December 20, 2011

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
Tennessee Valley Authority	)	
Completion and Operation License	)	Docket No. 50-391OL
Watts Bar Nuclear Plant Unit 2	)	
	)	

DECLARATION OF SHAWN PAUL YOUNG, PH.D.

Under penalty of perjury, I, Shawn Paul Young, declare as follows:

I. STATEMENT OF PURPOSE AND PROFESSIONAL QUALIFICATIONS

1. My name is Shawn Paul Young, Ph.D. I have been retained by Southern Alliance for Clean Energy ("SACE") as an expert consultant in this matter. I submit this declaration as a private consultant to SACE in this matter.

2. I am currently employed as a Fish Biologist for the Kootenai Tribe of Idaho. I also maintain a private environmental consulting business. My current business address is P.O. Box 507, Bonners Ferry, Idaho 83805.

3. My professional and educational experience is summarized in the curriculum vitae attached to this declaration. To summarize, I received a B.S. in Environmental Studies from Northland College; a M.S. in Aquaculture, Fisheries, and Wildlife Biology from Clemson University; and a Ph.D. in Fisheries and Wildlife Sciences from Clemson University. I have fourteen years of experience researching the effects of human activities on fisheries and aquatic ecosystems. In addition to my professional qualifications, I am an avid outdoorsman. I have fished, hunted, and enjoyed nature in every manner since my early childhood.

4. As listed in my curriculum vitae, I have authored and published peer-reviewed articles and reports relevant to fisheries and aquatic ecology. I have been consulted by public, state, federal, and academic sectors in the subject area of fish and aquatic ecology. I have delivered scientific presentations at numerous professional meetings, academic seminars, and citizen fishing association functions.

5. I am familiar with the application of Tennessee Valley Authority ("Applicant" or "TVA") for an Operating License ("OL") at the Watts Bar Nuclear Plant site and related documents, including TVA's 2007 Final Supplemental Environmental Impact Statement ("FSEIS"); the Draft Final Environmental Statement ("DFES") issued by the NRC Staff in December 2011; and the Joint Affidavit of TVA staff, Dennis Scott Baxter and John Tracy Baxter, and experts, Dr. Charles Coe Coutant and Dr. Paul Neil Hopping, supporting TVA's Motion for Summary Disposition of Contention 7. I have reviewed these documents with particular reference to their description and analysis of the additional unit's expected heat budget, water intake, water consumption, and thermal discharge into the Tennessee River; and the proposed reactor's potential impacts on the aquatic organisms of the Tennessee River.

6. I am providing this declaration in support of Intervenors' Contention 7 -- Impacts on Aquatic Resources of the Tennessee River. That contention and its supporting declaration expressed my view that TVA's conclusion in the FSEIS that the cumulative impacts of WBN Unit 2 on aquatic ecology will be insignificant is not reasonable or adequately supported. My opinion was based on three fundamental problems with TVA's data and analysis. First, TVA mischaracterizes the current health of the ecosystem as good, and therefore fails to evaluate the impacts of WBN2 in light of the fragility of the host environment. Second, TVA relies on outdated and inadequate data to predict thermal impacts and the impacts of entrainment and

impingement of aquatic organisms in the plant's cooling system. Third, TVA fails completely to analyze the cumulative effects of WBN2 when taken together with the impacts of other industrial facilities and the effects of the many dams on the Tennessee River. This declaration explains the basis for my scientific opinion that the concerns I raised in Contention 7 have not been resolved by the studies cited in TVA's Motion for Summary Disposition, the NRC Staff's DFES, or the Joint Affidavit submitted by TVA's experts.

7. I have arrived at my conclusions dealing with the matters stated herein based upon material fact found within the documents related to Watts Bar Nuclear Units 1 and 2, and within relevant scientific literature produced by other scientists pertaining to this subject, and believe them to be true and correct. The opinions and conclusions I express in this affidavit are my own and should not be attributed to any other person or entity.

II. <u>SUMMARY OF MY PROFESSIONAL OPINION REGARDING TVA'S ASSERTIONS.</u>

1. Relying on several studies that it has conducted in response to Contention 7, as well as the DFES, TVA claims that it has resolved the three major deficiencies identified in Contention 7. But this is not correct.

2. With respect to the inadequacy of TVA's previous data and analyses, TVA has made some progress by collecting new data on entrainment, impingement, freshwater mussels, and thermal impacts during 2010. But TVA has only started to catch up with its failure to collect the appropriate data that would be reasonably sufficient to evaluate impacts on aquatic resources by collecting only one year of data for entrainment, impingement, freshwater mussels, and thermal impacts over the preceding years. TVA still has not collected an amount of data that is reasonably necessary to evaluate the effects of WBN1 on aquatic organisms in the Tennessee

River, and therefore it does not have enough information to extrapolate the impacts of WBN2. See pars. III-A.5, III-B.3-4, and III-C.1-2 below.

3. In addition, there are still big gaps in the information that TVA has collected. For example, TVA collected entrainment data for the Condenser Cooling Water ("CCW") system only and did not include the Supplemental Condenser Cooling Water ("SCCW") system. See par. III-A.4 below. In addition, TVA did not collect impingement data for all key locations. See par. III-B.5 below. And TVA's Hydrothermal Study does not address important paramaters such as Outfall 101 or the amount of time that fish larvae remain in the thermal plume. See par. III-C.4 below.

4. Finally, TVA's description of its method of analyzing aquatic impacts indicates a troubling lack of care or competence. For example, by adding widely divergent diurnal and nocturnal entrainment measurement, TVA violates guidance of the U.S. Environmental Protection Agency ("EPA") and grossly overstates the size and diversity of the fish population. See pars. III-C.6 and III-C.10 below. Some of the studies relied on by TVA had to be revised after they were released, indicating that TVA has significant problems ensuring the quality of its measurements and analyses. See pars. III-A.2 and III-A.11, and pars. III-C.6-9 below. It is reasonable to expect that the results from TVA's biological studies will be accurate in order to support TVA's conclusions. In too many instances, however, TVA makes significant mistakes.

5. With respect to TVA's mischaracterization of the health of the aquatic environment as good, TVA has done nothing to alleviate my concern. Although as discussed above, TVA's data collection is insufficient to present a reasonable picture of the health of the Tennessee River, the data that TVA has collected do not indicate, as TVA claims, that WBN1's impacts on the aquatic

ecosystem have been insignificant. Rather, they point to already-significant aquatic impacts by WBN1 that are likely to be significantly exacerbated by the operation of WBN2.

6. Further, despite alarming evidence of significant decline in the diversity and numbers of aquatic organisms in the Tennessee River in the vicinity of WBN, TVA continues to assert that the aquatic health of the river is good. The only way that TVA can present such a clean bill of health is to mischaracterize the baseline condition of the Tennessee River as a large reservoir where one would expect to see a limited number of species of aquatic organisms. In reality, the Tennessee Rive is a fragile and rapidly deteriorating riverine ecosystem with remnants of the greatest species diversity of any river in the United States. By falsely painting a rosy picture of aquatic health in the river, TVA understates the significance of the impacts of WBN1 and WBN2, and thus minimizes the benefits that could be achieved by implementing alternatives that would reduce the impacts of the cooling system on organisms in the river.

7. Finally, TVA still does not address the cumulative impacts of WBN2 in conjunction with the impacts of the numerous water impoundments on the Tennessee River, or with other industrial facilities such as the ten fossil fuel-burning plants, the six nuclear reactors that are already in operation, and the five additional reactors for which TVA has sought operating licenses. The combined operation of WBN1 and WBN2, by itself, may cause changes in how Watts Bar Dam is operated. TVA and the NRC Staff both acknowledge that in order to stay within thermal discharge limits stated in the NPDES that requests for additional discharge from Watts Bar Dam may be needed. Thus, operating WBN alone would change reservoir operations in the middle- Tennessee Basin that would be supported by water releases or hydrological adjustments in upper-Tennessee River Basin. The effects of more alterations to the hydrological cycle of the basin on aquatic organisms, especially the already declining native fish

and freshwater mussel species, must be addressed. Given the extensive portfolio of energy and industrial facilities that the Tennessee River supports and that the management agencies must maintain adequate water for all these facilities, this is an extremely important omission.

III. STATEMENT OF PROFESSIONAL OPINION REGARDING ADEQUACY OF TVA'S RECENT BIOLOGICAL STUDIES TO ADDRESS THE ENVIRONMENTAL IMPACTS OF THE PROPOSED WATTS BAR 2 NUCLEAR POWER PLANT ON AQUATIC ORGANISMS

Over the past two years, TVA has conducted or revised eight studies which it claims to resolve the concerns raised by Contention 7. The studies are the following:

- Aquatic Environmental Conditions in the Vicinity of Watts Bar Nuclear Plant During Two Years of Operation, 1996-1997 (June 1998, Revised June 2010) ("Revised Aquatics Study")
- Comparison of 2010 Peak Spawning Seasonal Densities of Ichthyoplankton at [WBN] at Tennessee River Mile 528 with Historical Densities During 1996 and 1997 (Apr. 2011, Revised Nov. 2011) ("Peak Spawning Entrainment Study")
- Fish Impingement at [WBN] Intake Pumping Station Cooling Water Intake Structure During March 2010 through March 2011 (Mar. 2011) ("Impingement Study")
- Hydrothermal Effects of the Ichthyoplankton from the Watts Bar Plant Supplemental Condenser Cooling Water Outfall in Upper Chickamauga Reservoir (Jan. 2011) ("Hydrothermal Study")
- Mollusk Survey of the Tennessee River Near [WBN] (Rhea County, Tennessee) (Oct. 28, 2010, Revised Nov. 24, 2010) ("Mollusk Survey")
- Results and Discussion of the 2010 Mollusk Survey of the Tennessee River Near [WBN] (Rhea County, Tennessee) (Mar. 2011) ("Discussion of Mollusk Survey")
- Comparison of Fish Species Occurrence and Trends in Reservoir Fish Assemblage Index Results in Chickamauga Reservoir Before and After WBN Unit 1 Operation (June 2010) ("RFAI Study")
- Analysis of Fish Species Occurrences in Chickamauga Reservoir – A Comparison of Historic and Recent Data (Oct. 2010) ("Fish Species Occurrences Study")

As discussed below, these studies do not resolve the concerns raised in Contention 7.

A. Revised Aquatics Study and Peak Entrainment Study

1. TVA asserts that it has revised its method for estimating entrainment impacts and has also collected raw data on actual entrainment associated with WBN1 for one year. TVA Motion at 14-15. TVA asserts that these studies show the rate of entrainment is very low. *Id.* In my professional opinion, however, TVA's studies do not provide a reasonable degree of support for the conclusion that the rate of entrainment is low. In fact, they indicate a rate of entrainment that is unacceptable.

2. The Revised Aquatics Study is a revision of the "Aquatics Study" for which TVA collected ichthyoplankton data in order to estimate entrainment at WBN Unit 1 only during April – June 1996 and 1997, not the entire year, a major shortcoming. The timing of the original Aquatic Study corresponded to the commencement of operation of WBN Unit 1. The study results were published in 1998. TVA concluded that WBN Unit 1 ichthyoplankton entrainment was low and had insignificant impacts on the fish community. In 2009, I identified major errors in this document that had major implications. TVA revised this study, and released a revision in 2010 that did not include an additional level of detail for data presentation and analysis to assess whether the errors were properly rectified. Further, TVA's conclusions remained unchanged. Based upon the original erroneous document, in 1998, TVA convinced the Tennessee Department of Environment and Conservation ("TDEC") to allow termination of the entrainment monitoring program mandated in the original NPDES permit. Therefore, since 1997, TVA had not collected any post-operational entrainment study at Unit 1.

3. After SACE's contention 7 was admitted, TVA conducted one year of entrainment monitoring during 2010 to compare the results against 1996 and 1997 entrainment data. The Peak Entrainment Study was a survey of the ichthyoplankton drift past the Supplemental Condenser Cooling Water ("SCCW") discharge (Outfall 113) and the Unit 1 water intake

pumping structure for the CCW system. The Peak Entrainment study was conducted in conjunction with the "Hydrothermal Study" in order to also determine ichthyoplankton abundance at the SCCW intake, and in the SCCW discharge under two different thermal mixing zone scenarios.

4. In the Peak Entrainment Study, TVA collected ichthyoplankton along a transect from riverbank to riverbank below the SCCW discharge plume and above the intake pumping structure (IPS) for the CCW. As such, the study provides only a minimal account of the conditions in the Tennessee River. In order to make a reasonable analysis of the impacts of WBN1 on the river and the likely impacts of WBN2, TVA should have been collecting entrainment data regularly since WBN1 went online in 1996. For any reasonable biologist, two measurements taken thirteen years apart would not provide a sufficient basis for an analysis of entrainment impacts. TVA should have collected data for at least three years after WBN1 began operating in order to determine any annual variability of ichthyoplankton abundance. And TVA should have updated those measurements after it decided to pursue an operating license for WBN2, with at least two more years of measurements.

5. TVA's data collection for the Peak Entrainment Study was incomplete because TVA reported entrainment measurements only for the CCW intake. Even though TVA collected ichthyoplankton samples at the SCCW intake and in Watts Bar forebay, TVA did not present the data or calculate entrainment rates for the SCCW within the Peak Entrainment Study. Instead, TVA only presented data on ichthyoplankton abundance near the SCCW intake within the Hydrothermal Study, and again did not present any entrainment rates. Thus, TVA failed to adequately estimate total entrainment at the WBN1 water intake structures. The omission is significant because Tables 2 and 3 of the "Hydrothermal Study" list the results of

ichthyoplankton abundance at and near the SCCW intake in Watts Bar Reservoir forebay. The results listed in the hydrothermal study show that 300% more fish larvae were captured at the SCCW intake on May 11-12, 2010 (Table 3) than were captured in the forebay nearby (Table 2). This indicates that a very high level of entrainment may be occurring at the SCCW intake. TVA, however, failed to recognize this significant material fact.

6. In any event, the results that TVA reported for the CCW intake show that WBN1 has had significant impacts on the aquatic environment and that operation of WBN2 is also likely to impose significant additional impacts. First, the Peak Entrainment Study shows that ichthyoplankton abundance in the vicinity of WBN has declined significantly since operation of WBN1 commenced. The abundance of ichthyoplankton was substantially lower in 2010 than in post-operational surveys during years 1996 and 1997 as calculated and listed by TVA in the Revised Aquatics Study. As stated in the Peak Entrainment Study at page 3 with respect to fish larvae:

> Average densities (525, 924, 282), peak seasonal densities (1,387; 1,699; 828) and dates of peak densities (06/03, 05/15, 05/16) for larvae during April through June 1996, 1997, and 2010, respectively, are presented in Table 5. *All of these values for samples collected during 2010 were slightly lower than the range of the two previous years (1996 and 1997) of monitoring.*

(emphasis added). TVA and the NRC Staff failed to properly acknowledge the significant decline as a very important material fact in their respective analyses and conclusions.

7. The Peak Entrainment Study also reported a decline in the number of fish eggs between 1996 and 2010: average densities were reported as 262, 150, and 75 and peak seasonal densities were reported as 1,095, 1,004, and 811 for April through June 1996, 1997, and 2010, respectively. The significance of this decline is not discussed by either TVA in its Motion or the NRC Staff in the DES.

8. Based on the data reported in the Peak Entrainment Study, (Table 7, p. 19), larger than anticipated entrainment events occurred at WBN1. Daily entrainment rates of fish larvae were as high as 8.65% (June 21, 2010) during peak ichthyoplankton abundance. In my professional opinion, such a high rate of entrainment may have adverse impacts on the fish community. This measurement is very significant, given that hydraulic entrainment will double at the IPS for the CCW with the addition of WBN2, likely doubling ichthyoplankton entrainment. Larval fish entrainment events may double from 8.5% to 17%, a rate of entrainment that would certainly have a significant impact on the health of the fish population.

9. The Peak Entrainment Study also reported in Table 7 that daily entrainment rates of fish eggs were as high as 4.08% (May 16, 2010) during peak ichthyoplankton abundance. In my professional opinion, an egg entrainment rate of 4% is high enough to have a potentially adverse impact on the fish community. This measurement is very significant, given that hydraulic entrainment will double at the IPS for the CCW with the addition of WBN2, likely doubling fish egg entrainment events from 4.0% to 8.0%. At 8%, the impacts would indeed be significant.

10. I am also concerned about potential errors in the Peak Entrainment Study. At page i, TVA stated that another revision should be released sometime this month, December 2011. This indicates to me that there may be more errors in the study.

11. Further, I identified errors in methodology TVA used to complete calculations in the "Hydrothermal Study" which may have consequences for the Peak Entrainment Study. Both studies should have used the same formula to calculate the number of ichthyoplankton within 1,000 m^3 of source water from the number of organisms actually captured in the volume of water actually sampled to catch those organisms. Within the Hydrothermal Study, the number of ichthyoplankton density per 1,000 m^3 of water was estimated to determine how many fish eggs

and fish larvae were exposed to high water temperatures in the SCCW thermal plume during the day and during the night. To arrive at an estimate of the daily abundance per 1,000 m^3 of water, the day and night estimates should have been averaged, not added together. See pars. III-C. 6-9, below in this declaration. Thus, results for daily ichthyoplankton abundance at the SCCW intake are incorrect; and since the two studies incorporate similar methods to estimate ichthyoplankton densities, similar errors in calculations may have been made in the Peak Entrainment Study also. However, the entrainment study lists results in a different manner that does not allow one to determine this.

12. In conclusion, the Revised Aquatic Study and the Peak Entrainment Study do not support TVA's conclusion that the environmental impacts from entrainment at the current IPS for the CCW intake with one reactor are insignificant, nor do they support a conclusion that the additional impacts of WBN2 would be insignificant. To the contrary, the data reported shows that the impacts from entrainment from the IPS for the CCW from one reactor unit alone may be large and warrants further investigation. Further, the Hydrothermal Study suggests that entrainment at the current SCCW intake may be also be significant with large impacts to the fish community.

13. As a general matter, TVA also mischaracterizes the relationship between river flow and entrainment. According to TVA, studies show that the hydraulic entrainment from dual unit operation will result in an additional entrained amount of 0.2% of the flow in the Chickamauga Reservoir. Statement of Material Facts, par. 22. TVA asserts that the resulting total hydraulic entrainment represents approximately 0.5% of the flow in the Chickamauga Reservoir; and that this increased hydraulic entrainment will result in a proportionate increase in entrainment of the ichthyoplankton present in the water column. *Id.*

14. TVA's calculation is only partly correct, and only accurate at a very specific river flow past WBN Plant. The 0.2% hydraulic entrainment for WB1 is based upon TVA using "a long term average river flow past WBN of 27,000 cfs." See Footnotes 58-60 and Joint Affidavit par. 37. However, the flow past WBN may vary widely depending on seasonal precipitation levels and daily operations of Watts Bar Dam immediately upstream of WBN. Therefore, hydraulic entrainment will vary depending on amount of water in the Tennessee hydrosystem and how much flow is released from Watts Bar Dam. For instance, using CCW water withdrawal rate of 88 cfs (NRC DFES Table 3-1 at page 3-9) and river flow of 3,500 cfs, which is the minimum amount of flow from Watts Bar Dam that permits TVA to discharge thermal and chemical effluent through Outfall 101, the hydraulic entrainment increases to 2.5% (12.5 times higher). Then, with the addition of Unit 2 doubling hydraulic entrainment, the hydraulic entrainment at a flow of 3,500 cfs further increases to approximately 5.0% (25 times higher). Also, with higher hydraulic entrainment, the probability of entraining more ichthyoplankton increases. However, one cannot assume that ichthyoplankton entrainment will increase proportionately. In fact, ichthyoplankton may increase exponentially. The increase depends on the proximity of ichthyoplankton to water intakes. Only data collected by field studies in combination with proper methods for calculation may accurately characterize ichthyoplankton entrainment under any level of hydraulic entrainment. I note that this is a similar issue in regards to impingement.

B. Impingement Study

1. TVA claims that impingement data it collected between March 2010 and March 2011 at the CCW intake show that impingement rates under normal conditions were unchanged from those that TVA historically measured at the CCW intake, but that unusually cold weather in the winter of 2011 produced high impingement rates. TVA also cites the DES for the proposition

that impingement impacts during operation of both WBN1 and WBN2 would be "too low to noticeably alter the aquatic community". TVA Motion at 16-17.

2. I disagree with TVA that the Impingement Study provides sufficient data on which to reach a conclusion about impingement impacts of either WBN1 or dual operation of WBN1 and WBN2.

3. Although WBN1 has been operating since 1996, the last time TVA took an impingement measurement for the CCW was in 1997. Although TVA has planned for some time to finish building and operate WBN2, it made no effort to measure impingement rates until 2010, after Contention 7 was admitted for a hearing. For any reasonable fish biologist, two measurements taken more than ten years apart would not suffice to provide the basis for any analysis of the impingement impacts of WBN1.

4. The circumstances of the 2010 measurements illustrate my point. In comparison to the 161 fish impinged in March 1996 through 1997, 13,573 were impinged in 2010. See Attachment 15, page 3. TVA attributes this exponential increase to cold weather in 2010. But it is also possible that the through-screen velocity of water flowing into the CCW intake is partially responsible for the high impingement rate. At page 1, the Impingement Study lists the through-screen velocity as 0.67 fps. The EPA recommends that through-screen velocity be kept below 0.5 fps, however, in order to reduce entrainment and impingement. Without more data over a period of several years, the contribution of the cold and plant operating conditions to the rate of impingement can only be guessed at. In short, it is not possible for TVA to make up for years of neglect in only one year.

5. TVA also failed to take impingement measurements for all key locations. The Impingement Study sampled fish impingement at the IPS for the CCW only, and did not include

the SCCW. A study was conducted in 2000 to evaluate impingement at the SCCW intake above Watts Bar Dam; however, this study did not monitor an entire year. This study still showed that impingements may also occur at the SCCW intake (p. 6, Watts Bar Nuclear Plant Supplemental Condenser Cooling System Fish Monitoring Program, January 2001); yet, TVA still did not conduct impingement monitoring at the SCCW during 2010 in conjunction with the CCW study to determine the cumulative impingement by current operations of WBN Unit 1.

C. Hydrothermal Study

1. In the Hydrothermal Study, TVA reports the results of monitoring the water temperatures in the thermal plume of the SCCW (Outfall 113) during May and August 2010. TVA recorded water temperatures during the two mixing zone scenarios that occur daily, the active mixing zone when Watts Bar Dam releases water and the passive mixing zone when Watts Bar Dam does not release water. TVA also completed ichthyoplankton sampling at and near the SCCW above Watts Bar Dam, and downriver of Watts Bar Dam below the actual thermal plume during both day and night. TVA asserts that the Hydrothermal Study shows that thermal discharges from WBN1 and WBN2 will not have a significant impact on aquatic organisms. TVA Motion at 18-19.

2. TVA should have conducted the study over several years to characterize thermal plume water temperatures and ichthyoplankton abundance that may vary across years due to variable climatic conditions, and due to variable operations of Watts Bar Dam caused by variable hydrological conditions in the Tennessee River Basin.

3. The Hydrothermal Study also failed to address important parameters. For instance, it did not include any data or analysis for Outfall 101 (discharge at the CCW diffuser), which releases heated effluent when the dam discharge exceeds 3,500 cfs. Outfall 101 should have been

included, especially in light of the fact that ichthyoplankton may drift through Outfall 113 mixing zone and then into the Outfall 101 mixing zone. This omission is significant.

4. In addition, contrary to statements in the Motion for Summary Disposition and the DFES, the Hydrothermal Study did not list nor discuss ichthyoplankton exposure rates i.e., the amount of time fish eggs and larvae remain in the thermal plume. The omission of this information is significant because the early life stages of fish, especially eggs and larvae are vulnerable to abrupt temperature change such as those found at Outfall 113 and 101, and exposure to such water temperature changes caused by WBN heat waste discharge may cause high mortality rates. Abrupt temperature changes are detrimental to fish eggs and larvae. Also, abrupt temperature change affects species differently. This is an important omission because a rapid increase of 5 – 10° F can kill fish eggs and fish larvae, and from the data presented, most of the ichthyoplankton likely experienced this as they drifted through the SCCW mixing zone. Further, not only are ichthyoplankton exposed to the SCCW thermal plume, but these same fish eggs and larvae then drift through the CCW diffuser thermal plume below. A second abrupt temperature increase further elevates risk of mortality from the heat discharged from WBN.

5. The Hydrothermal Study is also deficient because TVA failed to report and discuss the fact that an alarming number of ichthyoplankton were likely entrained by the SCCW and subsequently killed by heat within the SCCW system before being discharged back into the river. This is an extremely important consideration in this matter. Further, the portion of ichthyoplankton in the Watts Bar Reservoir forebay not directly entrained and killed by the SCCW would likely pass through the dam and then still would be subjected and potentially killed by the waste heat in the SCCW and CCW (Outfalls 113 and 101) thermal plumes. The use of the SCCW creates a "double whammy" for fish eggs and larvae, likely causing an

alarming level of mortality. TVA does not adequately describe this situation or adequately analyze presented data that shows significant mortality may be occurring via both pathways.

6. The conclusions of the Hydrothermal Study are also based on incorrect methodology that leads to distorted results. In reporting the results of ichthyoplankton sampling, TVA added the daytime and nighttime measurements rather than averaging them, thus giving a distortedly high population reading. For instance Table 4 on page 25 of the Hydrothermal Survey shows that on May 11-12, 2010, during daytime sampling, TVA estimated 75 organisms per 1,000 m^3 of water at the SCCW outfall. During the nighttime sampling, TVA estimated 8,232 organisms for the same volume of water. TVA then reported the number of organisms per volume of 1,000 m^3 of water for the sampling period as 8,307. In actuality, however, the number of organisms ranged between 75 and 8,232, with an average of approximately 4,153 fish larvae per 1000 m^3 of water during a 24-hour diel cycle.

7. There is no controversy about what method TVA should have employed – it is listed in the "Materials and Methods" section of TVA's April 2011 "Peak Entrainment Study." For TVA not to notice another significant error in its own reporting raises fundamental questions regarding TVA's methodology for all of its studies.

8. TVA's methodological error has several implications in the analyses of impacts on the fish community. This error results in the overstatement of the size of the fish population in the river, which in turn will lead to an understatement of the percentage of fish that are affected by entrainment. This has major implications for the validity of the "Entrainment Study" because it results in an incorrect estimate of the percentage of organisms that were entrained at the CCW. If the same error found in the Hydrothermal Study was made during calculations of ichthyoplankton abundance for the Peak Entrainment Study, the results listed in the Peak

Entrainment Study are not accurate, and TVA conclusions are not based on accurate material facts. In addition, the original Aquatics Study also had major errors, and one cannot be sure those errors have been remedied in the Revised Aquatics Study. Both documents used to compare post-operation entrainment and the associated impacts have had major errors casting doubt on the validity of TVA's analyses and conclusions.

9. Another significant error can be found in Tables 5 through 10. Table 10 lists the total ichthyoplankton abundance found at the five different sampling stations across the survey transect. However, the reported total number of ichthyoplankton captured is less than the reported number of ichthyoplankton that were captured at just *one* of the individual sampling stations. This error raises serious questions about the actual results of the study, not to mention TVA's competence and quality assurance procedures for conduct of biological monitoring and anlaysis.

10. TVA also failed to note the significance of the great discrepancy between the daytime and night-time population measurements, or to analyze how they may be affected by daily variations in thermal plume temperature. In light of the size of the discrepancy, TVA should have undertaken more studies of the differences between daytime and nighttime fish populations. It should also evaluate changes in nighttime operations to reduce the rate of entrainment of aquatic organisms.

11. The Hydrothermal Study showed that thermal discharge observed for current operation of Unit1 is already near the limits set in the NPDES permit. TVA's temperature data shows that it is staying within its permit limit of a 5°F daily average change from upriver temperature at the downstream edge of the mixing zone; however, the results from the May and August 2010 tests show that it is operating on the edge of those limits with only Unit 1 operating. As stated at

page 5, the maximum difference between ambient and surface temperature reached 5°F during the May night test, 5.34°F during the May day test, and 5.36°F during the August day test. Also, at the point of discharge, the Hydrothermal Study shows that SCCW discharge water is 10°F hotter than the water above the SCCW thermal plume and above Watts Bar Dam. Organisms drifting downriver nearest the point of discharge will likely suffer from this abrupt temperature change, especially fish eggs and larvae. These impacts were not considered by TVA. See above in par. 4.

D. Mollusk Survey, Discussion of Mollusk Survey, and Revised Aquatics Study

1. As discussed in Contention 7, TVA's assertion in the FEIS that mussel health is "excellent" because their population is "constant" is contradicted by evidence that mussel populations are declining. Contention 7 at page 33. TVA responded to my criticism by hiring a consultant to conduct a new mussel survey utilizing new and expanded methodology. The study site evaluated mussel beds within transects in the same general areas as previous TVA mussel surveys near WBN Plant. Each mussel was identified by species and age. TVA compared the results from the 2010 study with previous mussel studies, including the post-operational mussel surveys in 1996 and 1997. The results from the 1996 and 1997 post-operational surveys are found within the original "Aquatic Study" published in 1998 and the recent "Revised Aquatics Study".

2. TVA no longer asserts that mussel health near WBN1 is excellent. Instead, it states that the studies it conducted "agree that the Chickamauga Reservoir in the WBN vicinity is not the ideal habitat for mussels." Statement of Material Fact, page 19. Nevertheless, TVA's experts state that the survey results demonstrated "that the current mussel community adjacent to WBN is stable and that some species are reproducing." Baxter and Coutant, par. 72. They assert that

the mussel community in the WBN vicinity is in "substantially similar condition as it was near the end of the previous operational monitoring period (1996 to 1997), in both species composition and the number of mussels collected." In addition, they state that the 2010 survey "collected juveniles of at least five mussel species, evidencing reproduction of mollusks in the WBN vicinity." *Id.* Based on these results, TVA contends that "there is no basis to support a finding that the relatively low densities of mussels in the WBN vicinity are the result of operation of WBN Unit 1."

3. I disagree with TVA's assertions. The data collected by TVA show that health of the freshwater mussel community around WBN1 is poor and declining. The data also show a connection between the poor health of the mussel community near WBN1 and the operation of WBN1.

4. There can be no doubt that the health of the mussel community near WBN1 is poor and also declining. The data provided in the Mollusk Survey show that freshwater mussel abundance has declined significantly in the area affected by the SCCW since it began cooling Unit 1 in 1999. TVA failed to address three significant trends reflected in this data. First, the abundance of mussels at the three study sites changed significantly between 1996-97 and 2010. In 1996-97, just before the SCCW went into operation for WBN1 in 1998, 344 mussels were collected from the upper bed located just upriver of WBN. That bed now lies within the SCCW discharge plume (p. 40, Revised Aquatics Study). By 2010 the abundance of mussels at the upper bed had been reduced by approximately half to 175 (p. 4, Mollusk Study). This is a major concern, given that the site is within the mixing zone for the SCCW outfall, which had not been in use for a substantial time prior to or during the 1996-97 surveys.

5. The data also show that mussel abundance in both the middle and lower sites increased since 1996-97 (p. 40, Revised Aquatics Study and p. 4, Mollusk Study. These increases may be due to better sampling techniques employed in 2010, or to better reservoir system management practices implemented at Watts Bar Dam. The Discussion of Mollusk Survey does not explain this development. Quite possibly, the SCCW may be thwarting a rebounding mussel population in the vicinity of WBN.

6. Second, the experimental boulder field to provide increased mussel habitat as a mitigation measure for the use of the SCCW had very few mussels – only five -- indicating this action was a failure. TVA's experts attribute this failure to the force of the water flowing from Watts Bar Dam. Baxter and Coutant, par. 70. But they do not acknowledge that the boulder field is located near the SCCW. The death of most relocated mussels, and the substantial decline of mussel numbers in the upper bed show the SCCW has and will continue to have substantial adverse impacts on the mussels near WBN.

7. Finally, the data indicates that a significant number of mussel species are still unable to reproduce and recruit new members to sustain their local populations. The recent survey found the presence of juveniles for four of the 17 species, indicating some reproduction and recruitment is taking place. However, for the other 13 species -- including two endangered species -- no juveniles were present, indicating a lack of reproduction and recruitment capacity, which will lead to eventual local extirpation. In addition, the four reproducing species that were found near WBN1 are just a fraction of the 64 mussel species known to once inhabit the Tennessee River in the vicinity of present day WBN Plant. Thus, only 6% of the indigenous freshwater mussel species remain viable at this time.

8. In paragraph 74 of their affidavit, TVA's experts assert that I erroneously extrapolated TVA's characterization of the Rservor Benthic Macroinvertibrate Index (RBMI") for the benthic macroinvertebrate community in the SBN vicinity, to the freshwater mussel community specifically. They are incorrect. My opinion is based on a passage in TVA's FSEIS on page 55 which states:

> Another aspect of the Vital Signs Monitoring Program is the benthic index, which assesses the quality of benthic communities in the reservoirs (including upstream inflow areas such as that around WBN). The tailwaters of Watts Bar Dam support a variety of benthic organisms *including several large mussel beds*. One of these beds has been documented along the right-descending shoreline immediately downstream from the mouth of Yellow Creek. To protect these beds, the state has established a mussel sanctuary extending 10 miles from TRM 520 to TRM 529.9. Since the institution of the Vital Signs Monitoring Program, the quality of the benthic community in the vicinity of the WBN site has remained relatively constant. The riverine tailwater reach downstream of Watts Bar Dam and WBN rated "good" in 2001 and the rating has increased to "excellent" in 2003-2005 (Appendix C, Tables C-4 and C-5).

(emphasis added). This paragraph specifically discusses freshwater mussels as part of the benthic community evaluated under TVA's Vital Signs Monitoring program. Mussels are benthic macroinvertebrates, and are represented in Metric 2 – "Long-lived Organisms" of the Reservoir Benthic Index (Table 6. Biological Monitoring of the Tennessee River near Watts Bar Nuclear Discharge, 2008). Therefore I did not misinterpret the passage stated in the FSEIS in expressing my opinion that when only four out of 64 (i.e., 6% of) freshwater mussel species once found in the vicinity of WBN remain reproductively viable, in no way can any aspect of the aquatic community be rated in "excellent" health.

9. I do not believe TVA has a reasonable basis for placing the blame for mussel decline solely on river impoundment. While it is clear that river impoundment has severely impacted the mussel community, the results of the 2010 surveys show an alarming decline of mussels in the vicinity of the SCCW. This is evidence that current WBN operations have had a large impact on

mussel health and that adding another reactor unit will increase and perpetuate these negative impacts.

10. Another factor which indicates that the health of macroinvertebrates in general is declining is the dominance of only four species including the Asiatic clam, a non-native, invasive species. As shown in the "Revised Aquatics Study" at page 34, during operational monitoring in 1996-1997, only four of 104 aquatic invertebrate species found made up 87.5%. Further, the average density of aquatic macroinvertebrates per square meter actually declined by more than 50% from 1997 to 2008 in the vicinity of WBN. In 1997, 424 organisms per square meter were reported (Appendix C. Aquatic Ecological Health Determinations for TVA Reservoirs – 1997). In 2008, only 187 organisms per square meter were reported (Table 8. Biological Monitoring of the Tennessee River near Watts Bar Nuclear Discharge, 2008). In 2007 and 2008, even TVA's Reservoir Benthic Index (RBI) score used to monitor the macroinvertebrate community fell to the "fair" category.

E. RFAI Study and Fish Species Occurrences Study

1. TVA uses Reservoir Fish Assemblage Index ("RFAI") "scores" to provide general ratings of the fish community within TVA reservoirs. As discussed by TVA's experts in par. 55, TVA uses the RFAI to determine whether a "Balanced Indigenous Population" is being maintained as required by the EPA under the Clean Water Act. As discussed in Contention 7 and my supporting declaration, I believe TVA's RFAI scores are biased and misleading, and do not properly reflect the true state of the Tennessee River's aquatic resources. TVA's RFAI Study and Fish Species Occurrence Study do not resolve my concerns.

2. In the Fish Species Occurrence Study, TVA analyzed and scored new and historical fish survey data to determine the current presence of fish species, and compared the presence of

species before and after operation of WBN Unit 1. TVA claims that a comparison of scores between 1993 and 2008 shows that both before and after operation of WBN1, TVA has maintained a "balanced indigenous population" ("BPI"). Statement of Material Facts at pp. 14-15. In the RFAI Study, TVA also concludes that "long-term data trends suggest that the ecological health of the fish community in Chickamauga Reservoir inflow has been maintained." See page 13 of Attachment 9. Furthermore, TVA states that: "The species composition of the fish assemblage of Chickamauga Reservoir has changed somewhat, but not markedly, over the decades of sampling by TVA." See page 19 of Attachment 10. Neither study remedies my concerns in Contention 7.

3. In my professional opinion, the RFAI and Fish Species Occurrence studies does not present a reliable or reasonably accurate picture of the health of aquatic organisms near WBN1, for several reasons. First, TVA's method for conducting RFAI studies has changed over the years, making the scores difficult to compare. And the history of the RFAI program indicates that the older scores are unreliable because the methodology for deriving those scores was questioned by EPA and others. In an EPA guidance document, for example, EPA includes improvement of the RFAI in a list of "Research Needs:"

> *Research Needs* -- TVA has been actively developing assessment tools for its reservoirs for several years. The move to a multimetric approach for reservoir fish began in 1990. Successive steps in this development process have brought continued improvement to the RFAI. Potential improvements in the fish indices include using a simple random sampling design rather than a fixed station design to enhance statistical validity with little increase in variability. Use of the index in reservoirs or other river systems is necessary to test its performance under a wider range of conditions than is available in the Tennessee river. *Correlation with known human-induced impacts remains a critical need before general acceptance of the fish index as a reliable method to address reservoir environmental quality.*

EPA 841-B-98-007 - Lake and Reservoir Bioassessment and Biocriteria: Technical Guidance Document, Appendix D: Biological Assemblages, Section D.5 Fish, pp. 176-177 (Undated).

(http://water.epa.gov/type/lakes/assessmonitor/bioassessment/upload/lakereservoirbioassess-biocrit-app-d.pdf) (emphasis added). Second, TVA's summation of data in the Fish Species Occurrence study is biased, and TVA attempts to portray sampling gear changes as the reason for the decline of fish species near WBN and Chickamauga Reservoir in general to mask the reality that the fish community has experienced significant decline pre- and post-WBN operation from cumulative man-made impacts to the aquatic ecosystem.

4. The scientific community has also criticized the RFAI's inability to correlate with environmental degradation or accurately reflect true patterns in environmental health within and among reservoirs:

> More recently, a second TVA reservoir version of the IBI [Index of Biotic Integrity] has been developed, termed the Reservoir Fish Assemblage Index (RFAI, Jennings, Karr, and Fore, personal communication). The RFAI has a somewhat different set of 12 metrics (Table 4), with the changes in metrics designed to improve sensitivity to environmental degradation and to increase adaptability to different types of reservoirs. *However, results from applications of both the original TVA version and the newer RFAI have often not accurately reflected what are believed to be the true patterns in environmental health within and among reservoirs*, and additional modifications will probably be necessary to develop better versions of the IBI for impoundments (Jennings, personal communication).

Davis, W. S., and T. S. Simon, Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making, pp. 260-261 (Lewis Publishers: 1995) (emphasis added).

5. However, even the biased RFAI scores declined post-operation, thus undermining TVA's claim that the RFAI scores show that the "good health" of aquatic organisms near WBN1 has not declined. TVA Joint Affidavit, par. 57.

6. Some of the problems with TVA's RFAI methodology can be seen in the 12 metrics described in Paragraph 52 of TVA Joint Affidavit for assessing four general categories of fish health characteristics: Species Richness and Composition, Trophic Composition, Abundance,

and Fish Health. For each metric, scores are given on a scale from 1 to 5, with a score of 5 indicating optimum health.

7. TVA's RFAI scores are predominantly biased by inappropriate assessments of the first category "Species Richness and Composition" and its 8 metrics (i - viii), and the lack of appropriate metrics within the third category "Abundance" (metric xi).

8. Species Richness and Composition – Metric (i) is described as:

> i. Total number of indigenous species: Greater numbers of indigenous species are considered representative of healthier aquatic ecosystems. As conditions degrade, numbers of species at an area decline.

Metric (i) is misleading because it reports only the mere presence of a species, and does not account for its actual abundance, reproductive viability, and future existence within the fish community under evaluation. There is no metric to account for this within the "Abundance" category. A threatened or endangered species would register positively under this metric even though its future existence is doubtful. Several indigenous species were present in only one or two years within a decade sampling period. Again, there is no metric to account for these important trends of indigenous fish decline within the "Abundance" category. Further, the percent of native species is biased by hatchery stockings of species that may otherwise have disappeared from Chickamauga Reservoir.

9. Appendix 1 of Attachment 9 to TVA's Motion illustrates my point. Appendix 1 shows that only one Largescale stoneroller was captured in 2004 and 2008 and zero were captured in all other years from 1999-2009. Yet, these two individuals that were collected during a 10-year sampling period represent species presence in Tables 2 and 3. Similarly, River redhorse (two individuals) and Smallmouth redhorse (one individual), which are Catostomids or suckers, show population trends near WBN similar to the Largescale Stoneroller. Thus, while one or two

individual fish could not reasonably be characterized as a healthy or even viable population, the RFAI considers its presence as a positive attribute. Further, several intolerant species were found during 2009 in the following numbers: Chestnut Lamprey (0), Steelcolor shiner (4), Emerald Shiner (1), Black redhorse (5), Golden redhorse (3), Northern Hogsucker (0). In comparison, several tolerant species were found during 2009 in the following numbers: Bluegill (471), Gizzard shad (131), and Largemouth bass (61). Nevertheless, in 2009, TVA gave this metric a score of 5 (see Attachment 9, p. 144, Appendix 2-A). In my view, given the extremely low abundance of indigenous fish species and the high abundance of tolerant species, this metric should receive a score of 1, or an equivalent metric should be incorporated into the "Abundance" category to properly represent the extremely low abundance of numerous indigenous species.

10. Metric (ii) in the category of "Species Richness and Composition" is described as:

> ii. Number of centrarchid species: Sunfish species (excluding black basses) are invertivores and a high diversity of this group is indicative of reduced siltation and suitable sediment quality in littoral areas.

Metric (ii) yields misleading results because it uses only one of several families of fishes that are commonly used to assess the status of a fish community, and because Centrarchids are not representative of the most vulnerable indigenous fish species. TVA neglected to use other families more representative of the Tennessee River such as Percidae (which includes darters), Catostomidae (i.e.,suckers), and Cyprinidae (i.e., minnows). These families were highly diverse and plentiful historically; are intolerant to human disturbance and pollution; and all have suffered severe decline in the Tennessee River. TVA gave this metric a 5, the highest score. The only attribute this reflects is that Centrarchids, which thrive in reservoirs, are well-represented. If one of the other three families were used, this metric would be scored a 1.

11. Metric (iii) in the category of "Species Richness and Composition" is described as:

> iii. Number of benthic invertivore species: Due to the special dietary requirements of this species group and the limitations of their food source in degraded environments, numbers of benthic invertivore species increase with better environmental quality.

As with metric (i), metric (iii) evaluates only the presence of a species, and does not account for its actual abundance, reproductive viability, and future existence in the environment under evaluation. Again, there is no similar metric in the "Abundance" category to measure the actual numbers of a species. If those factors were taken into account, TVA could not have given this metric a score of 3. Given the steep decline of benthic invertivores as described in par. 9, the score should be 1.

12. Metric (iv) in the category of "Species Richness and Composition" is described as:

> iv. Number of intolerant species: This group is made up of species that are particularly intolerant of physical, chemical, and thermal habitat degradation. Higher numbers of intolerant species suggest the presence of fewer environmental stressors. The higher number of these species would be a positive indicator

Metric (iv) should account for status of suckers, minnows, and darters as well as locally endangered or extirpated species such as sturgeon and paddlefish because these fish are intolerant and in decline. As with metrics (i) and (iii), metric (iv) evaluates only the presence of a species, and does not account for its actual abundance, reproductive viability, and future existence in the environment under evaluation. Again, there is no similar metric in the "Abundance" category to measure the actual numbers of a species. If those factors were taken into account, TVA could not have given this metric a score of 5. This metric suffers from the same bias as Metric (i). TVA gave this metric a score of 5, but it should have received a score of 1.

13. Metric (v) and Metric (vi) in the category of "Species Richness and Composition" are described as:

> v. Percentage of tolerant individuals (excluding Young-of-Year): This metric signifies poorer water quality with increasing proportions of individuals tolerant of degraded conditions.
>
> vi. Percent dominance by one species: Ecological quality is considered reduced if one species inordinately dominates the resident fish community.

Metric (v) should identify a fish species community that is dominated by species tolerant of disturbance and poor water quality. Metric (vi) should identify a fish species community that is unbalanced and dominated by only one or few species. These are negative attributes whose scores should be inversely proportional to the degree they exist. TVA's RFAI sampling shows a high percentage of tolerant species such as bluegills. See par. 19 below. Further, the fish community is currently dominated by bluegills (See par. 19); thus, the score should be a 1. TVA, however, gave Metric (v) a score of 3. TVA correctly gave Metric (vi) a score of 1, which is evidence that the fish community no longer supports a balanced indigenous population.

14. Metric (vii) in the category of "Species Richness and Composition" is described as:

> vii. Percentage of non-indigenous species: This metric is based on the assumption that non-indigenous species reduce the quality of resident fish communities.

Like metrics (v) and (vi), this is a negative attribute, whose score should be inversely proportional to the degree it exists. Metric #7 should identify a fish species community that has a significant number of non-indigenous species, i.e. species that are not indigenous to the Tennessee River whether intentionally or unintentionally stocked. TVA sampling shows several non-indigenous species present; and, that the percent of native species is biased by hatchery stockings of species that may otherwise have disappeared from Chickamauga Reservoir. TVA properly scored this metric with a 1, again indicating that the fish community no longer supports a balanced indigenous population.

15. Metric (viii) in the category of "Species Richness and Composition" is described as:

> viii. Number of top carnivore species: Higher diversity of piscivores is indicative of the availability of diverse and plentiful forage species and the presence of suitable habitat.

Metric (viii) should identify a fish species community that is in proper balance with an adequate carnivore population, or fish that eat other fish and serve as the upper food chain predators. However, this metric may also be biased by hatchery stockings that are used to support a sport fishery. Often hatchery supplementation is used to artificially support a fish population for recreational purposes when the aquatic system no longer supports natural reproduction. Recreational fisheries often target these predatory fish species such as striped bass, sauger, and walleye, all of which are stocked by the State of Tennessee into Chickamauga Reservoir because of lack of natural reproduction to support fishing. The lack of reproduction is due to the alterations of the Tennessee River and the resulting poor ecological health. While TVA scored this metric at 5, the score should be a 3.

16. The category "Abundance" is as equally important as "Species Richness and Composition"; yet, "Abundance" is only represented by one metric (metric xi) as compared to "Species Richness and Composition" which is represented by eight metrics. This is a major omission that leads to the inappropriately high RFAI scores that overstates the health of the fish community. Metric xi is described as:

> xi. Average number per run (number of individuals): This metric is based upon the assumption that high quality fish assemblages support large numbers of individuals.

Metric (xi) is highly biased by the ever-increasing numbers of bluegills and other species that thrive in a man-made environment and now dominate the fish community. The increase of bluegills masks the low number of other native species in decline. TVA, scoring this metric based upon the definition, gave it a 5. However, if this category incorporated similar metrics as "Species Richness and Composition" based upon actual abundance, or number of individuals captured, all of the metrics designed to monitor indigenous fish species would receive RFAI scores of 1, the lowest possible.

17. Paragraph 53 of the Joint Affidavit describes the method for evaluating total RFAI scores as follows:

> Because there are 12 metrics, RFAI scores range from 12 to 60. The aquatic community health is indicated by the following ranges of scores: 12-21 ("Very Poor"), 22-31 ("Poor"), 32-40 ("Fair"), 41-50 ("Good"), or 51-60 ("Excellent").

TVA's final 2009 RFAI score for the area near WBN Plant was a 44 in the "Good" category. Correcting for the bias of the RFAI would lead to a score of 28, or a "Poor" rating of the health of the fish community. I believe the "poor" rating, which is a significantly different picture of the fish community in the vicinity of WBN than that of TVA's analyses, more accurately represents the status of the fish community of the Tennessee River in the vicinity of WBN Plant.

18. The score that I estimated is also consistent with other data which show a decrease in the level of diversity and the size of existing populations since WBN1 began operating. For instance, a comparison of the NRC's 1978 Final Environmental Impact Statement (FEIS) for WBN Units 1 & 2 (Table C-21) and the NRC's 2008 Final Supplemental Environmental Impact Statement (FSEIS) for WBN Unit 2 (Table 3.3.1) shows that the Chickamauga Reservoir experienced a 24% decline of freshwater fish species between 1970-73 and 1991-1996. Further, Vital Signs and Biological Monitoring reports from 1994 list 36 fish species that were captured

in Upper Chickamauga Reservoir, and reports from 1999-2009 show the number of species declined to between 24 and 31 for a given year, another 14% decline.

19. Evidence that the fish community near WBN is greatly unbalanced may be found by analyzing TVA electrofishing data in Aquatic Ecological Health Determinations for TVA Reservoirs –1994, Table 8, Page 352, and within Biological Monitoring of the Tennessee River Near Watts Bar Nuclear Plant Discharge, 2008, Table 3, Page 18. These data show that in 1994, bluegill -- a species that thrives in man-made habitats and are thus popular for stocking in small ponds across the United States -- comprised only 27% of all fish in TVA's sampling in Upper Chickamauga Reservoir. However, during 2008 sampling, bluegill comprised 63% of all fish captured in Upper Chickamauga Reservoir at areas downstream of Watts Bar Nuclear Plant Discharge. Upon further examination, Centrarchids in general (the family of fishes that is comprised of bluegill, sunfishes, and black-basses) make up 78% of all fish near WBN. A fish community that is made up of 78% bluegill, sunfishes, and black-basses is more indicative of a farm pond than the most biologically diverse freshwater ecosystem in North America. Further, by adding gizzard shad, another species that may thrive in reservoirs, the percent increases to 91%. This results in a very low abundance, whether stated in terms of percent composition and actual numbers, of other native riverine fish species that should be found in the Tennessee River near WBN. When this is compared to 1994 when Centrarchids comprised only 58% and gizzard shad 10%, there is evidence that the fish community is extremely unbalanced, and the percent of indigenous riverine species has continued to decline since WBN1 became operational.

20. Thus, these data show that the fish community has undergone significant negative changes since WBN1 became operational and the current health of the fish community is poor. The data certainly do not support the existence of a Balanced Indigenous Population or "BIP."

F. Failure to Discuss Cumulative Impacts

1. TVA has not addressed the cumulative impacts on the Tennessee River Basin from combined operation of WBN Units 1 and 2. The combined operation will increase cooling water needs and increase thermal and chemical discharge. These consequences of adding yet another energy production facility will have adverse impacts on the whole system with large impacts to the upper-basin tributaries that also support highly diverse and unique fish and mussel species. TVA manages the Tennessee River as one hydrosystem; thus, changes in water consumption or changes in flow to accommodate energy and industrial facilities in one area will affect the rest of the system. Further, the quantity of water available at Watts Bar Dam and then released into Chickamauga Reservoir determines the management of the rest of the hydrosystem, especially water releases from the upper basin. Therefore, if WBN Plant requires flow in order to operate at maximum efficiency and to remain within NPDES permit limits, the entire upper basin or at least the aquatic ecology of 10 different tributaries with a high number of fish and mussels will be affected. This is supported by the following excerpts from TVA's discussion of water management policy on its website (http://www.tva.gov/river/lakeinfo/systemwide.htm):

- "In May 2004, the TVA Board of Directors approved a new policy for operating the Tennessee River and reservoir system. This policy shifts the focus of TVA reservoir operations from achieving specific summer pool elevations on TVA-managed reservoirs to managing the flow of water through the river system. The new policy specifies flow requirements for individual reservoirs and for the system as a whole."
- "System-wide flow requirements ensure that enough water flows through the river system to meet downstream needs."

- "When water must be released to meet downstream flow requirements, a fair share of water is drawn from each reservoir. System-wide flows are measured at Chickamauga Dam, located near Chattanooga, Tenn., because this location provides the best indication of the flow for the upper half of the Tennessee River system."
- "If the total volume of water flowing into Chickamauga Reservoir is less than needed to meet system-wide flow requirements, additional water must be released from upstream reservoirs, resulting in some drawdown of these projects. How much water is released depends on the time period and the total volume of water in storage in 10 tributary reservoirs: Blue Ridge, Chatuge, Cherokee, Douglas, Fontana, Nottely, Hiwassee, Norris, South Holston and Watauga."

2. For all the reasons discussed above, TVA has not resolved the concerns raised by Contention 7. Therefore the contention should not be dismissed.

Under penalty of perjury, I declare that the foregoing facts are true and correct to the best of my knowledge, and that the expressions of opinion are based on my best professional judgment.

____
Shawn Paul Young, Ph.D.
P.O. Box 507
Bonners Ferry, ID 83805

Dated: December 20, 2011

Shawn P. Young, *PhD*
P.O. Box 507
Bonners Ferry, ID 83805
(765) 427 - 3997
syfishhead@msn.com

EDUCATION

PhD	Fisheries Sciences	May 2005	Clemson University, Clemson, SC
MS	Fisheries Sciences	Aug 2001	Clemson University, Clemson, SC
BS	Environmental Studies	May 1996	Northland College, Ashland, WI

PROFESSIONAL EXPERIENCE

Environmental Consultant	Private practice	Jan 2005 – Present
Fish Biologist	Kootenai Tribe of Idaho	July 2011 - Present
Fisheries Researcher	GADNR/Clemson Univ.	Feb 2010 – Nov 2011
Lecturer/Scientist	University of Idaho	Aug 2008 - Sep 2009
Visiting Scientist	University of Iceland	July 2008 - Aug 2008
Visiting Assistant Professor	Purdue University	Aug 2007- May 2008
Postdoctoral Researcher	Clemson University	Oct 2006 - Aug 2007
Fish Biologist/Facility Manager	Clemson University	Jun 1999 - May 2006
Fisheries Technician	Idaho Fish and Game	Apr 1997 - June 1999

Environmental Consultant - Aquatic Ecology / Fisheries Expert

Private Practice, Owner – Shawn Paul Young LLC Environmental Consulting

- *Savannah Harbor, GA:* Impacts of dredging on Shortnose sturgeon, Atlantic sturgeon, and other native fish
- *Savannah River, GA:* Flow regulation effects on fish in the Savannah River.
- *Wateree River, SC*: River flows and fish habitat - Wateree Dam FERC Re-licensing.
- *Pee Dee River, NC*: River flows and fish habitat - Tillery Dam FERC Re-licensing.
- *Watts Bar Nuclear, TN*: Nuclear reactor impacts to fish and mussel populations - Tennessee River – Chickamauga Reservoir.

- *Bellefonte Nuclear, AL*: Nuclear reactor impacts to fish and mussel populations -Tennessee River – Guntersville Reservoir.
- *Vogtle Nuclear, GA*: Nuclear reactor impacts to fish and mussel populations – Savannah River.
- *North Anna Nuclear, VA*: Nuclear reactor impacts to fish populations – Pamunkey River - North Anna Reservoir
- *Watts Bar NPDES, TN*: Permit comments concerning pollution discharged from operation of nuclear reactors.
- *Tennessee Water Quality Standards*: Comments to strengthen water quality standards and protections during triennial review.

Fish Biologist

Kootenai Tribe of Idaho; Bonners Ferry, ID (July 2011 – Present)

I assist the Kootenai Tribe in all aspects of its Native Fish Program including the aquaculture and restoration of the federally endangered Kootenai River White Sturgeon population. I am one of the technical leads on the design of a new hatchery facility and on the development of a restoration and monitoring strategy for burbot and kokanee. I also represent the Kootenai Tribe on interagency matters including the Kootenai River White Sturgeon Recovery Team and the Kootenai River / Libby Dam Flow Technical Committee. I will also be involved in a large-scale physical habitat restoration effort to restore ecosystem function to a highly altered segment of the Kootenai River in order to rebuild native fish populations.

Fisheries Researcher

Georgia Department of Natural Resources; Albany, GA and Department of Forestry and Natural Resources; Clemson University, Clemson, SC (Feb 2010 – November 2011)

I led a field investigation of spawning Alabama shad in the Apalachicola River, FL. My primary objectives were to estimate spawning population size, to evaluate fish passage at Jim Woodruff Lock and Dam, to determine use of Flint and Chattahoochee Rivers as spawning habitat and juvenile rearing habitat by Alabama shad that passed through the navigation lock, and to determine age, growth, and population structure. I also led the investigation of otolith microchemistry to determine ontogenetic shifts in habitat/anadromy and natal origin, and to determine the role of environmental factors play in recruitment success. My study's ultimate objectives were to halt decline of the Alabama shad and ensure a continued self-sustaining population, with hopes to restore historical abundance.

Researcher – Fisheries Biology and Ecophysiology

University of Idaho; Dept of Fish and Wildlife Resources, Moscow, ID (Dec 2008 – September 2009)

As a member of a a research team, I investigated the physiology of wild and hatchery-raised adult Snake River steelhead kelts through life stages from pre-spawn to outmigration to the Pacific Ocean, and the potential to restore wild Snake River steelhead by captive reconditioning of kelts and transport around the Snake/Columbia River hydrosystem.

Lecturer – Fisheries Management

University of Idaho; Department of Fish and Wildlife Resources, Moscow, ID (Fall 2008)

FISH 418 – Fisheries Management w/ Lab

Visiting Scientist

University of Iceland; Reykjavik, Iceland (July 2008)

I was invited by a colleague to investigate physiological differences between genetically distinct components of the Icelandic Atlantic Cod stocks.

Visiting Assistant Professor - Fisheries and Aquatic Sciences

Purdue University; Department of Forestry and Natural Resources; West Lafayette, IN (Aug 2007 – May 2008)

FNR 546 - Fish Ecology
FNR 545 - Fisheries Management
FNR 501 – Limnology
FNR 371 – Watershed Hydrology Practicum
FNR 103 - Introduction to Environmental Conservation

Post-Doctoral Researcher - Adjunct Professor

Dept. of Forestry and Natural Resources: Clemson University, Clemson, SC (Oct 2006 – August 2007)

My research focused on fish ecology and behavior in altered rivers. I conducted research on anadromous and resident fish species in the Apalachicola River. Research objectives were to estimate Alabama shad spawning population size, monitor behavior/movement during spawning migration, and determine passage efficiency at lock-and-dam facilities. I also studied the age, growth, and reproductive ecology of three catostomids and skipjack herring. As another aspect of studying altered river systems, I conducted studies of freshwater mussels to evaluate tagging methods, movement after relocation, and behavior in fluctuating flow regimes. *(please refer to Publications)*.

Committees:

Age, growth, and fecundity of Alabama shad in the Apalachicola River. Thesis. T. Ingram. 2006.
Population estimate of spawning Alabama shad in the Apalachicola River. Thesis. P. Ely. 2007.
Genotype-specific spawning behavior of striped bass in the Apalachicola River. Thesis. M. Noad. 2007.
Paleochannel delineation of the Neuse River, North Carolina. Thesis. B. Wrege. 2007.

WFB 840 Fish Ecology (Team-taught course)
ENR 302 Natural Resource Measurements (Team-taught course)
WFB 300 Wildlife and Fisheries Biology (Team-taught course)

Research Biologist / Fish – Aquatic Organism Research Facility Manager

Aquatic Animal Research Laboratory; Clemson University, Clemson, SC (June 1999 – May 2006)

I conducted research and managed facilities at a leading fisheries/aquaculture research laboratory. Our research specialized in identifying factors that affect fish and aquatic invertebrate physiology, behavior, and population dynamics. I conducted research on habitat requirements of marine, estuarine, anadromous, and freshwater species at the larval, juvenile, and adult life-history stages. *(Please refer to Publications and Presentations)*. I also assisted with the research and preparation of the following:

- Using mixed-ion supplementation in Pacific white shrimp culture. 2007. Thesis. K. Parmenter.
- Multi-scale habitat associations of selected primary burrowing crayfish. 2006. Dissertation. S. M. Welch.
- Low-salinity resistance of juvenile cobia (Rachycentron canadum). 2006. Thesis. K. L. Burkey.
- Responses of Pacific white shrimp (Litopenaeus vannamei) to water containing low concentrations of total dissolved solids. 2005. Thesis. A. D. Sowers.
- Responses of hybrid striped bass exposed to waterborne and dietary copper in fresh- and saltwater. 2003. Dissertation. G. K. Bielmyer.
- Ecology and culture of Procambarus acutus acutus. 2003. Dissertation. Y. Mazlum.
- Effects of environmental and dietary factors on tolerance of Nile tilapia Oreochromis niloticus to low temperature. 2002. Dissertation. H. L. Atwood.
- Low-temperature tolerance of southern flounder Paralichththys lethostigma: effect of salinity. 2000. Thesis. W. E. Taylor.

Through the South Carolina Cooperative Fish and Wildlife Research Unit, I also completed a dissertation and thesis that utilized several telemetry field studies to identify seasonal migration patterns, daily movement patterns, and seasonal habitat selection in relation to reservoir limnology/ hydroelectric generation; sources and magnitude of mortality; temporal and spatial patterns of mortality; and, potential to successfully live-release striped bass angled during fishing tournaments. *(Please refer to Publications and Presentations)*. Through graduate coursework, I also acquired extensive knowledge of fisheries science and management; physiology, ecology and conservation of aquatic organisms; limnology and hydrology; and experimental statistics. *(Please see transcripts).*

Through collaboration with the SC Cooperative Fish and Wildlife Research Unit, I also assisted with the following:

- Reproductive ecology and seasonal migrations of robust redhorse (Moxostoma robustum) in the Savannah River, Georgia and South Carolina. 2006. Dissertation. T. B. Grabowski.
- A behavioral comparison of hatchery-reared and wild shortnose sturgeon in the Savannah River, South Carolina-Georgia. 2003. Thesis. D. Trested.

- Diel movement of hatchery-reared and wild shortnose sturgeon in the Savannah River, South Carolina-Georgia. 2003. Thesis. T. E. Griggs.
- Movement of migrating American shad in response to flow near a low head lock and dam. 2003. Thesis. S. T. Finney.
- Population size and movement of American shad at New Savannah Bluff Lock and Dam. 2002. Thesis. M. M. Bailey.
- Seasonal and diel movement of largemouth bass in a South Carolina stream. 2001. Thesis. T. A. Jones.
- Habitat utilization by striped bass in Lake Murray, South Carolina. 2001. Thesis. J. J. Schaffler.

Fisheries Technician

Idaho Dept of Fish & Game; Lewiston & Bonners Ferry, ID (April 1997 - May 1999)

My first appointment was in the Lewiston office where I conducted snorkeling surveys to determine abundance and distribution of anadromous and potadromous salmonids in the Clearwater River Basin.

My second position was in the Bonners Ferry Kootenai River Field station where I assisted research on the effects of hydroelectric operations on behavior and survival of salmonids (rainbow trout and bull trout), burbot, and white sturgeon in the Kootenai River, ID-MT. Major responsibility was to conduct fieldwork for large-scale telemetry and capture studies to acquire knowledge of seasonal movements, migratory behavior, and recruitment.

PUBLICATIONS:

Fish Ecology and Management:

1. **Young, S.P.**, T. I. Ingram, and J. Tannehill. (*in review*). Passage of spawning Alabama shad at Jim Woodruff Lock and Dam, Apalachicola River, Florida. Submittal: Transactions of the American Fisheries Society.

2. **Young, S.P.**, T. I. Ingram, and J. Tannehill. (*in review*). Survival and behavior of transported shoal bass *Micropterus cataractae* in the Flint River, Georgia. Submitted: North American Journal of Fisheries Management.

3. Ingram, T. I., **S. P. Young,** and J. Tannehill. (*in revision*). Age, growth, and fecundity of spawning Alabama shad at Jim Woodruff Lock and Dam, Apalachicola River, Florida. Submittal: Transactions of the American Fisheries Society.

4. **Young**, **S. P.**, P. Ely, T. Grabowski, and J. J. Isely. (*in review*). Effects of river flow on age, growth, fecundity, and reproductive strategy of catostomids in the Apalachicola River, Florida. Submittal: Environmental Biology of Fishes.

5. **Young**, **S. P.**, P. Ely, M. Noad, and J. J. Isely. (*in revision*). Age, growth, and relative abundance of skipjack herring in the Apalachicola River, Florida.

6. **Young, S.P.** 2011 Annual Report – Population size, passage, and spawning behavior of Alabama shad, *Alosa alabamae*, in the Apalachicola River Basin, Florida-Georgia. Prepared for Georgia Department of Natural Resources and National Marine Fisheries Service.

7. **Young, S.P.** 2010 Annual Report – Population size, passage, and spawning behavior of Alabama shad, *Alosa alabamae*, in the Apalachicola River Basin, Florida-Georgia. Prepared for Georgia Department of Natural Resources and National Marine Fisheries Service.

8. **Young, S.P.**, P. Ely, T. Grabowski, and J. J. Isely. 2010. First Record of *Carpiodes velifer* (highfin carpsucker) in the Apalachicola River, Florida. Southeastern Naturalist 9(1):165-170.

9. Grabowski, T. B., **Young**, **S. P.,** Libungan, L. A., Steinarsson, A., and G. Marteinsdottir. (2009). Evidence of

phenotypic plasticity and local adaption in metabolic rates between components of the Icelandic cod (*Gadus morhua* L.) stock. Environmental Biology of Fishes 86:361-370.

10. Barczak, S., and **S. P. Young**. 2009. Water use impacts from increased energy production on Georgia's aquatic resources. 2009 Georgia Water Resources Conference.
11. Ely, P. and **Young, S. P.**, and J. J. Isely. 2008. Population size and relative abundance of Alabama shad reaching Jim Woodruff Lock and Dam, Apalachicola River, Florida. North American Journal of Fisheries Management 28:827-831.
12. **Young, S. P**. and J.J. Isely. 2007. Summer diel behavior of striped bass using tailwater habitat as summer refuge. Transactions of the American Fisheries Society 136: 1104-1112.
13. **Young**, **S. P.**, and J.J. Isely. 2006. Post-tournament live-release survival, dispersal, and behavior of adult striped bass. North American Journal of Fisheries Management 26: 1030-1033.
14. **Young**, **S. P.**, and J.J. Isely. 2004. Temporal and spatial estimates of adult striped bass mortality from telemetry and transmitter return data. North American Journal of Fisheries Management 24: 1112-1119.
15. **Young, S. P.** and J.J. Isely. 2002. Striped bass annual site fidelity and habitat utilization in J. Strom Thurmond Reservoir, South Carolina-Georgia. Transactions of the American Fisheries Society. 131: 828-837.
16. Isely, J. J., **S. P. Young**, T. A. Jones, and J. J. Schaffler. 2002. Effects of antenna placement and antibiotic treatment on loss of simulated transmitters and mortality in hybrid striped bass. North American Journal of Fisheries Management. 22: 204-207.

Fish physiology and aquaculture:

17. Burkey, K. B., **S. P. Young**, J. R. Tomasso, and T. I. J. Smith. 2007. Low-salinity resistance of juvenile cobia. North American Journal of Aquaculture 69: 271-274.
18. **Young, S. P.**, J.R. Tomasso, and T.I.J. Smith. 2007. Survival and water balance of black sea bass held in a range of salinities and calcium-enhanced environments after abrupt salinity change. Aquaculture 258: 646-649.
19. Atwood, H.L.; **S.P. Young**, J.R. Tomasso, and T.I.J. Smith. 2004. Resistance of cobia, *Ranchycentron canadum*, juveniles to low salinity, low temperature, and high environmental nitrite concentrations. Journal of Applied Aquaculture 15: 191-195.
20. Atwood, H.L.; **S.P. Young**, J.R. Tomasso, and T.I.J. Smith. 2004. Information on selected water quality characteristics for the production of black sea bass, *Centropristis striata*, juveniles. Journal of Applied Aquaculture 15: 183-190.
21. Atwood, H.L.; **S.P. Young**, J.R. Tomasso, and T.I.J. Smith. 2003. Effect of temperature and salinity on survival, growth, and condition of juvenile black sea bass. Journal of the World Aquaculture Society 34: 398-402.
22. Atwood, H. L.; **S. P. Young**, J. R. Tomasso, and T.I.J. Smith. 2001. Salinity and temperature tolerances of black sea bass juveniles. North American Journal of Aquaculture 63: 285-288.

Aquatic invertebrate conservation:

23. **Young, S. P**. and J. J. Isely. (2008). Tag retention, relocation probability, and mortality of passive integrated transponder and dummy transmitter tagged *Elliptio complanata* in a South Carolina Piedmont stream. Molluscan Research.
24. **Young, S. P**. and J. J. Isely. (*in revision*). Behavioral response of the freshwater mussel *Elliptio complanata* to fluctuating water levels. Submittal: Journal of North American Benthological Society.
25. **Young, S. P**. and J. J. Isely. (*in progress*). Behavior of translocated freshwater mussels *Elliptio complanata* in a South Carolina piedmont stream.

Aquatic invertebrate physiology and aquaculture:

26. Parmenter, K. and Bisesi, J., **S. P. Young**, S. J. Klaine, H. L. Atwood, J. R. Tomasso, and C. L. Browdy. 2009. Culture of pacific white shrimp *Litopenaeus vannamei* in a variety of mixed- ion solution. North American Journal of Aquaculture 71:134-137.

27. Sowers, A. D. and **Young, S. P.,** M. Grosell, C. L. Browdy , and J. R. Tomasso. 2006. Hemolymph osmolality and cation concentrations in *Litopenaeus vannamei* during exposure to low concentrations of dissolved solids: Relationship to potassium flux. Comparative Biochemistry and Physiology 145(2): 176-180.

28. Sowers, A. D.**,** D. M. Gatlin, **S. P. Young**, J. J. Isely, C. L. Browdy, and J. R. Tomasso. 2005. Responses of *Litopenaeus vannamei* (Boone) in water containing low concentrations of total dissolved solids. Aquaculture Research 36: 819-823.

29. Sowers, A. D. and **Young, S. P.,** J. J. Isely, C. L. Browdy , and J. R. Tomasso. 2004. Nitrite toxicity to *Litopenaeus vannamei* in water containing low concentrations of sea salt or mixed salts. Journal of the World Aquaculture Society 35: 445-451.

30. Atwood, H.L.; **S.P. Young**, J.R. Tomasso, and C. L. Browdy. 2003. Survival and growth of pacific white shrimp, *Litopenaeus vannamei*, postlarvae in low salinity and mixed-salt environments. Journal of the World Aquaculture Society 24: 518-523.

SELECTED PRESENTATIONS:

Young, S.P. 2008. Ecophysiology of Iceland's Atlantic cod stocks. University of Idaho. Moscow, ID.

Young, S.P. 2007. Thermal biology of fish. Penn State University. State College, PA.

Young, S.P. 2007. Population estimates and passage of Alabama shad at Jim Woodruff Lock and Dam, Apalachicola River - Florida. Purdue University. West Lafayette, IN.

Young, S.P. 2006. Behavioral thermoregulation and metabolic scope of striped bass in various aquatic environments. Austin Peay University. Clarksville, TN.

Young, S.P. 2006. Behavioral thermoregulation and metabolic scope – Lecture for comparative anatomy and physiology. Clemson University. Clemson, SC.

Young, S.P. and J.J. Isely. 2005. Post-tournament live-release survival, dispersal, and behavior of adult striped bass. American Fisheries Society annual meeting. Anchorage, AK.

Young, S.P. 2005. Behavioral thermoregulation in fish. Lake Superior State University. Sault-sainte Marie, MI.

Young, S.P. and J.J. Isely. 2005. Striped bass ecology and management. Clarks Hill Striped Bass Anglers Association. Augusta, GA.

Young, S.P. and J.J. Isely. 2005. Post-tournament live-release survival, dispersal, and behavior of adult striped bass. Trout Unlimited. Upstate South Carolina Chapter.

Young, S.P. and J.J. Isely. 2004. Temporal and spatial estimates of adult striped bass mortality from telemetry and transmitter return data. Annual meeting of the American Fisheries Society. Madison, WI.

Atwood, H.L.; **S.P. Young**, J.R. Tomasso, and T.I.J. Smith. 2004. Effect of temperature and salinity on survival, growth, and condition of juvenile black sea bass. 28th Annual Larval Fish Conference, Early Life History Section, American Fisheries Society. Clemson, SC.

Atwood, H.L.; **S.P. Young**, J.R. Tomasso, and T.I.J. Smith. 2004. Resistance of cobia juveniles to low salinity and low temperature. 28th Annual Larval Fish Conference, Early Life History Section, American Fisheries Society. Clemson, SC.

Young, S.P. 2004. Learning in Fishes: from three-second memory to culture. Department of Biological Sciences. Clemson University.

Young, S.P. 2003. Life skills training for hatchery fish: Social Learning and Survival. Department of Biological Sciences. Clemson University.

Young, S.P. 2003. Mechanisms for learning during early life stages of fish: Imprinting, Homing, and Con-specific Learning. Dept of Biological Sciences. Clemson University.

Young, S.P. 2002. Strain-specific characteristics to manage sub-populations of fish species. Department of Biological Sciences. Clemson University.

AWARDS:

- Animal Research Committee Excellence Award. 2004. Clemson University.
- Animal Research Committee Excellence Award. 2003. Clemson University.
- Outstanding Classified Employee Award. 2003. Clemson University.
- Employee Performance Award. 2003. Clemson University.