIII, pp. 424-429. The 6th World Multiconference on Systemics, Cybernetics, and Informatics (SCI 2002), Orlando, FL.

Scott MJ, LW Vail, and A Kemanian. 2002. “Integrated Impact of Climate Warming on Yakima Valley Water Demand and Availability.” PNWD-SA-5613, Battelle—Pacific Northwest Division, Richland, WA.

Scott MJ, LW Vail, JA Jaksch, CO Stockle, and A Kamenian. 2002. "Early Warning of ENSO Events For Regional Agriculture." PNWD-SA-5834, Battelle—Pacific Northwest Division, Richland, WA

Skaggs R, and LW Vail. 2002. "Adaptive Management Platform: Approach and Application." PNNL-SA-36755, Pacific Northwest National Laboratory, Richland, WA.

Vail LW. 2002. "Adaptive Management in Nooksak River, Wa Flow Selection." PNNL-SA-36605, Pacific Northwest National Laboratory, Richland, WA.

Vail LW, and R Skaggs. 2002. “Adaptive Management Platform for Natural Resources in the Columbia River Basin.” PNNL-13875, Pacific Northwest National Laboratory, Richland, WA.

Vail LW, and R Skaggs. 2002. “Integrated Process Modeling to Assess Performance of Salmon Recovery Strategies.” PNNL-13903, Pacific Northwest National Laboratory, Richland, WA

Vail LW, MS Wigmosta, R Prasad, and CK Knudson. 2002. “Accelerated Climate Prediction Initiative.” PNNL-SA-36759, Pacific Northwest National Laboratory, Richland, WA.

Ramsdell JV, K Rhoads, CA Brandt, LW Vail, PR Nickens, PL Hendrickson, DA Neitzel, and EE Hickey. 2001. “Generic Environmental Impact Statement for License Renewal of Nuclear Plants Supplement 3 Regarding Arkansas Nuclear One, Unit 1.” PNNL-13473, Pacific Northwest National Laboratory, Richland, WA.

Scott MJ, LW Vail, and CK Knudson. 2001. “El Nino and the Yakima Valley.” PNWD-SA-5597, Battelle—Pacific Northwest Division, Richland, WA.

Scott MJ, JA Jaksch, and LW Vail. 2001. "Water Exchanges: Tools to Beat Climate Variability." PNWD-SA-5425, Battelle—Pacific Northwest Division, Richland, WA.

Scott MJ, LW Vail, A Kemanian, and CO Stockle. 2001. "Integrated Impact of Climate Warming on Irrigated Crop Production." PNWD-SA-5468, Battelle—Pacific Northwest Division, Richland, WA.

Scott MJ, LW Vail, JA Jaksch, CO Stockle, and A Kemanian. 2001. "Integrated Impact of Climate Warming on Irrigated Crop Production." PNWD-SA-5596, Battelle—Pacific Northwest Division, Richland, WA

Skaggs R, LW Mays, and LW Vail. 2001. "Application of Enhanced Annealing to Ground Water Remediation Design." Journal of the American Water Resources Association 37(4):867-875

Skaggs R, LW Mays, and LW Vail. 2001. "Simulated Annealing With Memory and Directional Search for Ground Water Remediation Design." Journal of the American Water Resources Association 37(4):853-866.

Vail LW, EA Jenne, HL Diefenderfer, WR Barchet, and LF Hibler. 2001. "Assessment of pH-Impaired Lakes for TMDL Development in New York State." PNWD-SA-5234, Battelle—Pacific Northwest Division, Richland, WA.

Vail LW, HL Diefenderfer, CK Knudson, and JD Carroll. 2001. “Assessment of pH-Impaired Lakes for TMDL Development in New York State.” PNNL-SA-35658, Pacific Northwest National Laboratory, Richland, WA.

Vail LW. 2001. "Application of Fuzzy Logic in Estimating Impact of Water and Land use Practices on Aquatic Habitat Diversity ." PNNL-SA-34213, Pacific Northwest National Laboratory, Richland, WA

Vail LW. 2001. "Drought 2001 Water Management Implications for the Yakima River Basin." PNWD-SA-5326, Battelle—Pacific Northwest Division, Richland, WA.

Vail LW, JA Jaksch, and CO Stockle. 2001. "Regional Climate Forecasts and Water Markets in Irrigated Agriculture." PNWD-SA-5375, Battelle—Pacific Northwest Division, Richland, WA.

Vail LW, MS Wigmosta, and R Prasad. 2001. "Impact of Climate on Aquatic Habitat in the Yakima River." PNNL-SA-35194, Pacific Northwest National Laboratory, Richland, WA.

Vail LW. 2001. "Adapting to Climate Change in the Yakima Basin." PNWD-SA-5488, Battelle—Pacific Northwest Division, Richland, WA.

Vail LW. 2001. "Impact of Climate on the Lower Yakima Basin." PNWD-SA-5489, Battelle—Pacific Northwest Division, Richland, WA

Kincaid CT, MP Bergeron, CR Cole, MD Freshley, VG Johnson, DI Kaplan, R Serne, GP Streile, DL Strenge, PD Thorne, LW Vail, GA Whyatt, and SK Wurstner. 2000. "Composite Analysis for Low-Level Waste Disposal in the 200 Area Plateau of the Hanford Site, Southeast Washington." In Environmental Toxicology and Risk Assessment: Recent Achievements in Environmental Fate and Transport Vol. 9; STP 1381, ed. Fred T. Price, Kevin V Brix, and Nancy K. Lane, pp. 104 - 117. Am. Soc. For Testing and Materials, West Conshohocken, PA

Scott MJ, LW Vail, JA Jaksch, KK Anderson, and CO Stockle. 2000. "Climate Forecasts and Water for Regional Irrigated Agriculture ." PNWD-SA-5050, Battelle—Pacific Northwest Division, Richland, WA.

Scott MJ, LW Vail, JA Jaksch, and KK Anderson. 2000. "Considerations for Management of Irrigation Water with Climate Variability ." PNWD-SA-5069, Battelle—Pacific Northwest Division, Richland, WA.

Rosenberg NJ, DJ Epstein, D Wang, LW Vail, R Srinivasan, and JG Arnold. 1999. "Possible Impacts of Global Warming on Hydrology of the Ogallala Aquifer Region." Climatic Change 42(4):677-692.

Bergeron MP, CR Cole, MD Freshley, NL Hassig, DI Kaplan, CT Kincaid, R Serne, GP Streile, DL Strenge, PD Thorne, LW Vail, GA Whyatt, and SK Wurstner. 1998. "Composite Analysis for Low-Level Waste Disposal in the 200-Area Plateau of the Hanford Site." PNNL-11800, Pacific Northwest National Laboratory, Richland, WA.

Geist, D, LW Vail, and DJ Epstein. 1996. "Analysis of Potential Impacts to Resident Fish From Columbia River System Operation Alternatives." Environmental Management 20 (2) :275-288.

Jenne, EA., SE Faulk, LW Vail, JP Zipperer, M. I. McKinley. 1994. "H_20TREAT Version 2.0 User's Manual: An Aid for Evaluating Water Treatment Requirements for Aquifer Thermal Energy Storage." In Proceedings of International Symposium on Aquifer Thermal Energy Storage. November 14-15, 1994, The University of Alabama, Tucaloosa.

Leung L, MS Wigmosta, SJ Ghan, JL Epstein, and LW Vail. 1996. "Application of a Subgrid Orographic Precipitation/Surface Hydrology Scheme to a Mountain Watershed." Journal of Geophysical Research 101:12,803-12,817

Leung L, MS Wigmosta, SJ Ghan, and LW Vail. 1994. "Regional Modeling of Climate-Hydrology Interactions." No clearance number available, Pacific Northwest National Laboratory, Richland, WA.

Vail, LW, and EA Jenne. 1994. "Optimizing the Design and Operation of Aquifer Thermal Energy Storage Systems." In Proceedings of International Symposium on Aquifer Thermal Energy Storage. November 14-15, 1994, The University of Alabama, Tucaloosa.

Brown, DR, KK Humphreys, and LW Vail. 1993. "Carbon Dioxide Control Costs for Gasification Combined-Cycle Plants in United States." PNL-SA-22634, Pacific Northwest Laboratory, Richland, Washington.

Scott, MJ, RD Sands, LW Vail, JC Chatters, DA Neitzel, and SA Shankle. 1993. "Effects of Climate Change on Pacific Northwest Water-Related Resources: Summary of Preliminary Findings." PNL-8987, Pacific Northwest Laboratory, Richland, Washington.

Vail, LW, EA Jenne, JP Zipperer, MI McKinley. 1993. "H_2O-TREAT User's Manual: An Aid for Evaluating Water Treatment Requirements for Aquifer Thermal Energy Storage Systems." PNL-8504, Pacific Northwest Laboratory, Richland, Washington.

Wigmosta, MS., DP Lettenmaier, and LW Vail. 1993. "A Distributed Hydrology-Vegetation Model for Mountainous Catchments." In Proceedings of Workshop on Distributed Hydrologic Modeling. July 1992, Venice Italy. International Association of Hydrologic Science. PNL-SA-23540, Pacific Northwest Laboratory, Richland, Washington.

Geist, DR, LW Vail, and D Daley. 1992. "Screening Analysis of Columbia River System Operation Alternatives for the Resident Fish Work Group." PNL-SA-10687, Pacific Northwest Laboratory, Richland, Washington.

Lettenmaier, DP, KL Brettman, and LW Vail, SB Yabusaki, and MJ Scott. 1992. "Sensitivity of Pacific Northwest Water Resources to Global Warming." Northwest Environmental Journal, 8:265-283. University of Washington, Seattle, Washington.

Vail, LW, EA Jenne, and LE Eary. 1992. "H_2O-TREAT: An Aid for Evaluating Water Treatment Requirements for Aquifer Thermal Energy Storage." Presented at the IECEC Conference. August 3-4, 1992, San Diego, California.

Vail, LW, MS Wigmosta, and DP Lettenmaier. 1992. "Influence of Vegetation, Topography, and Climate on Hydrologic Processes in a Mountainous Catchment." PNL-SA-20673A, Pacific Northwest Laboratory, Richland, Washington.

Wigmosta, MS, LW Vail, DP Lettenmaier. 1992. "Simulations of Distributed Lard Surface Fluxes and Runoff from a Mountainous Drainage Basin." Presented at the 1992 Fall Meeting of America Geophysical Union, San Francisco, California.

Eary, LE, EA Jenne, LW Vail, and DC Girvin. 1991. "Recovery of the Highly Acidified Clearwater Lake Watershed, Ontario, Canada, Simulated with ILWAS Model." Applied Geochmistry. 6:613-634.

Yabusaki, SB, LW Vail, and DP Lettenmaier. "Impact of Global Climate Change on the Water Resources of the Pacific Northwest." Presented at Hydrology Days 1991. Fort Collins, Colorado.

Lettenmaier, DP, KL Brettman, and LW Vail. 1990. "Robustness of a Multiple-Use Reservoir to Seasonal Runoff Shifts Associated with Climate Change." PNL-SA-18266, Pacific Northwest Laboratory, Richland, Washington.

Vail, LW, DP Lettenmaier, and SB Yabusaki. 1990. "Simulations of Hydrologic Response of Mountainous Catchment to Alternative Climate." Presented at Fall American Geophysical Union Conference, San Francisco, California. PNL-SA-18582, Pacific Northwest Laboratory, Richland, Washington.

Eary, LE, EA Jenne, LW Vail and DC Girvin. 1989. "Numerical Models for Predicting Watershed Acidification." Archives of Environmental Contamination and Toxicology.
18:29-53.

Vail, LW. 1989. "ATES/Heat Pump Simulations Performed with the ATESSS Code." In Proceedings of the Third Workshop on Solar-Assisted Heat Pumps with Ground-Coupled Storage. January 16-18, 1988, Gothenborg, Sweden.

Vail, LW. 1989. "Status of Numerical Models for ATES." In U.S. Department of Energy Thermal Energy Storage Research Activities Review, 1989 Proceedings. March 15-17, 1989, New Orleans, Louisiana. CONF-89-0351.

Jenne, EA, LF Eary, LW Vail, DC Girvin, MJ Monsour, LF Hibler, TB Miley, and A Liebetrau. 1988. "An Interim Report on Evaluation and Analysis of Dynamic Watershed Acidification Models (Magic II, ETD, and ILWAS)." Prepared for the U.S. Environmental Protection Agency, Washington, D.C.

Kannberg, LD, and LW Vail. 1988. "Stratigraphy Effects on Energy Recovery for Aquifer Thermal Energy Storage." STES Newsletter 10:3. International Council for Thermal Energy Storage, Public Works Canada, Ottawa Canada.

Dauble, DD, RM. Ecker, LW Vail, and DA Neitzel. 1987. "Downstream Extent of the N. Reactor Plume." PNL-6310, Pacific Northwest Laboratory, Richland, Washington.

Dauble, DD, LW Vail, and DA Neitzel. 1987. "Evaluation of the Potential for Fish Passage through the N. Reactor and Hanford Generating Project Discharges." PNL-6309, Pacific Northwest Laboratory, Richland, Washington.

Droppo, JG, LW Vail, and RM Ecker. 1987. "Final Report on INSEA User's Manual, Environmental Performance Model of Incineration-At-Sea Operations." Prepared for the U.S. Environmental Protection Agency, Office of Marine and Estuarine Protection, Washington, D.C.

Gale, JR, Macleod, J Whelan, CR Cole, and LW Vail. 1987. "Hydrogeological Characterization of the Stripa Site." SKB-87-15, Swedish Nuclear Fuel and Waste Management, Stockholm, Sweden.

Shafer, JM, and LW Vail. 1987. "Screening Method for Contaminant Plume Control." Journal of Water Resource Management and Planning Division, American Society of Civil Engineers 113:3, May 1987.

Droppo, JG, LW Vail, CJ English, and RM Ecker. 1986. "Technical Support for the Ocean Incineration Regulation Model, Part 1 - Review and Recommendations, Part 2 - Revised Model." Prepared for the U.S. Environmental Protection Agency, Office of Marine and Estuarine Protection, Washington, D.C.

Cole, CR, LW Vail, GM Petrie, and RL Skaggs. 1985. "Ground Water Modeling on Small Computers: Past, Present, and Future," BN-SA-2074. In Proceedings of ASCE Hydraulics Division Conference. August 13-16, 1985, Orlando, Florida.

Onishi, Y, RM Ecker, DS Trent, SB Yabusaki, and LW Vail. 1985. "Oceanographic Modeling of Beaufort Sea in Relation to the Proposed Lisborne Development." Volumes I and II. Prepared for ARCO Alaska, Inc. by Battelle, Pacific Northwest Laboratories, Richland, Washington.

Vail, LW, LD Kannberg, and CT Kincaid. 1985. "A Computer Code for Analyzing the Performance of Aquifer Thermal Energy Storage Systems." In Proceedings of International Conference on Energy Storage for Building Heating and Cooling. September 22-27, 1985, Toronto, Ontario, Canada. PNL-SA-12870, Pacific Northwest Laboratory, Richland, Washington.

Kincaid, CT, LW Vail, and JL Devary. 1983. "Stochastic Ground Water Flow Analysis - FY81 Status Report." PNL-4025, Pacific Northwest Laboratory, Richland, Washington.

Vail, LW, and CT Kincaid. 1983. "A Simple Areal Flow Model: A Screening Tool for Managing Aquifer Thermal Energy Storage Systems." In Proceedings of International Conference on Subsurface Heat Storage. June 6-8, 1983, Stockholm, Sweden. PNL-SA-11126, Pacific Northwest Laboratory, Richland, Washington.

Vail, LW, and CT Kincaid. 1983. "Numerical Model for Analysis of Multiple Well ATES Systems." In Proceedings of the DOE Physical and Chemical Energy Storage Annual Contractors' Review Meeting. September 12-14, 1983, Arlington, Virginia. CONF-830974.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
SOUTHERN NUCLEAR OPERATING CO.	)	Docket No. 52-011-ESP
	)	
(Early Site Permit for Vogtle ESP Site)	)	

AFFIDAVIT OF MICHAEL T. MASNIK CONCERNING
PREFILED TESTIMONY ON ENVIRONMENTAL CONTENTIONS 1.2 AND 1.3

I, Michael T. Masnik, do declare under penalty of perjury that my statements in *NRC Staff Testimony of Dr. Michael T. Masnik, Anne R. Kuntzleman, Rebekah H. Krieg, Jill S. Caverly, and Lance W. Vail Concerning Environmental Contention EC 1.2*, and in *NRC Staff Testimony of Dr. Michael T. Masnik, Rebekah H. Krieg, Jill S. Caverly, and Lance W. Vail Concerning Environmental Contention EC 1.3*, as well as in my attached statement of professional qualifications are true and correct to the best of my knowledge, information, and belief.

Executed in Accord with
10 C.F.R. § 2.304(d)

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Michael T. Masnik

Executed at Rockville, Maryland
This 9th day of January, 2009

Michael T. Masnik
STATEMENT OF PROFESSIONAL QUALIFICATIONS
UNITED STATES NUCLEAR REGULATORY COMMISSION
Washington, D.C.

I am currently employed as a Senior Aquatic Ecologist in the Office of New Reactor Operations, U. S. Nuclear Regulatory Commission (NRC). As a senior member of the staff I am responsible for understanding and assessing the non-radiological impacts of nuclear power generation on a variety of aquatic environments.

I hold a Bachelor of Science in Conservation from Cornell University (1969), a Master of Science in Zoology from Virginia Polytechnic Institute and State University (1971), and a Doctor of Philosophy in Zoology also from Virginia Polytechnic Institute and State University (1975).

While at Virginia Polytechnic Institute and State University (VPI&SU), I undertook research in a variety of areas, specializing in zoogeography and distribution of freshwater fishes in large river systems. Other areas of research which resulted in published papers include thermal studies on fishes, recovery of damaged aquatic ecosystems, and development of sampling methodology for fish and macroinvertebrates. I have authored or co-authored some 16 publications on the above areas or research. My formal education has encompassed and emphasized studies in Zoology, Aquatic Ecology, Ichthyology, and Evolutionary Biology. Prior to joining the Federal government I participated as scientific staff for a Duke University Caribbean cruise conducting oceanographic investigations, and served as a consultant, through VPI&SU, for American Electric Power Company, Koppers Company, Inc., U.S. Army Corps of Engineers, and the Tennessee Valley Authority. I was also employed by Ichthyological Associates as a field biologist investigating the fisheries resources of the Delaware Bay as part of a baseline study for several new nuclear stations.

I joined the Atomic Energy Commission, the predecessor to the NRC, in 1974 as a Fisheries Biologist performing and overseeing NEPA reviews for nuclear power reactor license applications. My principal expertise was in evaluating the impacts of various cooling system designs and intake structures on fish and shellfish in source and receiving waterbodies. In the late 1970s and early 1980s I participated in the initial licensing reviews for more than 10 sites, three alternative site reviews and investigated numerous environmental events involving aquatic resources occurring at operating nuclear power stations. In 1976, as the NRC representative, I participated in the development of U.S. Environmental Protection Agency's draft Guidance for Evaluating the Adverse Impact of Cooling Water Intake Structures on the Aquatic Environment as well as the 316(a) Technical Guidance Manual and Guide for Thermal Effects Sections of Nuclear Facilities Environmental Impact Statements. I also provided expert testimony at a number of NRC administrative hearings on a variety of environmental topics including shipworms, alternative site reviews, impingement and entrainment, and shortnose sturgeon. I developed the NRC staff's practices related to Commission compliance to the Endangered Species Act.

In 1982 I became the Technical Assistant to the Director of the Three Mile Island (TMI-2) Program Office. For the next 13 years I provided technical oversight on all aspects of the TMI-2 cleanup. I made over 15 containment entries at TMI-2, conducted numerous inspections and surveys developed custom technical specifications for the damaged facility, and oversaw the preparation of three supplements to the programmatic environmental impact statement on the cleanup. I provided expert testimony at an administrative hearing on the impacts of disposal of

the TMI-2 accident generated water. From 1982 to 1995 I served as the Designated Federal Official (DFO) to the NRC sponsored TMI-2 Advisory Panel. During my tenure as the DFO the panel held over 65 public meetings in the Harrisburg, PA area. In 1993, as the TMI-2 cleanup effort neared its conclusion I assumed project management responsibilities for the decommissioning of the Trojan Nuclear Power Plant. Trojan was the first large PWR to permanently cease operation and immediately begin active decontamination and dismantlement.

In 1997 I became first Acting, then Section Chief, of the Decommissioning Section in the NRC's Office of Nuclear Reactor Regulation (NRR). I was responsible for the project management of 19 permanently shutdown reactors. I also oversaw the implementation of NRC's 1996 final rule on decommissioning and the development of the 2002 Generic Environmental Impact Statement on the decommissioning of nuclear power reactors. During my tenure as Section Chief I made numerous presentations on the subject before industry, trade, and professional society meetings. In 1997, along with two coworkers, I developed and taught a one week course on reactor decommissioning at the University of Kiev, Ukraine. During my assignment to the TMI-2 cleanup effort and then as Chief of the Decommissioning Section I continued to periodically assist the NRC in the specialized areas of aquatic impact assessment and compliance with the Endangered Species Act. In the early 1990s I assisted in the development of the Generic Environmental Impact Statement for License Renewal of Nuclear Plants, and the Final Environmental Impact Statement, Operating License Stage, for the Watts Bar Nuclear Station Unit 1.

In 2001, with the transfer of the responsibility for decommissioning within the NRC to the office of Nuclear Materials Safety and Safeguards I joined the license renewal effort in NRR, again as an expert in environmental impacts assessment. Since 2001 I has served as the license renewal environmental project manager for the St. Lucie, Browns Ferry, and the Oyster Creek nuclear stations, worked on numerous other license renewals as well as several early site permits serving as the Commission's expert in aquatic and terrestrial ecology, and water intake design. I also was responsible for or assisted in conducting formal and informal endangered species consultations for a number of nuclear power stations including Crystal River, Hatch, Saint Lucie, and Turkey Point. I provided oversight in the preparation of the aquatic and in some cases the hydrological sections of the supplemental environmental impact statements for license renewal for the following both closed-cycle and once through nuclear stations: Arkansas, Turkey Point, Saint Lucie, Fort Calhoun, North Anna, Surry, Catawba, Ginna, Summer, Cook, Quad Cities, Millstone, Vermont Yankee, Nine Mile Point, Monticello, FitzPatrick and Wolf Creek.

In early 2007 I transferred to the NRC's Office of New Reactors to devote myself full time to the environmental assessment of the construction and operation of new reactors, both at existing as well as Greenfield sites, on aquatic ecosystems. I am the NRC's principal contact for endangered species concerns with the National Marine Fisheries Service (NMFS) Southeast Regional Office (SERO). I assisted in the development of the Biological Assessment for the Vogtle Early Site Permit (ESP) application that was submitted to SERO for their review. I have also provided oversight to the aquatic ecology and hydrology sections for the preparation of the environmental impact statements for the North Anna, Clinton, and Grand Gulf ESP sites. I am currently providing technical oversights to the Grand Gulf, North Anna, Bellefonte, Vogtle, and Levy Combined License Applications as well as the Vogtle ESP. I am a member of the American Fisheries Society.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
SOUTHERN NUCLEAR OPERATING CO.	)	Docket No. 52-011-ESP
	)	
(Early Site Permit for Vogtle ESP Site)	)	

AFFIDAVIT OF REBEKAH HARTY KRIEG CONCERNING
PREFILED TESTIMONY ON ENVIRONMENTAL CONTENTIONS 1.2, 1.3 AND 6.0

I, Rebekah Harty Krieg, do declare under penalty of perjury that my statements in *NRC Staff Testimony of Dr. Michael T. Masnik, Anne R. Kuntzleman, Rebekah H. Krieg, Jill S. Caverly, and Lance W. Vail Concerning Environmental Contention EC 1.2*, in *NRC Staff Testimony of Dr. Michael T. Masnik, Rebekah H. Krieg, Jill S. Caverly, and Lance W. Vail Concerning Environmental Contention EC 1.3*, and in *NRC Staff Testimony of Mark D. Notich, Anne R. Kuntzleman, Rebekah H. Krieg, Jill S. Caverly, and Lance W. Vail Concerning Environmental Contention EC 6.0,* as well as in my attached statement of professional qualifications are true and correct to the best of my knowledge, information, and belief.

Executed in Accord with
10 C.F.R. § 2.304(d)

_____
Rebekah Harty Krieg

Executed at Richland, Washington
This 9th day of January, 2009

Resume

Rebekah Harty Krieg

Ecology Group
U.S. DOE's Pacific Northwest National Laboratory, operated by Battelle
P.O. Box 999 K6-85
Richland, WA. 99352
(509) 371-7155 (509) 371-7160 (fax)

Education:

M.S. in Fisheries and Oceanographic Sciences, University of Washington, 1983

B.S. in Biology , Washington State University, 1979.

Experience:

Senior Research Scientist (1979-2002 and 2005 – present) Battelle, Pacific Northwest National Laboratory, Richland, WA.

Technical Reviewer for the aquatic ecology sections of the Combined License (COL) application in support of the U.S. Nuclear Regulatory Commission's (NRC's) environmental evaluation of Tennessee Valley Authority's application for a COL for Bellefonte Units 3 and 4..

Technical Reviewer for the aquatic ecology sections of the Early Site Permit (ESP) application in support of the U.S. Nuclear Regulatory Commission's (NRC's) environmental evaluation of Southern Nuclear Corporation's application for an ESP for Vogtle Units 3 and 4.

Preapplication Team lead for COLs for Summer (SCEG), Bellefonte (TVA), Levy (Progress Energy), and Victoria (Exelon). Aquatic Ecology reviewer for Comanche Peak preapplication.

Technical contributor on project to assist the Army Corps of Engineers (Walla Walla District) develop configuration and operation plans for their hydroelectric projects to meet the requirements of the Biological Opinion on anadromous salmonid species listed under the Endangered Species Act.

Task leader for the Knowledge Management portion of the Infrastructure for New Reactor Environmental Reviews project. This project includes developing tools (GIS, comment databases, collaboration sites) for the Nuclear Regulatory Commission and their contractors to use during the environmental reviews that will occur when applications are received for new power reactor licenses.

Technical leader for NRC's review of license renewal applications. Managed interdisciplinary teams that provided technical support to the NRC on their review of the

environmental impacts related to the renewal of operating licenses for commercial nuclear power stations. Specifically Ms. Krieg managed the team that developed the Supplemental Environmental Impact Statement for the Oconee Nuclear Station and co-managed the teams for McGuire and Catawba.

Technical leader for development of an interdisciplinary team that provided assistance to the NRC on the development of a Supplemental Environmental Impact Statement for the Watts Bar Nuclear Plant.

Deputy Team lead for updating and revising the Environmental Standard Review Plan (ESRP), NUREG-1555.

Project Manager for assisting the NRC with development of a Generic Environmental Impact Statement (GEIS) to decommissioning of commercial nuclear power reactors. Includes the development of a revision to the Generic Environmental Impact Statement (GEIS) on Decommissioning that was originally published in 1988, development of Regulatory Guides and review plans related to the initial phases of the decommissioning process, technical review of the types of accidents that are of concern during the decommissioning process and the development of a handbook related to decommissioning for resident inspectors.

Project Manager to provide technical assistance to the NRC on the cleanup of Three Mile Island, Unit 2. Included occupational dose calculations, safety evaluations, development of supplements to a programmatic environmental impact statement, and measurement of fuel quantities remaining in the facility.

Provided technical support to the U.S. Department of Energy (DOE) in relation to the use of collective dose as a performance measurement, the development of guidance for fetal/reproductive health hazards from ionizing radiation and chemicals and extremity dosimetry.

Publications:

Krieg, RH, E.E. Hickey, J.R. Weber, and M.T. Masnik. 2004. *Nuclear Power Plants, Decommissioning of* contained in *Encyclopedia of Energy*. Cutler J. Cleveland, Editor-in-Chief. Volume 4. Elsevier Inc. Oxford, England.

Minns, JL, MT Masnik, R. Harty and EE Hickey. 2000. *Staff Response to Frequently Asked Questions Concerning Decommissioning of Nuclear Power Reactors*. NUREG-1628. U.S. Nuclear Regulatory Commission. Washington, DC.

Strom, D.J., R. Harty, E.E. Hickey, R.L. Kathren, J.B. Martin, and M.S. Peffers. 1998. *Collective Dose as a Performance Measure for Occupational Radiation Protection Programs: Issues and Recommendations*. PNL-11934. Pacific Northwest National Laboratory. Richland, Washington.

Durbin, N. E and R. Harty. *U.S. Experience with Organizational Issues During Decommissioning*. 1997. Prepared for the Swedish Nuclear Power Inspectorate. SKI 9X:X; PNWD-2419.

Harty, R., K. L. Swinth, and R. J. Traub. 1996. *Assessment and Control of Fetal Exposures. Proceedings of the Thirtieth Hanford Symposium on Health and the Environment: Current Topics in Occupational Health.* Applied Occupational and Environmental Hygiene. Vol. 11, No. 4, pp 354-358.

Harty, R., W. D. Reece, and C. D. Hooker. 1990. *Performance Testing of Extremity Dosimeters, Study 2.* NUREG/CR-5540, PNL-7276, Pacific Northwest Laboratory, Richland, Washington.

Harty, R., W. D. Reece, C. D. Hooker, and J. C. McDonald. 1990. *Performance Testing of Extremity Dosimeters Against a Draft Standard.* PNL-7277, Pacific Northwest Laboratory, Richland, Washington.

Harty, R., W. D. Reece, and C. D. Hooker. 1987. *Performance Testing of Extremity Dosimeters.* PNL-6218, NUREG/CR-4959, Pacific Northwest Laboratory, Richland, Washington.

Herrington, W. N., R. Harty, and S. E. Merwin. 1987. *Occupational Radiation Exposures Associated with Alternative Methods of Low-Level Waste Disposal.* PNL-6217, NUREG/CR-4938, Pacific Northwest Laboratory, Richland, Washington.

Harty, R., and G. A. Stoetzel. 1986. *Occupational Dose Estimates for a Monitored Retrievable Storage Facility.* PNL-5744, Pacific Northwest Laboratory, Richland, Washington.

Harty, R., W. D. Reece and J. A. MacLellen. 1986. *Extremity Dosimetry at U.S. Department of Energy Facilities.* PNL-5831, Pacific Northwest Laboratory, Richland, Washington.Reece, W. D., R. Harty, L. W. Brackenbush and P. L. Roberson. 1985. *Extremity Monitoring: Considerations for Use, Dosimeter Placement, and Evaluation.* NUREG/CR-4297, U.S. Nuclear Regulatory Commission, Washington, D.C.

Munson, L. F., and R. Harty. 1985. *Possible Options for Reducing Occupational Dose from the TMI-2 Basement.* NUREG/CR-4399, U.S. Nuclear Regulatory Commission, Washington, D.C.

Parkhurst, M. A., D. E. Hadlock, R. Harty and J. L. Pappin. 1985. *Radiological Assessment of BWR Recirculatory Pipe Replacement.* NUREG/CR-4494, U.S. Nuclear Regulatory Commission, Washington, D.C.

Reece, W. D., R. T. Hadley, R. Harty, J. Glass, J. E. Tanner and L. F. Munson. 1984. *Personnel Exposure from Right Cylindrical Sources (PERCS).* NUREG/CR-3573, U.S. Nuclear Regulatory Commission, Washington, D.C.

Fisher, D. R., and R. Harty. 1982. "The Microdosimetry of Lymphocytes Irradiated by Alpha Particles." Int. J. Radiat. Biol. 41(3):315-324.

W. E. Kennedy, Jr., E. C. Watson, D. W. Murphy, B. J. Harrer, R. Harty and J. M. Aldrich. 1981. *A Review of Removable Surface Contamination on Radioactive Materials Transportation Containers.* NUREG-CR/1858, PNL-3666, Pacific Northwest Laboratory, Richland, Washington.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
SOUTHERN NUCLEAR OPERATING CO.	)	Docket No. 52-011-ESP
	)	
(Early Site Permit for Vogtle ESP Site)	)	

AFFIDAVIT OF DR. CHRISTOPHER B. COOK CONCERNING
PREFILED TESTIMONY ON ENVIRONMENTAL CONTENTIONS 1.2, 1.3
AND 6.0 AND REBUTTAL TESTIMONY ON ENVIRONMENTAL CONTENTION 1.2

I, Dr. Christopher B. Cook, do declare under penalty of perjury that my statements in *NRC Staff Testimony of Dr. Michael T. Masnik, Anne R. Kuntzleman, Rebekah H. Krieg, Dr. Christopher B. Cook, and Lance W. Vail Concerning Environmental Contention EC 1.2 (as corrected and refiled on February 2, 2009 and February 26, 2009)*, in *NRC Staff Testimony of Dr. Michael T. Masnik, Rebekah H. Krieg, Dr. Christopher B. Cook, and Lance W. Vail Concerning Environmental Contention EC 1.3 (as corrected and refilled on February 2, 2009 and February 26, 2009)*, in *NRC Staff Testimony of Mark D. Notich, Anne R. Kuntzleman, Rebekah H. Krieg, Dr. Christopher B. Cook, and Lance W. Vail Concerning Environmental Contention EC 6.0 (as corrected and refilled on February 2, 2009 and February 26, 2009,* and in NRC Staff Rebuttal testimony of *Dr. Michael T. Masnik, Anne R. Kuntzleman, Rebekah H. Krieg, Dr. Christopher B. Cook, and Lance W. Vail Concerning Environmental Contention EC 1.2 (as corrected and refiled on February 26, 2009*) (including to the extent it modifies my testimony in the Staff's prefiled direct testimony on EC 1.2)*,* as well as in my attached statement of professional qualifications are true and correct to the best of my knowledge, information, and belief.

Executed in Accord with
10 C.F.R. § 2.304(d)

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Christopher B. Cook

Executed at Rockville, Maryland
This 26th day of February, 2009

Christopher Bruce Cook
STATEMENT OF PROFESSIONAL QUALIFICATIONS

Current Position

Senior Hydrologist
Hydrologic Engineering Branch
Division of Site and Environmental Reviews
Office of New Reactors
U.S. Nuclear Regulatory Commission

Education

Ph.D., Civil and Environmental Engineering, University of California at Davis, 2000
M.S., Civil and Environmental Engineering, University of California at Davis, 1993
B.S., Civil Engineering, Colorado State University, 1991

Professional Experience

Dr. Cook joined the U.S. Nuclear Regulatory Commission in 2007. Prior to joining the NRC, he was employed as a Senior Research Engineer at the Pacific Northwest National Laboratory (PNNL) for over seven years. Dr. Cook's professional experience covers a diverse set of hydrology-related areas including basic and applied research and regulatory compliance assessments. Past research areas have focused on the use of multi-dimensional hydrodynamic and water-quality modeling of surface water systems, including simulation of complex density-driven flows in stratified environments, and field instrumentation relevant to environmental fluid mechanics.

NRC Experience

Hydrologic Reviews for New Plant Applications. Dr. Cook's duties include support of NRC reviews associated with early site permits and combined license applications. Dr. Cook is currently the lead hydrologist for the Bell Bend, Bellefonte, Grand Gulf, and North Anna combined license applications. Responsibilities associated with these reviews include preparation of hydrology-related sections of the Safety Evaluation Report (SER) and Environmental Impact Statement (EIS). Safety-related assessments include a broad range of surface water and groundwater site hazard assessments. Responsibilities on the EIS reviews include assessment of water-use and water-quality impacts to the environment from construction and operation of the proposed nuclear reactor, as well as evaluation of alternatives to the proposed action.

IAEA Safety Standard Development. Dr. Cook is currently assisting with the development of hydrology-related sections of the new International Atomic Energy Agency (IAEA) Safety Guide DS417, "Meteorological and Hydrological Hazards in Site Evaluation for Nuclear Installations." This new guide will both update and combine Safety Guide NS-G-3.5 "Flood Hazard for Nuclear Power Plants on Coastal and River Sites" and Safety Guide NS-G-3.4 "Meteorological Events in Site Evaluation for Nuclear Power Plants."

Private Sector Experience

Hydrologic Site Safety Reviews for Early Site Permits. PNNL Task Manager. Dr. Cook prepared surface water hydrology (Section 2.4) sections of the Safety Evaluation Reports (SERs) associated with the North Anna (NUREG-1835), Clinton (NUREG-1844), and Grand Gulf (NUREG-1840) early site permit applications. Assessments included a broad range of site hazards, including flooding from extreme storm events and cascade-failure of upstream dams.

Hydrology-Related Environmental Reviews for Early Site Permits. PNNL Task Manager. Dr. Cook provided assessments for the hydrology-related sections of the Environmental Impact Statements associated with the North Anna (NUREG-1811), Clinton (NUREG-1815), Grand Gulf (NUREG-1817), and Vogtle (NUREG-1872; draft) early site permit applications. Assessments include a broad range of water-use and water-quality impacts to the environment from both construction and operation of the proposed nuclear reactors.

Field Assessment and Simulation of Temperature Fluctuations in the Lower Snake River. PNNL Principal Investigator and Project Manager. Dr. Cook lead a multi-year project to monitor and model temperature fluctuations in the lower Snake River (contract totaling over $1 million per year). He applied three-dimensional numerical models to simulate transient density currents at the confluence of the Clearwater and Snake rivers, and a two-dimensional laterally-averaged model to simulate temperature variations throughout the 140 river mile reach downstream to the confluence of the Snake and Columbia rivers. *In situ* measurements in the confluence region focused on density gradients and their impacts on juvenile Chinook salmon migration, and included the use of a wide range of field instrumentation.

Analysis and Simulation of 3-D Free-Surface Hydrodynamics near Hydroelectric Dams. PNNL Principal Investigator and Project Manager. Dr. Cook participated in and managed several free-surface computational fluid dynamics (CFD) modeling projects to compute water velocities, turbulence intensities, and pressure variations (including hydraulic loads) to assist with designing various hydraulic structures at several hydroelectric dams. Typical examples are an analysis of the spillway and tailrace conditions at The Dalles Dam (Columbia River) and simulation of entrance conditions at the Bonneville Second Powerhouse Ice and Trash Sluiceway (Columbia River).

Three-Dimensional Hydrodynamic and Water Quality Simulation of a Terminal Basin Lake. UC Davis Post-Graduate Research Engineer. While at the University of California at Davis, Dr. Cook modified and applied the multi-dimensional finite element model RMA10 to the Salton Sea, California. To calibrate and verify the model, a team lead by Dr. Cook implemented a year-long field data monitoring program to obtain *in situ* water current (ADCP) and quality (e.g. temperature, salinity, pH, and dissolved oxygen) information. Applications of the computational model focused on management alternatives to restore the Salton Sea's degrading saline environment.

Selected Publications and Technical Reports

Cook, C. B., M. C. Richmond, and J. A. Serkowski. (2007). "Observations of Velocity Conditions near a Hydroelectric Turbine Draft Tube Exit using ADCP Measurements." *Journal of Flow Measurement and Instrumentation*, 18(3):148-155.

Cook, C. B., G. A. McMichael, J. A. Vucelick, B. Dibrani, E. E. Hockersmith, C. A. Duberstein, I. D. Welch, B. J. Bellgraph, C. A. McKinstry, P. S. Titzler, D. A. Ogden, B. P. Sandford, R. K. Kirkham, and M. D. Bleich. (2007). "Lower Monumental Reservoir Juvenile Fall Chinook Salmon Behavior Studies." *Battelle–Pacific Northwest Division*, PNWD-3800, Richland, Washington, July.

Cook, C. B., B. Dibrani, J. A. Serkowski, M. C. Richmond, P. S. Titzler, and G. W. Dennis. (2006). "Acoustic Doppler Current Profiler Measurements in the Tailrace at John Day Dam." *Pacific Northwest National Laboratory*, PNNL-15627, Richland, Washington, January.

Cook, C. B., B. Dibrani, M. C. Richmond, M. D. Bleich, S. P. Titzler, and T. Fu. (2006). "Hydraulic Characteristics of the Lower Snake River during Periods of Juvenile Fall Chinook Salmon Migration." *Pacific Northwest National Laboratory*, PNNL-15532, Richland, Washington, January.

Johnson, G. E., M. E. Hanks, F. Khan, C. B. Cook, J. Hedgepeth, R. P. Mueller, C. L. Rakowski, M. C. Richmond, S. L. Sargeant, J. A. Serkowski, and J. R. Skalski. (2005). "Hydroacoustic Evaluation of Juvenile Salmonid Passage at The Dalles Dam in 2004." *Pacific Northwest National Laboratory*, PNNL-15180, Richland, Washington.

Johnson, R. L., M. A. Simmons, C. A. McKinstry, C. S. Simmons, C. B. Cook, R. S. Brown, D. K. Tano, S. L. Thorsten, R. LeCaire, and S. Francis. (2005). "Strobe Light Deterrent Efficacy Test and Fish Behavior Determination at Grand Coulee Dam Third Powerplant Forebay." *Pacific Northwest National Laboratory*, PNNL-15007, Richland, Washington, February.

Cook, C. B., L. W. Vail, and D. L. Ward. (2005). "Report on the North Anna Early Site Permit Water Budget Model (LakeWBT) for Lake Anna." *Pacific Northwest National Laboratory*, PNNL-14944, Richland, Washington, January.

Cook, C. B. and M. C. Richmond. (2004). "Simulating the Flow Field Upstream of the Dworshak Dam Regulating Outlets." *Pacific Northwest National Laboratory*, PNNL-14591, Richland, Washington, March.

Cook, C. B. and M. C. Richmond. (2004). "Monitoring and Simulating 3-D Density Currents at the Confluence of the Snake and Clearwater Rivers", in *Critical Transitions in Water and Environmental Resources Management*, eds. G. Sehike, D. Hayes and D. Stevens, American Society of Civil Engineering Press, 2004.

Cook, C. B., C. L. Rakowski, M. C. Richmond, S. P. Titzler, A. M. Coleman, and M. D. Bleich. (2003). "Numerically Simulating the Hydrodynamic and Water Quality Environment for Migrating Salmon in the Lower Snake River." *Pacific Northwest National Laboratory*, PNNL-14297, Richland, Washington.

Cook, C. B., G. T. Orlob, and D. W. Huston. (2002). "Simulation of Wind-Driven Circulation in the Salton Sea: Implications for Indigenous Ecosystems." *Hydrobiologia*, 473: 59-75.

Cook, C. B., and M. C. Richmond. (2001). "Simulation of Tailrace Hydrodynamics using Computational Fluid Dynamics (CFD) Models." *Pacific Northwest National Laboratory*, PNNL-13467**,** Richland, Washington.

Cook, C.B. (2000). "Internal Dynamics of a Terminal Basin Lake: A Numerical Model for Management of the Salton Sea." Ph.D. dissertation, Department of Civil and Environmental Engineering, University of California, Davis.

Cook, C.B. (1993). "A One-Dimensional Model to Simulate Water Infiltration and Redistribution in Soils." M.S. thesis, Department of Civil and Environmental Engineering, University of California, Davis.

Abt, S. R., C. B. Cook, K. Staker, and D. Johns. (1991). "Small Parshall Flume Rating Corrections." *Journal of Hydraulic Engineering,* American Society of Civil Engineering, 118(5): 798-802.

Selected Conference Proceedings

Cook, C. B., G. A. McMichael, J. A. Vucelick, and B. Dibrani (2007). "Interactions between underflow conditions in a reservoir and emigration of juvenile fall Chinook salmon", *American Fisheries Society Annual Meeting*, San Francisco, September.

Prasad, R., L. W. Vail, C. B. Cook, and G. Bagchi. (2005). "Establishment of Safety-Related Site Characteristics Based on Consideration of External Sources of Flooding at Nuclear Power Plant Sites in the United States of America." In *Proceedings of International Workshop on External Flooding Hazards at Nuclear Power Plant Sites*, Kalpakkam, India, August.

Cook, C. B., M. C. Richmond, J. A. Serkowski, and L. L. Ebner. (2002). "Free-Surface Computational Fluid Dynamics Modeling of a Spillway and Tailrace: Case Study of The Dalles Project." *Hydrovision 2002*, Portland, Oregon, July.

Cook, C. B., D. W. Huston, M. R. Jensen, G. T. Orlob, and S. G. Schladow. (1998). "Internal Dynamics of a Large Saline Lake: Field Investigation and Monitoring of the Salton Sea, California." *1998 Ocean Sciences Meeting*, AGU and ASLO, San Diego, February.

Professional Affiliations

American Society of Civil Engineers
American Geophysical Union