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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, REBEKAH H. KRIEG, DR. CHRISTOPHER B. COOK, AND LANCE W. VAIL CONCERNING ENVIRONMENTAL CONTENTION EC 1.3

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

A1(a). (MTM) My name is 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). (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, Georgia. A statement of my professional qualifications is attached hereto.

A1(c). (LWV) My name is Lance 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.

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.

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 evaluation of impact to aquatic organisms due to interactions with the proposed station intake and discharge structures. My assessment of impact 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") (Exhibit NRC000001). I also had technical input to the descriptive information contained in Section 2.7.2 of the FEIS.

A2(b). (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 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 worked under the technical oversight of Dr. Michael T. Masnik of the NRC.

A2(c). (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 NUREG 1872, Final Environmental Impact Statement for an Early Site Permit (ESP) at the VEGP site," August 2008 ("FEIS").

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.

Q3. What is the purpose of this testimony?

A3. (ALL) The purpose of this testimony is to present the NRC Staff's views with respect to Contention EC 1.3, which challenges the adequacy of the alternatives analysis of a dry cooling system in the FEIS.

Q4(a). Are you familiar with Contention 1.3?

A4(a). (ALL) Yes. Contention EC 1.3, submitted in this proceeding by the Center for a Sustainable Coast, Savannah Riverkeeper, Southern Alliance for Clean Energy, Atlanta Women'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 March 12, 2007, alleges that:

> The [Environmental Report (ER)] fails to satisfy 10 C.F.R. § 51.45(b)(3) because its analysis of the dry cooling alternative is inadequate to address the appropriateness of a dry cooling system given the presence of extremely sensitive biological resources.

(MTM, RHK) 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. It is our understanding that the contention concerns the adequacy of the alternatives analysis regarding the appropriateness of a dry cooling system for VEGP Units 3 and 4. Specifically, it alleges that the Staff is required to perform a more in-depth alternatives analysis given the presence of extremely sensitive biological resources.

(LWV, CBC) 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 declaration of Barry W. Sulkin, dated November 9, 2007, the declaration of Bill Powers dated November 12, 2007, and the declarations of Thomas C. Moorer dated October 17, 2007 and James W. Cuchens dated October 15, 2007. It is our understanding that the contention concerns the adequacy of the alternatives analysis regarding the appropriateness of a dry cooling system for VEGP Units 3 and 4. Specifically, it alleges that the Staff is required to

perform a more in-depth alternatives analysis given the presence of extremely sensitive biological resources

(All) The Staff discusses system design alternatives, including plant cooling systems, in section 9.3 of the FEIS. That FEIS section discusses once-through cooling systems, dry cooling towers, and wet/dry hybrid cooling towers. Our testimony therefore focuses on the Staff analysis documented in the FEIS. However, in preparing this testimony we have also considered and referenced the specific documents listed below:

- NUREG-1555 Standard Review Plans for Environmental Reviews for Nuclear Power Plants ("ESRP") (2000) (Exhibit NRC000009).
- NUREG-1555 Standard Review Plans for Environmental Reviews for Nuclear Power Plants ("ESRP") Rev. 1 (2007) (Exhibit NRC000010).
- United States Environmental Protection Agency, "National Pollutant Discharge Elimination System; Regulations Addressing Cooling Water Intake Structures for New Facilities; Final Rule" 66 Fed. Reg. 65,256, (December 18, 2001) (Exhibit NRCR00035)
- Regulatory Guide 4.2 Rev. 2, "Preparation of Environmental Reports for Nuclear Power Stations" (1976) (Exhibit NRC000007).
- Status Review of the Atlantic sturgeon, (prepared by the Atlantic Sturgeon Status Review Team for the National Marine Fisheries Service National Oceanic and Atmospheric Administration dated February 23, 2007, updated with corrections on July 27, 2007) (Exhibit NRC000025).
- 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. (Exhibit NRC000017).
- Draft Interim Report of Fish Impingement and Entrainment Assessment at the Plant Vogtle Electric Generating Plant (Exhibit NRC000030).
- Richmond, A.M. and B. Kynard. 1995. "Ontogenetic Behavior of Shortnose Sturgeon, Acipenser brevirostrum." Copeia (1):72-182. (Exhibit NRC000046).
- Hall J.W., T.I.J. Smith, and S.D. Lamprecht. 1991. "Movements and Habitats of Shortnose Sturgeon, Acipenser brevirostrum, in the Savannah River." Copeia 1991 (3):695-702 (Exhibit NRC000047).
- 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. (Exhibit NRC000022).

- 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." (Exhibit SNC000022).

I. Cooling System Designs

Q5. Describe briefly the cooling system that is proposed in the application.

A5. (LWV, CBC) The applicant proposes a closed-cycle wet cooling system. Exhibit NRC000001 at 3-5 to 3-8. In a closed-cycle wet cooling system, the majority of the heat is dissipated to the atmosphere through the evaporation of water. A fraction of the water withdrawn from the river is returned as blowdown to the river. The entire volume of the water evaporated is assumed to be consumed. In contrast, the water returned to the river is generally not assumed to be consumed. Conversely, an open-cycle cooling once-through system withdraws vastly more water than a closed-cycle wet cooling system and returns all the reject heat to the water body as sensible heat instead of discharging it to the atmosphere. Compared to a once-through system, a closed-cycle system results in greater net loss of water to the water source, in this case the Savannah River.

Q6. What regulations or guidance does the Staff follow in evaluating alternatives to the cooling system proposed by the applicant?

A6. (LWV, CBC) Pursuant to 10 C.F.R. 51.45(b)(3), the Staff must consider alternatives to the proposed heat dissipation system. The Staff analyzes heat dissipation design alternatives using the guidance in Section 9.4.1 of the ESRP. Exhibit NRC000010 at 9.4.1-1 to 9.4.1-13.

Q7. Did the Staff evaluate cooling system design alternatives in the FEIS? Did the analysis include evaluation of a dry cooling system?

A7. (LWV, CBC) Yes, in Chapter 9 of the FEIS, the Staff considered open-cycle once–through, and closed-cycle dry or wet/dry hybrid cooling systems. The Staff found that a

once-through system for both units would withdraw essentially the entire flow of the river during a low flow period, making this alternative clearly unsuitable for the VEGP site and not preferable to the proposed closed-cycle wet cooling system. Exhibit NRC000001 at 9-26. The Staff determined that a wet/dry closed-cycle alternative would reduce the impacts to water supply and water quality. *Id*. The Staff also determined that a dry closed-cycle cooling system would eliminate impacts to water supply and water quality. *Id.* at 9-27.

Q8. Please describe in general terms the "dry cooling" system design the Staff considered.

A8. (LWV, CBC) As considered by the Staff in the FEIS, a dry cooling system transfers reject heat to the atmosphere as sensible heat, whereas wet cooling transfers most of the heat into the latent heat of evaporation of water. Simply stated, dry cooling systems transfer heat to the atmosphere by heating up the air, whereas wet cooling towers transfer heat by adding water vapor to the atmosphere. Therefore, a dry cooling system involves moving large volumes of air to exchange heat directly to the air and is limited by the temperature of the air. A wet cooling tower is controlled by the air temperature and relative humidity. The effect of the humidity (wet bulb temperature) makes it easier for wet cooling systems to obtain a lower temperature of cooling water being returned to the condenser in most conditions.

Q9. Did the Staff reach a conclusion as to whether a dry cooling system would be preferable to the wet tower system proposed for Units 3 and 4?

A9. (LWV, CBC) Yes, the Staff found that a dry cooling system would not be environmentally preferable to the proposed wet tower system. *Id*.

Q10. Would dry cooling largely eliminate impacts on aquatic biota (by eliminating thermal and chemical discharges as well as losses to organisms due to impingement and entrainment)?

A10. (MTM) Yes. Dry cooling towers would transfer sensible heat directly to the atmosphere. The makeup flow rate to the circulating water system would be negligible. It is

estimated to be on the order of one gallon per minute. There would be no routine blowdown from the circulating water system. Therefore, with no makeup other than the one gallon per minute mentioned above and no blowdown, there would be no impingement or entrainment of any significance and no thermal or chemical discharges from a dry cooling system.

Q11. If dry cooling would eliminate those impacts, what was the Staff's basis for concluding that dry cooling would not be preferable to the proposed wet cooling system?

A11. (LWV, CBC, MTM) The Staff explicitly states in the FEIS that use of a dry cooling system would essentially eliminate all impacts to water resources (including with respect to water use, water quality, and aquatic ecosystems). Exhibit NRC000001 at 9-26 and 9-27. However, the Staff also acknowledges that there would be some disadvantages with use of a dry cooling system, including with respect to land use, fuel use, spent fuel transport, and spent fuel storage. *Id.* at 9-27. Dry cooling systems involve very large heat-exchange surface areas that would require more land area than an equivalent capacity natural-draft or mechanical-draft cooling system. As mentioned in the answer to Question 8, the temperature of cooling water being returned to the condenser would be lower for a wet cooling system than a dry cooling system, thereby allowing the plant with the wet cooling system to operate at a higher electrical generation efficiency. Therefore, a dry cooling system would have an increase in fuel use and an associated increase in spent fuel transport and spent fuel storage to match the electrical output of a similar plant with wet cooling.

Q12. Were the disadvantages of dry cooling mentioned in the FEIS (parasitic energy costs such as fans, reduced generation efficiency, fuel cycle, land use, etc.) the sole basis for the Staff's conclusion with respect to whether a dry cooling system would be preferable at the Vogtle ESP site?

A12. (LWV) No. The FEIS stated that even with those disadvantages, the Staff might consider a dry cooling system to be a preferred option if the proposed wet tower system would

cause significant adverse impacts to water availability, water quality, or aquatic resources. *Id.* at 9-27.

Q13. Did the Staff find that the proposed wet tower system would cause significant adverse impacts?

A13. (MTM, LWV) No. In Chapters 4, 5, and 7 of the FEIS, the Staff concluded that the impacts of the proposed cooling tower system would be SMALL.

Q14. Did the Staff consider the arguments set forth by the Applicant and Joint Intervenors regarding the technical feasibility of using a dry cooling system at VEGP?

A14. (LWV, CBC) In connection with the Applicant's motions for summary disposition of the admitted contentions, the Applicant and the Joint Intervenors presented arguments concerning the technical feasibility and costs of a dry cooling alternative for the AP1000 reactor design at the VEGP ESP site. The Staff has not evaluated the technical feasibility or precise costs of using dry cooling for the AP1000 design at Vogtle and takes no position regarding the merits of either the Joint Intervenors' or the Applicant's testimony concerning technical feasibility. Instead, the Staff has relied on the rationale presented in this testimony and in the FEIS. However, because both filings occurred before the FEIS was completed, the Staff was familiar with the general arguments presented by both of the other parties. The Applicant and Joint Intervenors appeared to agree that compared to the proposed wet-tower design, dry cooling would A) require more land, B) cost more to implement, and C) decrease the operating efficiency of the plants. The Staff thus understands the other two parties to dispute the magnitude of these impacts, but not their existence.

Q. 15. How did the Staff decide whether to consider dry cooling in more detail in the FEIS?

A. 15. (LWV) Section 9.4.1 of the ESRP states:

> The depth of the analysis should be governed by the nature and magnitude of proposed heat dissipation system impacts predicted by the reviews of ESRP Chapters 4.0 and 5.0. If adverse impacts are predicted, the reviewers should

> coordinate in identifying and analyzing means to mitigate these impacts. The proposed system with any verified mitigation schemes (i.e., measures and controls to limit adverse impacts) should be the baseline system against which alternative heat dissipation systems are compared. The nature and adversity of the remaining unmitigated impacts for this baseline system should establish the level of analysis required in the review of alternative systems. This should permit staff evaluation and conclusions with respect to the environmental preference of these alternatives. When no adverse impacts have been predicted for the proposed system and the system will comply with the requirements of the CWA, the reviewer should conclude that there are no environmentally preferable heat dissipation-system alternatives.
>
> Exhibit NRC000010 at 9.4.1-5.

Based on the Staff's assessment that all the heat dissipation system related impacts in Chapters 4.0 and 5.0 of the FEIS were SMALL and the Staff's assessment that there would be some adverse impacts with the subject alternative (dry cooling), the Staff determined that there are no preferable heat dissipations systems. Exhibit NRC000001 at 9-27.

Q16. Why did the Staff not consider dry cooling in more detail in the FEIS?

A16. (MTM, LWV) From the perspective of assessing impacts to the aquatic biota, the Staff concluded that impingement and entrainment losses due to operation of the proposed intake, and station thermal and chemical discharges, even under low flow river conditions, would only have at most a SMALL impact on aquatic organisms. *Id.* at 5-39. Additionally, water use and water quality impacts would also be SMALL. A SMALL impact is defined in Section 1 of the FEIS on page 1-4 as "environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource." *Id.* at 1-4.

Consistent with ESRP Section 9.4.1, the depth of the Staff's system design alternatives analysis was governed by the nature and magnitude of proposed heat dissipation system impacts predicted by the reviews of FEIS Chapters 4.0 and 5.0. The Staff determined in Chapters 4 and 5 that the impacts to water resources from the proposed wet cooling tower system were SMALL. If the Staff had instead reached a conclusion that water-related impacts were greater than SMALL, the Staff would have identified and analyzed alternatives in greater depth.

In other words, the impacts from the proposed cooling system provided the baseline against which impacts from alternative heat dissipation systems were compared. The nature of the water impacts that the Staff analyzed for this baseline cooling system (SMALL) established what depth of analysis was required in the review of alternative cooling systems. As further described in Chapter 5 of the FEIS, the Staff determined impacts would be SMALL for the proposed system because of the availability of water in the Savannah River to meet the consumptive and nonconsumptive requirements of the closed-cycle cooling system and to assimilate effluents under both normal conditions and even under drought conditions. This SMALL impact and the fact that several disadvantages of the dry-cooling alternative were identified provided the basis for the Staff's concluding that the identified alternative heat dissipation-system alternative would not be environmentally preferable to the proposed wet cooling system.

II. Impacts to Aquatic Resources

Q17. The admitted contention refers to the appropriateness of a dry cooling system given the presence of "extremely sensitive biological resources." Is the Staff familiar with that term?

A17. (MTM) Yes. The Staff is familiar with the term. It appears in the U.S. EPA's December 18, 2001 rulemaking entitled "National Pollutant Discharge Elimination System; Regulations Addressing Cooling Water Intake Structures for New Facilities; Final Rule." Exhibit NRCR00035. Section V.C. of the December 18, 2001 rulemaking states:

> Although EPA has rejected dry cooling technology as a national minimum requirement, EPA does not intend to restrict the use of dry cooling or to dispute that dry cooling may be the appropriate cooling technology for some facilities. This could be the case in areas with limited water available for cooling or waterbodies with extremely sensitive biological resources (e.g., endangered species, specially protected areas).

Id. at 65,282.

Q18. What does the Staff believe the EPA meant in establishing this category of aquatic biota?

A18. (MTM) The construct "extremely sensitive biological resource" is mentioned only once in the 91 page rulemaking. It is not defined in the *Federal Register* notice and is not a term that is commonly used elsewhere in evaluating impact. The State of California does refer to a category of "sensitive biological resources"; however, I believe the use of that category, in an official context, is limited to the State of California. The December 18, 2001 U. S. EPA rulemaking does provide two general examples of extremely sensitive biological resources they are: "endangered species" and "specially protected areas." *Id.* at 65,282. It is not clear whether these examples refer to just Federally-protected endangered species or Federally-protected threatened and endangered species and/or state protected species. It is also unclear if the examples given are all inclusive or whether there are other categories or examples of

extremely sensitive biological organisms. In my opinion, the U.S. EPA recognized that under certain limited situations where there are formally-protected species or habitat that potentially could be seriously harmed by operation of a water withdrawal system, or the consumptive use of the withdrawn water might remove or alter significantly the aquatic environment affecting protected or valued species, or that habitat critical to the existence of the species might be harmed, the use of dry cooling may be warranted. I believe "extremely sensitive biological resources" used by the U.S. EPA is a subset and a more restrictive category than the NRC Staff's concept of "important species."

Q19. Did the Staff in the FEIS identify species in the vicinity of the site that could be considered "extremely sensitive biological resources?

A19. (RHK, MTM) The Staff did not use the concept of "extremely sensitive biological resources" in its review. Instead, the Staff relied on the concept of "important species" as defined in Regulatory Guide (RG) 4.2 (Exhibit NRC000007 at 2-3, 2-4), Section 2.7 of the FEIS, and ESRP Section 2.4.2-7 (Exhibit NRC000009) to assess the impact from VEGP Units 3 and 4 on aquatic resources. For a more in depth discussion of "important species," see the Staff's response to Questions 10 and 11 in the testimony for Environmental Contention 1.2. Not all species identified by the Staff as "important" would be considered "extremely sensitive biological resources." However, as we understand the concept all "extremely sensitive biological resources" would likely be considered "important." Therefore, the Staff in the FEIS did evaluate the potential impacts to any other species that might be considered "extremely sensitive biological resources" and concluded that the impacts, if any, would be minor. Exhibit NRC000001 at 5-36 to 5-37, 5-41 to 5-42.

There are no specially protected aquatic areas in the vicinity of the VEGP site that could be adversely affected by operation of two additional units. The only Federally protected aquatic species occurring in the vicinity of the VEGP site is the shortnose sturgeon, *Acipenser brevirostrum*. The Joint Intervenors identified two species present in the Savannah River that

they claim would qualify as "extremely sensitive biological resources." Those are the endangered shortnose sturgeon and the State of Georgia endangered robust redhorse, *Moxostoma robustum*. The robust redhorse is not afforded Federal protection under the Endangered Species Act. However, both the shortnose sturgeon and the robust redhorse are considered by the NRC Staff to be "important species" and potential impacts to these two species as a result of the operation of two additional units at the VEGP site using wet closed-cycle cooling are discussed in the FEIS. *Id.* at 5-36, 5-41 to 5-42.

Q20. Has the Staff identified any species since the publication of the FEIS that would be considered an "important species" and would they likely be adversely affected by operation of the proposed VEGP units 3 and 4?

A20. (RHK) In the FEIS, the Staff identified the Atlantic sturgeon (*Acipenser oxyrinchus*) as a species of concern. *Id.* at 2-89. 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 Atlantic sturgeon's Federal listing status was changed from "species of concern" to "candidate species" on October 17, 2006. 71 Fed. Reg. 61,022, 61, 023. While being a candidate species affords no legal protection under the Endangered Species Act, the Atlantic sturgeon should have been included in the FEIS under the definition of "important species" as provided in ESRP 2.4.2. Exhibit NRC000009 at 2.4.2-6.

The Atlantic sturgeon is known to inhabit the Savannah River in the vicinity of the VEGP site and has a life history that is similar to that of the shortnose sturgeon (*A. brevirostrum*) in that it is anadromous, has adhesive eggs that are deposited on the bottom substrate, usually on hard surfaces, and the larvae tend to stay near the bottom until the yolk sac is fully absorbed, at which time they move downstream to rearing grounds in the estuarine waters. Exhibit NRC000025 at 3, 4. The potential for impact of an adult or juvenile sturgeon from impingement and thermal discharges at the proposed VEGP site is low because the older juveniles and

adults are large fish that can easily avoid impingement and the size of the thermal plume is small enough that they can avoid the plume. The potential for entrainment is also low because the eggs are demersal and adhere to hard surfaces and the larvae tend to stay near the bottom. *Id.* at 4. Thus, the Staff concludes that the Atlantic sturgeon will not be adversely affected by the proposed VEGP units.

Q21. The Joint Intervenors identified the shortnose sturgeon (SNS) and the robust redhorse (RR) as extremely sensitive biological resources. How did the Staff assess the potential for impact to these two species due to the operation of two additional units at the Vogtle site?

A21. (RHK, MTM) The Staff looked at the distribution and life history of the robust redhorse and the shortnose sturgeon in the middle Savannah River and evaluated potential impacts due to plant operation. The Staff determined the susceptibility of the species to impingement, entrainment, and thermal effects. The susceptibility of the robust redhorse to impingement, entrainment and thermal effects is discussed in section 5.4.2.6 of the FEIS. Exhibit NRC000001 at 5-36. The susceptibility of the shortnose sturgeon to impingement, entrainment and thermal effects is discussed in Section 5.4.3.2 of the FEIS. *See Id.* at 5-41, 5-42. Impacts to shortnose sturgeon are discussed more with regard to impingement and entrainment in the response to questions 24, 30 and 33 of the Staff's testimony for Environmental Contention 1.2.

The Staff in Section 5.4.2.6 of the FEIS concluded that the potential for impact to the robust redhorse from entrainment and thermal discharges would be minor because the nearest spawning area was located about 25 RM upstream of the VEGP site, the eggs develop in gravel and the larval fish remain in the gravel until all yolk material has been absorbed. *Id.* at 5-36. In addition, the adult robust redhorse has been observed to stay primarily in the main channel as they move up and downstream. Exhibit NRC000017 at 1148, 1152. Further, although not explicitly stated in the FEIS, the adult robust redhorse is a large fish that can easily avoid

impingement and the size of the thermal discharge plume is small enough that it can avoid the plume.

No shortnose sturgeon larvae or robust redhorse larvae were identified in the entrainment sampling that was performed by Southern during the impingement and entrainment sampling program that was received by the Staff after the publication of the FEIS. Exhibit NRC000030 at 23, 25, Appendix D.

The Staff in Section 5.4.3.2 of the FEIS concluded that the potential for impact of the shortnose sturgeon is small from entrainment and thermal discharges because the 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 5-41, 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, 180. Further, 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 111-118 and upstream at RM 171-172. Exhibit NRC000047 at 695. Collins and Smith 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. Further, although not explicitly stated in the FEIS, the shortnose sturgeon is a large fish that can easily avoid impingement. In addition, the size of the thermal plume is small enough so that the shortnose sturgeon can avoid the plume.

A biological assessment (BA) was prepared for the shortnose sturgeon because it is a Federally-listed endangered species. The BA was forwarded to the National Marine Fisheries Service (NMFS) Southeastern Regional Office for its review and concurrence. NMFS

concluded in a letter that was received by the U.S. NRC after the FEIS was published; that this proposed action is unlikely to adversely affect shortnose sturgeon. Exhibit SNC000022 at 4.

Q22. In light of the above, why is the Staff's analysis in the FEIS sufficiently detailed to predict impacts on important species like the redhorse?

A22. (MTM) ESRP 2.4.2 states that "the type of data and information needed will be affected by site- and station-specific factors, and the degree of detail should be modified according to the anticipated magnitude of potential impacts." Exhibit NRC000009 at 2.4.2-2. The Staff considered the distribution, abundance, relevant life history data and past sampling and assessments in the river system for each of the "important species" and then assessed the potential impacts that the design, location and operating parameters of the structures, systems and components of the VEGP Units 3 and 4 cooling water system would have on the populations of the important fish and shellfish. If the distribution, abundance, relevant life history, or past data collected in the Savannah River did not identify a causal link to a particular impact category (impingement, entrainment, or thermal effects) that could result in a population level impact to that species, then a SMALL impact was predicted.

For example, the robust redhorse is a large fish and relatively strong swimmer and could easily avoid the thermal plume and impingement on the intake screens. Exhibit NRC000001 at 5-36. No robust redhorses have been impinged on the screens at VEGP Units 1 and 2 during the impingement sampling program. Exhibit NRC000030. The species is a prolific spawner and spawns over habitat unlike that found in the vicinity of the site. The station will take only a small percentage of the flow in the river. Impingement and entrainment losses related to operation of all four units at the site will not result in a detectable impact to the population, nor is the species likely to be affected by the thermal discharge; therefore, the Staff has enough information to predict that any impact to the species will be minor. Exhibit NRC000001 at 5-36.

Q23. As part of that determination, did the Staff find that the proposed cooling system would have significant adverse impacts to any important species, including the shortnose sturgeon and the robust redhorse?

A23. (RHK) No. The Staff determined that the potential for impact to the state-listed robust redhorse from entrainment, impingement, and thermal or chemical discharges would be minor as discussed in Section 5.4.2.6 of the FEIS on page 5-36 and that for the robust redhorse and all other aquatic biota the impacts from operation would be SMALL. Exhibit NRC000001 at 5-39. The Staff also determined that the impacts to the shortnose sturgeon would be SMALL, as discussed in Section 5.4.3.2 of the FEIS. *Id.* at 5-41, 5-42. It is the Staff's opinion that because the impacts to important species are SMALL, the impacts to any extremely sensitive biological organisms will also be SMALL since, as discussed in the response to Question 19, as the Staff understands the concept, "important species" would include all "extremely sensitive biological resources." These impacts are also discussed in detail in Questions 24 and 33 in the Staff's testimony for Environmental Contention 1.2.

III. <u>Conclusions</u>

Q. 24 Please summarize the impacts to aquatic resources from the proposed design and from a dry cooling system.

A24. (MTM)The Staff determined that impacts from the wet tower system on aquatic resources would be SMALL. The Staff also found that a dry cooling system would largely eliminate those impacts.

Q. 25 Given that the impacts to shortnose sturgeon and robust redhorse could, in theory, be rendered even smaller by using a dry cooling system, why did the Staff not therefore view dry cooling as the preferred option?

A25. (MTM, LWV) The Staff determined that operation of VEGP Units 3 and 4 would result in the mortality of fish and shellfish due to impingement and entrainment of organisms from the withdrawal of cooling water and mortality due to thermal effects related to the station

discharge. *Id.* at Section 5.4.2. However, the Staff found that the overall impact to aquatic resources due to the operation of two additional units at the VEGP site would be SMALL. This conclusion is discussed in more detail in questions 25, 26, 33 and 53 of the Staff's testimony for Environmental Contention 1.2. A SMALL impact is defined in the FEIS as "environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource." *Id.* at 1-4. The Staff acknowledges that the use of dry cooling would eliminate all or almost all of the mortality associated with station operation including any mortality or morbidity to the shortnose sturgeon, the robust redhorse, other "important species," and the Atlantic sturgeon. The Staff, however, found that a further reduction in mortality and morbidity was unnecessary for these species since impacts at the population level would be undetectable. NEPA does not require the selection of the most preferable alternative, and in this case the wet cooling and dry cooling tower alternatives are predicted to have the same level of impact on the Savannah River population for both the shortnose sturgeon and robust redhorse as well as the other "important species" and the Atlantic sturgeon.

Additionally, the Staff's assessment of impact to the shortnose sturgeon was confirmed by the National Marine Fisheries Service Southeastern Region (NMFS SERO). On January 25, 2008, the Staff forwarded a Biological Assessment related to the two additional units planned for the VEGP site to NMFS SERO. In a letter dated August 11 2008, NMFS SERO found that the construction and operation of two additional units at the VEGP site is not likely to adversely affect the shortnose sturgeon. Exhibit SNC000022. This completed the Staff's Endangered Species Act consultation responsibilities for this facility.

Further, as discussed in Section I of our testimony, the Staff determined impacts would be SMALL for the proposed system because of the availability of water in the Savannah River to meet the consumptive and nonconsumptive requirements of the closed-cycle cooling system and to assimilate effluents under both normal conditions and even under drought conditions.

This SMALL impact and the fact that several disadvantages of the dry-cooling alternative were identified provided the basis for the Staff's concluding that the identified dry-cooling alternative would not be environmentally preferable to the proposed wet cooling system.

Q26. Given the above answers, is the Staff required to do a more in depth analysis of cooling alternatives? And why is the Staff's analysis of the dry cooling alternative sufficient to satisfy 10 CFR 51.45(b)(3)?

A26. (All) No, the Staff is not required to provide a more in-depth analysis of cooling alternatives. The Staff followed the guidance given in ESRP 9.4.1 and described the alternative cooling system in the FEIS and determined that a dry-cooling system would not be preferable to the proposed wet tower system for VEGP Units 3 and 4. Exhibit NRC000001 at 9-26.

This analysis is sufficient to satisfy 10 CFR 51.45(b)(3), which states:

> (3) Alternatives to the proposed action. The discussion of alternatives shall be sufficiently complete to aid the Commission in developing and exploring, pursuant to section 102(2)(E) of NEPA, ''appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources.''

The Staff, in Section 9.3 of the FEIS, identifies and discusses alternative cooling technologies and discloses the associated potential impacts of such alternatives. *Id.* at 9-24 to 9-27.

Q27. Does this conclude your testimony?

A27. (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)

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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)

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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
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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)

_____
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