Chapter 5 Environmental Impacts of Station Operation

Chapter 5 presents the potential environmental impacts of operation of the new Vogtle Electric Generating Plant (VEGP) Units 3 and 4. In accordance with 10 CFR 51, impacts are analyzed and a single significance level of potential impact to each resource (i.e., small, moderate, or large) is assigned consistent with the criteria that the Nuclear Regulatory Commission (NRC) established in 10 CFR 51, Appendix B, Table B-1, Footnote 3 as follows:

SMALL — Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource. For the purposes of assessing radiological impacts, the Commission has concluded that those impacts that do not exceed permissible levels in the Commission's regulations are considered small.

MODERATE — Environmental effects are sufficient to alter noticeably, but not to destabilize, any important attribute of the resource.

LARGE — Environmental effects are clearly noticeable and are sufficient to destabilize any important attributes of the resource.

Mitigation of adverse impacts, if appropriate, is presented. This chapter is divided into 12 sections:

- Land Use Impacts (Section 5.1)
- Water Related Impacts (Section 5.2)
- Cooling System Impacts (Section 5.3)
- Radiological Impacts of Normal Operations (Section 5.4)
- Environmental Impacts of Waste (Section 5.5)
- Transmission System Impacts (Section 5.6)
- Uranium Fuel Cycle Impacts (Section 5.7)
- Socioeconomics Impacts (Section 5.8)
- Decommissioning Impacts (Section 5.9)
- Measures and Controls to Limit Adverse Impacts During Operations (Section 5.10)
- Transportation of Radioactive Materials Impacts (Section 5.11)
- Non-radiological Health Impacts (Section 5.12)

The following definitions should help the reader understand the scope of the discussion:

- VEGP site — the 3,169 acres existing site as described in the Unit 1 and Unit 2 licenses
- New plant (VEGP Units 3 and 4) foot-print — the approximately 500 acres within the existing VEGP site that will encompass the construction and operation of the new nuclear units

- Vicinity — the area within approximately the 6- to 10-mile (depending on the issue) radius around the VEGP site
- Region — the area within approximately the 50-mile radius around the VEGP site

5.1 Land Use Impacts

The following sections describe the impacts of Units 3 and 4 operations on land use at the VEGP site, the 6-mile vicinity, and associated transmission line corridors, including impacts to historic and cultural resources. Operation of VEGP Units 3 and 4 is not anticipated to affect any current or planned land uses.

5.1.1 The Site and Vicinity

5.1.1.1 The Site

Land use impacts from construction are described in Section 4.1.1. The only additional impacts to land use from operations will be the impacts of solids deposition from cooling tower drift. Cooling tower design is discussed in Section 3.4.2 and impacts of the heat dissipation system, including deposition, are discussed in Section 5.3.3.1 and 5.3.3.2. Impacts will be restricted to an area of approximately 3,300 feet around the towers, most in a north-northeast direction. The towers will be approximately 2,600 feet from the nearest site boundary to the west and approximately 6,000 feet to the north-northeast site boundary, so any effects will be localized on VEGP property. As discussed in Section 5.3.3.1.3, the predicted solids deposition is below the concentrations which could damage sensitive vegetation. Southern Nuclear Company (SNC) concludes that impacts to land use from Units 3 and 4 operations will be SMALL and will not warrant mitigation.

5.1.1.2 The Vicinity

As described in Section 2.5, the impact evaluation assumes that the residences of the new units' employees will be distributed across the region in the same proportion as those of the current employees. SNC estimates the new two unit-work force will be 662 additional on-site employees (Section 3.10.3). Section 5.8.2 describes the impact of 662 new employees on the region's housing market and the increases in tax revenues. Understanding tax revenues is important because some land-use changes can be driven by increased property taxes.

Approximately 20 percent (132) of the new employees are expected to settle in Burke County. Relatively few employees live in Burke County in the vicinity of VEGP; the area is rural, with few utilities or amenities. Much of the land is part of the Yuchi Wildlife Management Area (WMA) or owned by Georgia Power Company (GPC), and unavailable for development. It is likely that the new employees who choose to settle in Burke County will purchase homes or acreage in the Waynesboro area, 15 miles from VEGP. Based on the 20 years of experience of the existing units, increased tax revenues will not spur development in the vicinity of VEGP.

Land within the vicinity on the South Carolina side of the Savannah River is in Barnwell County and is owned by the Federal government and unavailable for development. No VEGP tax revenues will go to Barnwell County, South Carolina.

SNC concludes that impacts to land use in the vicinity will be SMALL and not warrant mitigation.

5.1.2 Transmission Corridors and Offsite Areas

Land use impacts to transmission corridors from operation of new units will be identical to impacts from existing units: GPC acquires transmission line rights-of-way (either by outright purchase of the land or easement) that give it access and control over how the land in the transmission corridor is managed. GPC ensures that land use in the corridors and underneath the high-voltage lines is compatible with the reliable transmission of electricity. Vegetation communities in these corridors are kept at an early succession stage by mowing and application of herbicides and growth-regulating chemicals. In some instances, GPC allows farmers to grow feed (hay, wheat, corn) for livestock or graze livestock in these rights-of-way. GPC also allows hunt clubs and individuals to plant wildlife foods for quail, dove, wild turkey, and white-tailed deer. GPC's control and management of these rights-of-way precludes virtually all residential and industrial uses of the transmission corridors, however. GPC has established corridor vegetation management and line maintenance procedures that will be used to maintain the new corridor and transmission line. SNC concludes that impacts to land use in transmission corridors or offsite areas will be SMALL and not require mitigation.

VEGP Units 3 and 4 will generate low-level radioactive wastes that will require disposal in permitted radioactive waste disposal facilities (Table 3.5-3) and non-radioactive wastes that will require disposal in permitted land fills (Table 3.6-3). Both types of waste are commonly generated and permitted facilities are located throughout the country. One of the goals of the Burke County comprehensive plan is to identify and acquire a site for a landfill. Units 3 and 4 will generate spent fuel, which will be stored on site until such time as DOE constructs and NRC licenses a high-level waste disposal facility. SNC concludes that impacts to offsite land use due to disposal of wastes generated at VEGP Units 3 and 4 would be SMALL and would not warrant mitigation.

5.1.3 Historic Properties and Cultural Resources

Table 2.5.3-3 lists properties in Burke County on the National Register of Historic Places. One property is within 10 miles of the VEGP site. The Savannah River Site (SRS) has been identified as being eligible for the National Register because of its contributions to the Cold War **(NSA 2006)**. As described in Section 2.5.3, the cultural resource survey identified 10 sites on VEGP, two of which are recommended for inclusion on the National Register and two for possible inclusion. Impacts to historic or cultural resources during operations will be less than the impacts of construction described in Section 4.1.3. All earth-disturbing activities at VEGP are conducted under procedures which prescribe actions to be taken if significant archaeological or paleontological artifacts are encountered.

GPC has a procedure that has identified 196 cultural properties on existing Vogtle transmission lines as noted in Section 2.2.2. The procedure also provides specifications for protecting them. The specifications address periodic reclearing, tree removal and trimming, inspections, normal maintenance, vehicle access, artifact collection, and protecting the Francis Plantation complex. The precise routes of new transmission corridors have not been determined, however, Table 2.5.3-3 lists National Register sites in the counties the line will cross. The procedure will be updated to include any cultural properties identified on the new corridor. SNC has determined that Units 3 and 4 operations will have a SMALL impact on historic or cultural resources and will not require mitigation beyond that discussed above.

Section 5.1 References

(NSA 2006) New South Associates, Intensive Archaeological Survey of the Proposed Expansion Areas at the Vogtle Electric Generating Plant, Burke County, Georgia, August.

5.2 Water Related Impacts

5.2.1 Hydrology Alterations and Plant Water Supply

VEGP Units 3 and 4 closed-cycle cooling systems will require makeup water to replace that lost to evaporation, drift (entrained in water vapor), and blowdown (water released to purge solids). As discussed in Chapter 3, makeup water for the natural draft cooling towers will be pumped from the Savannah River. The expected rate of withdrawal of Savannah River water to replace water losses from the circulating water system will be 18,612 and 37,224 gallons per minute (gpm) for one and two-unit operations, respectively (see Table 3.0-1). The maximum rate of withdrawal will be 28,892 and 57,784 gpm for one and two-unit operation, respectively.

Water withdrawn for cooling tower makeup is: (1) returned to the river with blowdown, (2) lost as evaporation, or (3) lost as drift. Water released to the river as blowdown is not lost to downstream users or downstream aquatic communities. Evaporative losses and drift losses are not replaced and are considered "consumptive" losses. Drift losses are very small compared to evaporative losses and were not considered in the analysis.

The assessment that follows is therefore focused on water use in the strictest sense, meaning water that it lost via evaporation rather than water that is withdrawn from, and later returned to, the Savannah River.

5.2.2 Water Use Impacts

5.2.2.1 Surface Water

Long-term (1985-2005) daily river flow records from the middle reaches of the Savannah River were used to estimate the monthly and annual average and low flows of the Savannah River at VEGP.

Current evaporative consumptive loss for the existing units is 30,000 gpm (Table 2.9-1). Based on the planned cooling system configuration, cooling tower evaporation rates are estimated to be 13,950-14,440 for one unit and 27,900-28,880 gpm for two units (see Table 3.0-1). The long-term monthly average Savannah River flows at the VEGP site varies from 3,157,000 to 6,381,000 gpm (Table 5.2-1).

Less than one percent (0.45 to 0.91 percent) of the monthly average Savannah River flow moving past VEGP will be lost to evaporation from the new units' cooling towers. Less than two percent (1.34 to 1.55 percent) of the monthly 7Q10 flows will be lost. When the amount of water lost to evaporation is compared to river flow, consumptive use is expected to be highest in summer and fall and lowest in the winter and spring (Table 5.2-1).

Consumptive losses of this magnitude will, under normal circumstances (typical flows), be barely discernible. During low-flow periods, operation of the proposed new units at VEGP will have a SMALL impact on the availability of water downstream of the plant, because no more than 1.55

percent of the river's flow will be consumed (Table 5.2-1). The cumulative impacts of four operating units are discussed in Section 10.5.

To evaluate the impact of consumptive water use on river level (river surface elevation), SNC calculated the effect of cooling tower evaporation on river stage and determined that predicted two-unit evaporative losses will lower the river level by 0.6 inch and 0.8 inch for average annual flow and annual 7Q10 flow, respectively. A water level reduction of this magnitude will not affect recreational boating in summer, when river use is at its highest, even during extreme low flow conditions. Consumptive water use will have a SMALL impact on river level and will not warrant mitigation.

5.2.2.2 Groundwater

As discussed in Section 2.3.2, SNC likely will use one groundwater well per unit to supply makeup water for each unit's Nuclear Island service water system, fire protection, demineralization system, and potable water system. Existing wells at VEGP are permitted to withdraw 6 million gallons per day monthly average (MGD) (4,167 gpm) and average 5.5 MGD annually (3,819 gpm).

As discussed in Section 2.3.2.2.2, three of VEGP's nine groundwater wells are capable of producing large volumes of water that can be used as a makeup water supply. Wells MU-1 and MU-2A are the site's primary production wells with Well TW-1 used as a backup well. Each of these wells is screened in the confined Cretaceous aquifer and two are also screened in the Tertiary. The wells have design yields of 2,000 gpm, 1,000 gpm, and 1,000 gpm, respectively. Any one of these wells is capable of providing enough water for current makeup water operations. The recharge area for these wells is located north of the site along a 10- to 30-mile wide zone across Georgia and South Carolina. The remaining six wells (Table 2.3.2-11) are located in the confined tertiary aquifer and are capable of providing water for specific site operations. As discussed, SNC plans to close MU-2A because it is in the new plant footprint and replace it with a new well of similar capacity.

In order to determine potential offsite impact during the operations phase of the new units, cumulative projected water usage was used to calculate drawdown at the site boundary as though all water uses pumped from a single onsite well. SNC has not determined the locations of the Units 3 and 4 wells, as a result this environmental report used the existing units' MU-2A well for the drawdown analysis due to its close proximity to the VEGP property boundary (5,700 feet) and because it is one of the site's primary production wells. Data used to input to an analytical distance-drawdown model was taken from VEGP's updated Final Safety Analysis Report (SNC 2005). A Transmissivity value of 158,000 gpd/ft was used. The Storativity value used (3.1×10^{-4}) in these calculations is an average of the values listed in Table 2.4.12-8 of the FSAR, calculated for the deeper production wells. Total VEGP groundwater use reported to EPD from 2001 through 2004 averaged 730 gpm. **(SNC 2000a,b, 2001a,b, 2002a,b,c, 2003a,b,**

2004a,b) This value was used as groundwater use value for the existing facility. SNC prepared a calculation package supporting this analysis.

Projected groundwater production requirements for the new units will average 752 gpm under normal operating conditions with a maximum use of 3,140 gpm during off-normal operations (Table 3.0-1). Off-normal operations for the existing units could use a maximum of 2,300 gpm groundwater.

Total groundwater use for all four units will be approximately 1,482 gpm under normal operating conditions. Modeling results have the two existing units reducing the potentiometric surface in the Cretaceous aquifer, measured at the VEGP property line, by approximately 5.9 feet by 2025. Two additional units (assuming they become operational in 2015/2016) will increase this drawdown to 12 feet by 2025, using the conservative assumptions in the model. By 2045, the potentiometric surface reduction will increase to 12.6 feet. For comparison, the two existing units would reduce the potentiometric surface to 6.1 feet by 2045.

Because pumping does not drawdown a confined aquifer, the availability of water for offsite users in the Cretaceous aquifer will not change. Local wells (Section 2.3.2.2.1) are generally within the overlying surficial or confined Tertiary aquifers and are much shallower than the VEGP wells. Local wells generally provide water for domestic use and agricultural use, and are typically wells of lower yield. Impacts to local water users will be SMALL and the existing permit withdrawal limits will not be exceeded under normal conditions. In the unlikely event several units look to operate under off-normal conditions permitted groundwater withdrawals could be exceeded. The cumulative impacts of four units on groundwater resources are discussed in Section 10.5. Impacts to groundwater will be SMALL during normal operations. Although off-normal conditions could result in exceeding existing permit limits for a short period of time, impacts to the Cretaceous aquifer will be SMALL.

5.2.3 Water Quality Impacts

5.2.3.1 Chemical Impacts

Cooling-tower based heat dissipation systems, such as the ones proposed for the new units at VEGP, remove waste heat by allowing water to evaporate to the atmosphere. The water lost to evaporation must be replaced continuously with makeup water to prevent the accumulation of solids and solid scale formation. To prevent build up of these solids, a small portion of the circulating water stream with elevated levels of solids is drained or blown down.

Because cooling towers concentrate solids (minerals and salts) and organics that enter the system in makeup water, cooling tower water chemistry must typically be maintained with anti-scaling compounds and corrosion inhibitors. Similarly, because conditions in cooling towers are conducive to the growth of fouling bacteria and algae, some sort of biocide must be added to the system. This is normally a chlorine or bromine-based compound. Table 3.6-1 list water treatment chemicals used for VEGP Units 1 and 2, which likely will be used in Units 3 and 4, as well.

SNC does not anticipate the need for treatment of raw water to prevent biofouling in the intake structure and makeup water piping. Water treatment will take place in the cooling tower basins, and will include the addition of biocides, anti-scaling compounds, and dispersants. Sodium hypochlorite and sodium bromide are used to control biological growth in the existing circulating water system and will likely be used in the new system as well. VEGP's National Pollutant Discharge Elimination System (NPDES) permit (Permit No. GA0026786), issued in May 2004, limits concentrations of Free Available Chlorine (when chlorine is used) and Free Available Oxidants (when bromine or a combination of bromine and chlorine is used) in cooling tower blowdown when the dechlorination system is not in use. Lower limits apply to discharge from the dechlorination system (which is released into the Savannah River via the Final Plant Discharge) when it is in use. The current VEGP NPDES permit contains discharge limits (for discharges from the cooling towers) for two priority pollutants, chromium and zinc, which at one time were widely used in the U.S. as corrosion inhibitors in cooling towers. The use of zinc was discontinued at VEGP Units 1 and 2 in 2005. Chromium has never been used at VEGP.

Operation of the new cooling towers will be based on four cycles of concentration, meaning that solids and chemical constituents in makeup water will be concentrated four times before being discharged and replaced with fresh water from the Savannah River. As a result, levels of solids and organics in cooling tower blowdown will be approximately four times higher than ambient concentrations. The projected blowdown flow of 28,880 gpm (Table 3.0-1) is 0.45 to 0.91 percent of the average flow and 1.34 to 1.55 percent of the average 7Q10 flow calculated for the VEGP site (Table 5.2-1). This equates to a dilution factor of from 60 to 120, depending on the time of year. Because the blowdown stream will be small relative to the flow of the Savannah River, concentrations of solids and chemicals used in cooling tower water treatment will return to ambient levels very soon after exiting the discharge pipe.

Even though cooling tower blowdown entering the Savannah River from VEGP cooling towers will be small and the chemicals it contains relatively innocuous, the discharge will have to be (NPDES) permitted by Georgia DNR and comply with applicable state water quality standards (Chapter 391-3-6 of the Rules and Regulations of the State of Georgia, "Rules and Regulations for Water Quality Control"). The segment of the Savannah River associated with Savannah Harbor is included on the Georgia Clean Water Act Section 303(d) List because of low dissolved oxygen (DO). Although the segment of the Savannah River adjacent to Vogtle is not on the 303(d) List, EPD will have to consider the effects of the discharge from all Vogtle units on the Savannah Harbor DO in developing the VEGP NPDES Permit. However, no effect is expected from the Units 3 and 4 discharge plume on the DO in the Savannah River Harbor. The level of treatment chemical residual in the VEGP plume is extremely low, since oxidant residuals have been neutralized and other chemicals are used in very low concentrations. Therefore, impacts of chemicals in the permitted blowdown discharge on the Savannah River water quality will be SMALL and will not warrant mitigation.

5.2.3.2 Thermal Impacts

As noted in the previous section, discharges from proposed new units will be permitted under the state of Georgia's NPDES program, which regulates the discharge of pollutants into waters of the state. In this context, waste heat is regarded as thermal pollution and is regulated in much the same way as chemical pollutants. SNC used CORMIX **(Jirka, Doneker and Hinton 1996)** Version 4.3 model to simulate the temperature distribution in the Savannah River resulting from discharge of Vogtle blowdown water. CORMIX is a U.S. Environmental Protection Agency (EPA) supported mixing zone model which emphasizes the role of boundary interactions to predict steady state mixing behavior and plume geometry. It is widely used and recognized as a state of the art tool for discharge mixing zone analyses **(CORMIX 2006a)**. The model has been validated in numerous applications and is endorsed by EPA **(CORMIX 2006b)**. SNC prepared a calculation package supporting this analysis.

Onsite hourly meteorological data for five years (1998-2002) were used as input to the simulation. River temperature data collected over the January 1985 – August 1996 period at a Savannah River monitoring station (Shell Bluff Landing) near VEGP were used to establish a correlation between water temperature and time of year (date). Long term daily river flow records in the Savannah River were obtained from U.S. Geological Survey (USGS) gaging stations upstream (Augusta) and downstream (Millhaven) of the VEGP location. Data were also obtained from the recently installed Waynesboro gaging station (at VEGP) for the period 1/22/05 through 9/30/05. The relationship among the flows at the three locations was used to synthesize a 20-year record of monthly low and average flows at VEGP. A (**USGS 2006**) river stage-discharge (river surface elevation versus river flow) rating curve table was used to define gage height for a given river flow. Cooling tower operating design curves were supplied by the tower manufacturer.

As discussed earlier in this section, the normal intake/discharge operating mode will be four cycles of concentration. When the river water contains high levels of dissolved and suspended solids, the plant may operate at two cycles of concentration in order to maintain circulating water concentrations within design bounds. Discharge (blowdown) flow rates were simulated for each hour of the data period for both two- and four-cycle operation.

Tables 5.2-2 through 5.2-5 give the range of blowdown parameters for each month of the year, based on hourly simulations over a 5-year period. The right-hand columns show the range for the entire 5-year period.

Based on the 5-year hourly simulation, the maximum blowdown temperature is expected to be 91.5°F, in July (Table 5.2-2); the blowdown temperature is expected to exceed 90°F for less than 7 hours per year. The maximum ΔT (blowdown temperature minus river temperature) is 30.9°F, and is expected to occur in winter (Table 5.2-3); ΔT of 20°F is exceeded 5 percent of the hours during the 5-year period. The maximum ΔT corresponds with the maximum heat discharge (discharge flow * ΔT). The minimum ΔT is -14.0°F, occurring in October. Negative ΔTs are seen 8 percent of the time; ΔTs less than -6.5°F are seen 0.5 percent of the time. Blowdown flow for four and two cycles of concentrations are presented in Tables 5.2-4 and 5.2-5. Table 5.2-6 summarizes discharge conditions over the five-year period for both two- and four-cycles of concentration.

5.2.3.3 Georgia Mixing Zone Regulations

The State of Georgia designates five classes of water use: Drinking Water Supply; Recreation; Fishing; Coastal Fishing; Wild River; and Scenic River. The Savannah River at VEGP is classified as water used for "Fishing." Georgia water quality regulations require that temperatures of such waters cannot exceed 90°F nor can they be increased by more than 5°F above intake (ambient) temperature. Specific sizes of mixing zones are not specified however, "[U]se of a reasonable and limited mixing zone may be permitted on receipt of satisfactory evidence that such a zone is necessary and that it will not create an objectionable or damaging pollution condition." **(DNR 2004)**

5.2.3.4 Discharge Design

Determination of the proposed 2-unit AP1000 blowdown discharge design described in Section 3.4.2.2 was based on the mixing zone necessary under worst case conditions: max-ΔT, 2 cycles of concentration (maximum discharge flow), and 7Q10 (minimum) river flow. A single submerged port with a vertical angle of 5° down from horizontal and 3' off the bottom was the conceptual discharge design used in the model. This configuration is similar to the placement and orientation of the existing VEGP discharge. If the mixing zone resulting from such a design was unreasonably large, a more complex multi-port diffuser would then have been considered.

The mixing zone size, shape and orientation are insensitive to the choice of vertical orientation of the port (i.e., angle in the vertical plane from horizontal) and height of the discharge above the river bottom. This is because discharge plume quickly attaches to the river bottom as a result of low pressure effects due to effluent jet entrainment requirements and the proximity of the river bottom to the discharge.

Changes in the port horizontal orientation (i.e., angle in the horizontal plane from downstream) changed the orientation of the mixing zone but only small changes were seen in the zone's extent as long as the port was not pointed downstream. As this angle increased from 0 (downstream) to 90 degrees (cross-stream), the mixing zone changed from a downstream to cross-stream orientation. The existing VEGP discharge is oriented 70 degrees counterclockwise from downstream (facing away from the near shoreline). That discharge is successfully operating; the horizontal orientation of the proposed discharge was chosen to mimic that of the existing discharge.

The size of the mixing zone decreases with decreasing port diameter. This is a result of the greater entrainment of blowdown into the river resulting from an increase in discharge velocity (the discharge velocity increases as the diameter decreases for the same flow). A design choice of port diameter is a compromise between mixing zone size (favored by smaller diameter) on one hand and pumping costs (possibly required to move the necessary flow through the discharge port at higher velocity) and river bed scour (caused by high jet velocity along the bed) on the other.

CORMIX results indicate that the mixing zone for a port diameter of 2 feet has less than half the extent as does one for a port diameter of 3 feet. Smaller proportional reductions in mixing zone extent per unit port area are seen for diameters less than 2 feet. Discharge velocities, on the other hand, increase dramatically (being inversely proportional to the square of the diameter). For discharge port diameters of 3, 2, and 1 foot, the discharge velocities for the worst case conditions considered are 8, 17, and 70 feet per second (fps), respectively. A 2-foot diameter port was chosen as a compromise between mixing zone and velocity considerations. It is noted that the existing VEGP blowdown discharge is successfully operating with a single 2-foot diameter port.

5.2.3.5 Bathymetry

In support of this analysis, river bottom elevations were surveyed from one bank to the other from the existing discharge to well downstream of the proposed discharge location (Appendix B). Figure 5.2-1 shows the river cross-section at, and 25 meters downstream from, location of the proposed discharge. Note that the figure is drawn with a tenfold vertical scale exaggeration so that details are clearly delineated. As will be shown (see Proposed Discharge Mixing Zone), this river stretch encompasses the proposed mixing zone.

As depicted in Figure 5.2-1, the river has a maximum depth of approximately 11.5 feet in the immediate area of the proposed discharge under low river flow (7Q10) conditions. However, that depth decreases by a foot within about 20 feet in the cross-stream direction and decreases by about 2.5 feet within 25 meters downstream of the proposed discharge location. Therefore, the river depth at the blowdown discharge (an input parameter required by the CORMIX model) was chosen as 9 feet (for 7Q10 river flow). The choice of this parameter is not important for design conditions because of the discharge's attachment to the river bottom (see Discharge Design, above). However, it is a conservative choice for less severe conditions, such as 4-cycles of concentration with average river flow. Note that, for average river flow, the river surface is 4.5 feet higher than for 7Q10 river flow.

CORMIX requires that the river cross-section be represented by a rectangle of dimensions [width x depth]. Cross-sections for low and average river flow were chosen such that the river cross-sectional areas were equal to those depicted in Figure 5.2-1. The low river flow cross-section was chosen as 290 feet x 9 feet and the average river flow cross-section as 303 feet x 13.5 feet.

The river velocity (river flow rate/ cross-sectional area) is approximately 1.5 and 2.3 fps for low and average river flow, respectively.

5.2.3.6 Existing Discharge

The mixing zone temperature excess of 5°F is based on the intake river temperature, which is upstream from both the existing and proposed discharges. The temperature analysis for the proposed new units' blowdown discharge must therefore include a component representing the effect of the existing VEGP blowdown discharge. The existing cooling tower design curves and 5-year meteorology were used to simulate the hourly blowdown temperatures from existing operations in the same manner as was described for the proposed towers. The existing blowdown temperature was that one calculated for the hour concurrent with that of each of the proposed blowdown discharge cases (see Table 5.2-6). The existing blowdown discharge flow rate was taken as 10,000 gpm (Table 2.9-1).

The river cross-section at the existing discharge was represented by a cross-section of 310 feet x 8 feet for low flow and 327 feet x 12.5 feet for average flow, with an additional 2 feet below the discharge. As described previously, the existing single-port discharge has the same diameter and orientation as that chosen for the proposed discharge.

CORMIX was used to calculate the temperature excess (above ambient) in the river resulting from the existing discharge at the proposed discharge location, 404 feet downstream. Table 5.2-7 gives the maximum (centerline of cross-section) temperature excess at that location for each of the discharge cases analyzed.

The existing discharge centerline temperature excess for the average case exceeds that for the max-T case. This reflects the temperature distribution of the former being narrower than that of the latter. If an average temperature excess over the width of the proposed plume were taken, the existing discharge component for the max-T case will exceed that of the average case. The use of centerline temperatures is conservative.

5.2.3.7 Proposed Discharge Mixing Zone

As described previously (see Georgia Mixing Zone Regulations) the mixing zone is defined in terms of the 5°F temperature excess (increase above intake temperature or ambient) and 90°F river temperature. The centerline temperature increase from the existing discharge was added in each case to the ambient river temperature prior to simulating the proposed discharge effects. The mixing zone temperature excess for the proposed discharge was then re-defined by decreasing the maximum allowable 5°F difference by the river temperature increase due to the existing discharge component from Table 5.2-7; the proposed discharge 90°F isotherm (only applicable for the max-T case) was defined based on the proposed discharge blowdown temperature and the ambient river temperature incremented as described.

Linear, areal, and volume characteristics of the mixing zone for the proposed discharge after the described adjustments are given in Table 5.2-8.

The 2 cycle, max-ΔT case results in the largest mixing zone; this case corresponds to the maximum heat discharge to the river. Even for this case, the mixing zone is demonstrably small. Allowing for approximately 20 feet between the river bank and the discharge port and adding the maximum cross-stream extent of 37 feet, less than 20 percent of the river width is impacted by the mixing zone and discharge structure. Approximately 11 percent of the bank to bank cross-sectional area of the river is impacted by the mixing zone and discharge structure (20 ft x 9 ft for the structure + 114.7 2 ft for the heated water). The volume of water affected by the mixing zone, 782 ft^3, is less than 1 percent of the volume (290 ft x 9 ft x 32.5 ft) in the river stretch from the discharge to the plumes furthest downstream extent.

Figures 5.2-2 and 5.2-3 show the max-ΔT mixing zone in the river for 2 and 4-cycle operation, respectively. Note that the vertical axis is exaggerated in order to depict greater plume detail. Although the four-cycle mixing zone is smaller than the two-cycle mixing zone, affecting less area and volume of water, it extends further downstream. Higher flows during two-cycle operation result in more advective (horizontal) heat transfer, and higher discharge velocities during two-cycle operation result in more mechanical (turbulent) heat transfer. As a result, the mixing zone predicted under normal four-cycle operation has a smaller area and volume but greater centerline temperatures.

The change in the 4-cycle max-ΔT mixing zone appearance approximately 40 to 50 feet along the plume trajectory reflects a flow change. In this region the plume is transitioning from a bottom attached jet to a more quiescent plume that is lifting off the river bottom. The plume is nearly parallel to the river flow at this point.

5.2.3.8 Bottom Scour

The cooling water system will typically be operating at 4 cycles of concentration. The discharge velocity for such operation is in the range of 3.1 to 6.7 fps (minimum and maximum blowdown flow from Table 5.2-4 divided by the discharge port area). The average river velocity is 2.3 fps. Because of these relatively low discharge velocities (<2 to <3 times average velocity) and rapid plume dilution, only minor scouring of the river bottom is expected.

During periods of 2 cycle operation, discharge velocities will range from 9.4 to 20.1 fps (see Table 5.2-5 for blowdown flow range) and somewhat more scouring could be expected. In any case, such scouring will be localized, as exhibited in Figure 5.2-4 which depicts the stream cross-section at the existing discharge and 25 meters downstream from it. One can infer from that figure that scouring occurs right at the discharge; evidence of scouring is apparent neither 25 meters downstream nor about 10 meters across-stream from the discharge.

5.2.4 Future Water Use

The water resources of the Savannah River are managed primarily by the Savannah District of the U.S. Army Corps of Engineers (USACE), which operates three large water management and control projects (Hartwell Dam and Lake, Richard B. Russell Dam and Lake, J. Strom Thurmond Dam and Lake) on the main stem of the river upstream of Augusta, a smaller lock and dam structure (New Savannah Bluff Lock and Dam) just downstream of Augusta, and maintains the Savannah Harbor navigation channel. Each of the three upstream dams is equipped with hydroelectric generating facilities, and the way water is stored at these dams and released to generate electricity influences Savannah River flows and the availability of water downstream of the J. Strom Thurmond Dam, including in the vicinity of VEGP.

More than 100 municipalities, industrial facilities, power plants, and agricultural operations withdraw water from the Savannah River. The majority of these water users are on the Georgia side of the river, downstream of Augusta **(USACE undated)**. The Savannah River supplies drinking water to two Georgia urban centers, Augusta and Savannah, and two booming coastal resort communities in South Carolina, Beaufort and Hilton Head. As salt water intrudes into coastal area aquifers, the fresh water of the Savannah River is expected to become an even more important source of drinking water.

Recognizing that numerous municipal and industrial users in two states were potentially at odds over the shared resource and planning for increased demands was essential, Congress authorized a comprehensive study of the Savannah River as one of the elements of the Water Resources Development Act of 1996 (PL 104-303). Section 414 of the Act directed the Secretary of the Army (Corps of Engineers) to conduct a comprehensive study to “address the current and future needs for flood damage prevention and reduction, water supply, and other related needs in the Savannah River Basin.”

The reconnaissance phase of the comprehensive study was ultimately funded in Fiscal Year 1998. During the reconnaissance phase, the Corps of Engineers worked closely with stakeholders in the basin to revalidate the major resources issues in the basin and outline and scope technical investigations. The *Savannah River Basin Comprehensive Reconnaissance Study (Study),* issued in July 1999, identified water reallocation issues in the Savannah River Basin and evaluated the extent of state interest in sharing the costs of the necessary feasibility studies **(USACE 1999)**. It also defined the issues and seven areas of concern, which it listed as water supply allocation, flood control, hydropower, water quality and flow, fish and wildlife, aquatic plant control, and recreation.

With regard to water supply, the *Study* noted that rapid population growth and industrial growth in the region had sharply increased demand for Savannah River water. The *Study* noted that there was no coordinated management of the Savannah River’s water supplies; regulatory agencies in Georgia and South Carolina operated independently and did not always coordinate assessments of Savannah River water use and availability. It called for studies to "properly assess" current water demand and allocation.

As regards water quality and flow, the *Study* reported that water quality in the Savannah River Basin was generally improving, the result of restrictions on pesticide use, improved sediment and erosion control, and better management of municipal and industrial wastewater. The *Study* identified two flow-related issues that required study, flows in the lower river in the area of Savannah and releases at the Thurmond Dam (Thurmond Power Plant). Adequate freshwater flows are necessary in the lower river to prevent salt water from moving upstream and degrading fish and wildlife habitat, particularly in the Savannah National Wildlife Refuge. Adequate releases at the Thurmond Dam are necessary to allow for assimilation of NPDES-permitted wastewaters entering the river in the Augusta area.

Since completion of the reconnaissance phase, Georgia and South Carolina have signed on as co-sponsors of the Comprehensive Study and taken on some of the financial burden. Study participants and stakeholders have met on a regular basis to identify issues of concern and discuss the use and storage of water in the basin. The needs identified by upper and lower basin users/stakeholders are different. Upper basin stakeholders are primarily concerned with adequate water storage in the pools of the various impoundments for activities such as recreation, lake shore development, and hydroelectric power. Lower basin stakeholders are more concerned with improving and optimizing flows in the unimpounded lower reaches of the river.

Table 5.2-1 Comparison of Savannah River Flows and VEGP Cooling Water Flows

	Average Flow[1,2]	7Q10 Flow	Maximum Withdrawal for CT Makeup (2 units)	Maximum CT Evaporation Rate (2 units)	Percent of Average Flow Lost to Evaporation	Percent of 7Q10 Flow Lost to Evaporation	Blowdown Flow	Blowdown as Percent of Average Flow	Blowdown as Percent of 7Q10 Flow
Jan	4,425,015	2,045,318	57,784	28,880	0.65	1.41	28,880	0.65	1.41
Feb	5,450,143	2,142,714	57,784	28,880	0.53	1.35	28,880	0.53	1.35
Mar	6,381,016	2,161,116	57,784	28,880	0.45	1.34	28,880	0.46	1.34
Apr	4,933,988	2,055,193	57,784	28,880	0.59	1.41	28,880	0.59	1.41
May	3,886,868	1,932,213	57,784	28,880	0.74	1.49	28,880	0.74	1.49
June	3,503,567	1,879,700	57,784	28,880	0.82	1.54	28,880	0.82	1.54
July	3,531,394	1,907,079	57,784	28,880	0.82	1.51	28,880	0.82	1.51
Aug	3,653,925	1,916,504	57,784	28,880	0.79	1.51	28,880	0.79	1.51
Sept	3,294,412	1,969,017	57,784	28,880	0.88	1.47	28,880	0.88	1.47
Oct	3,490,551	1,858,605	57,784	28,880	0.83	1.55	28,880	0.83	1.55
Nov	3,157,070	1,891,818	57,784	28,880	0.91	1.53	28,880	0.91	1.53
Dec	3,999,524	1,956,001	57,784	28,880	0.72	1.48	28,880	0.72	1.48

[1] all flows in gallons per minute
[2] based on data from 1985-2005

Table 5.2-2 Monthly and Five-Year Blowdown Temperatures (°F)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Five Year
Min	42.4	44.0	46.1	52.8	60.7	67.9	69.5	65.5	62.2	53.9	49.6	42.6	42.4
Average	62.6	64.4	66.8	72.4	76.9	81.4	83.1	82.3	78.2	73.3	68.1	62.5	72.6
Max	81.5	80.3	83.0	85.4	88.3	90.4	91.5	91.1	88.4	86.3	81.3	81.0	91.5

Table 5.2-3 Monthly and Five-Year ΔT (Blowdown Temperature Excess Above Ambient River, °F)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Five Year
Min	-9.1	-8.5	-6.5	-8.9	-7.2	-5.1	-8.4	-10.9	-9.8	-14.0	-9.7	-10.8	-14.0
Average	11.6	13.1	11.8	11.1	8.7	7.2	5.7	5.2	4.9	6.2	8.1	8.4	8.5
Max	30.9	29.1	28.0	25.0	20.8	17.5	13.6	14.1	15.6	19.1	23.1	26.2	30.9

Table 5.2-4 Blowdown Flow for Four Cycles of Concentration Operation (gpm per unit)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Five Year
Min	2208	2315	2448	2783	3168	3504	3657	3332	3198	2833	2684	2228	2208
Average	3302	3436	3566	3796	3994	4053	4098	4098	3982	3764	3592	3343	3751
Max	4160	4268	4346	4486	4570	4681	4601	4713	4614	4410	4264	4201	4713

Table 5.2-5 Blowdown Flow for Two Cycles of Concentration Operation (gpm per unit)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Five Year
Min	6624	6945	7344	8348	9503	10513	10971	9995	9594	8498	8053	6685	6624
Average	9905	10308	10697	11389	11981	12158	12293	12293	11945	11291	10776	10029	11252
Max	12480	12804	13038	13458	13711	14043	13802	14138	13842	13230	12791	12602	14138

Table 5.2-6 Discharge Parameters For Blowdown Modeling

Case	Discharge Temperature (°F)	Discharge ΔT (°F)	Discharge Flow (4 Cycles of Concentration, gpm per unit)	Discharge Flow (2 Cycles of Concentration, gpm per unit)
Max-T	91.5	13.6	4576	13728
Max-ΔT	81.5	30.9	4094	12281
Min-ΔT	54.4	-14.0	2869	8605
Average	72.6	8.5	3751	11252

Table 5.2-7 Temperature Excess (Above Ambient) at the Proposed Discharge Location as a Result of the Existing Vogtle Discharge

Discharge Case	River Temperature Increase 404 feet Downstream from Existing Discharge (°F)
Max-T	0.30
Max-ΔT	0.81
Min-ΔT	-0.32
Average	0.36

Table 5.2-8 Proposed Discharge Mixing Zone Statistics

Case	Furthest downstream extent, ft from discharge	Furthest cross-stream extent, ft from discharge	Surface area (horizontal projection), ft^2	Cross-sectional area (vertical projection perpendicular to flow), ft^2	Volume, ft^3
5°F Temperature Increase Above Intake Temperature, 2 Cycles of Concentration					
Max-T	11.2	20.9	57.0	25.4	61.8
Max-ΔT	32.5	37.3	295.9	114.7	781.6
Min-ΔT	11.1	17.1	50.3	21.5	55.7
Average	5.4	10.0	13.4	6.0	7.4
5°F Temperature Increase Above Intake Temperature, 4 Cycles of Concentration					
Max-T	9.7	11.1	33.1	13.0	33.6
Max-ΔT	57.2	21.8	197.4	47.9	375.0
Min-ΔT	9.9	8.1	26.6	9.1	25.7
Average	2.1	2.2	2.2	1.7	0.8
90°F River Temperature					
Max-T (2 Cycles of Concentration)	2.6	6.3	2.0	0.9	0.2
Max-T (4 Cycles of Concentration)	2.2	4.3	1.3	0.6	0.2

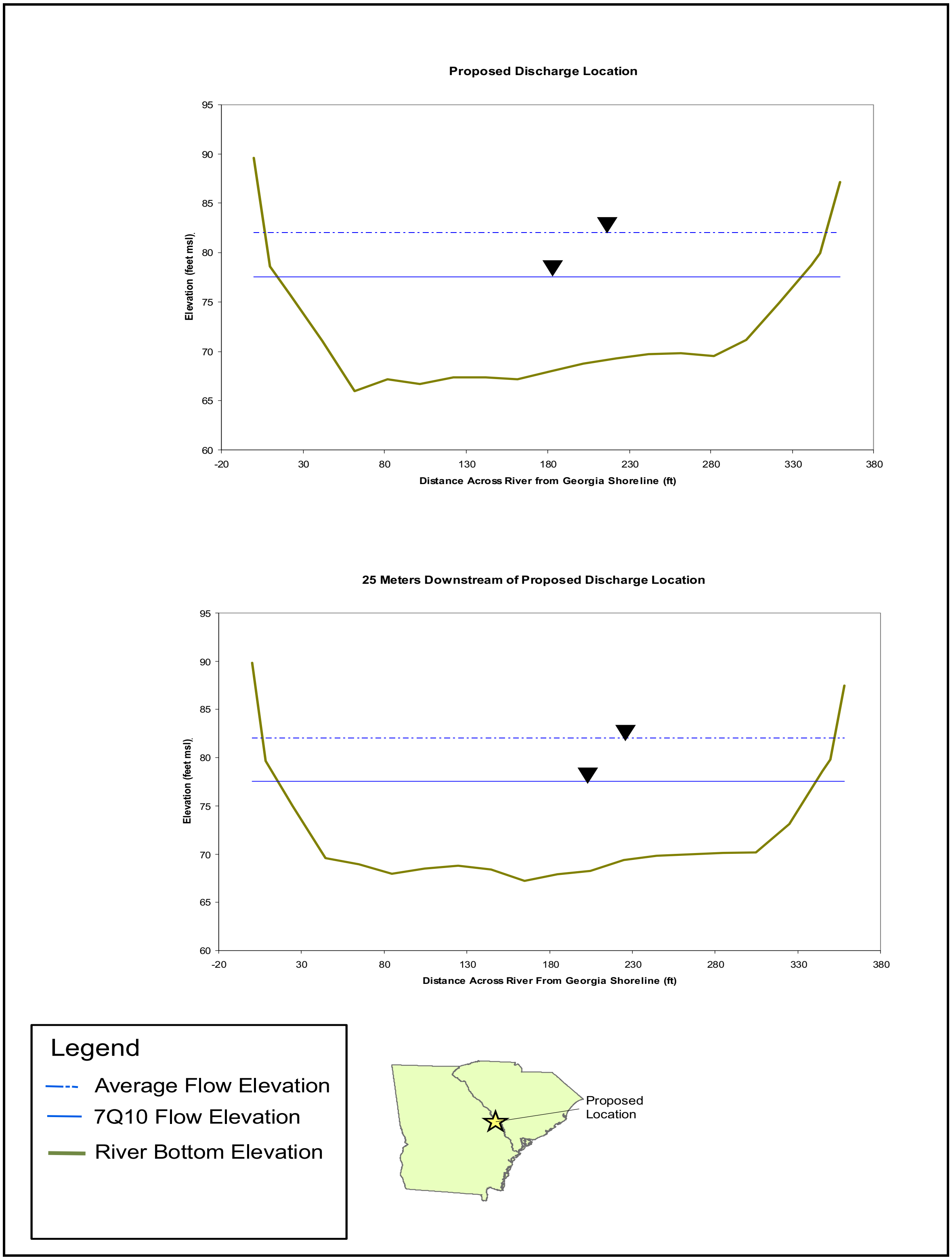

Figure 5.2-1 River Cross Sections at Proposed Discharge Location

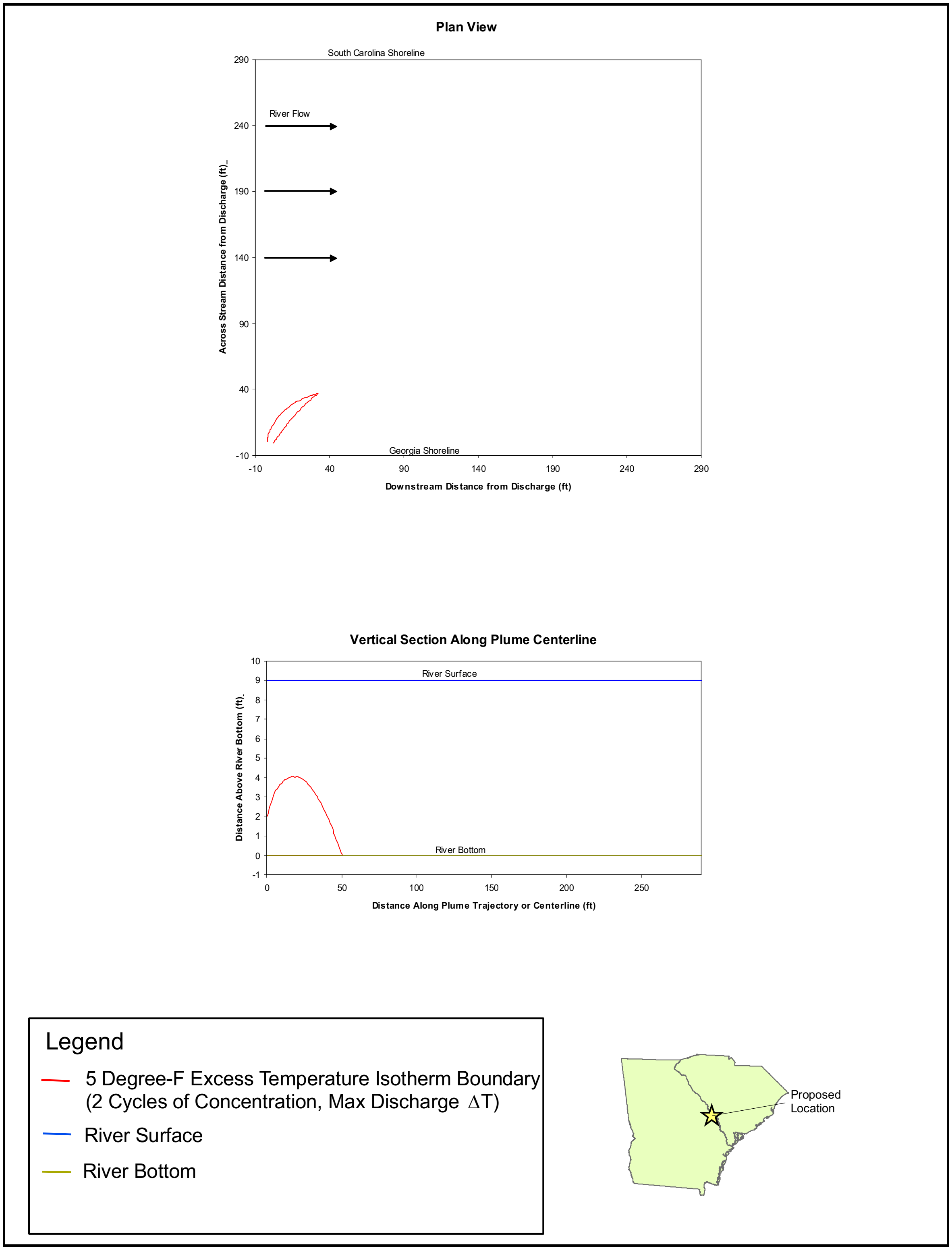

Figure 5.2-2 Mixing Zone for 2 Cycles of Concentration and Maximum Discharge ΔT

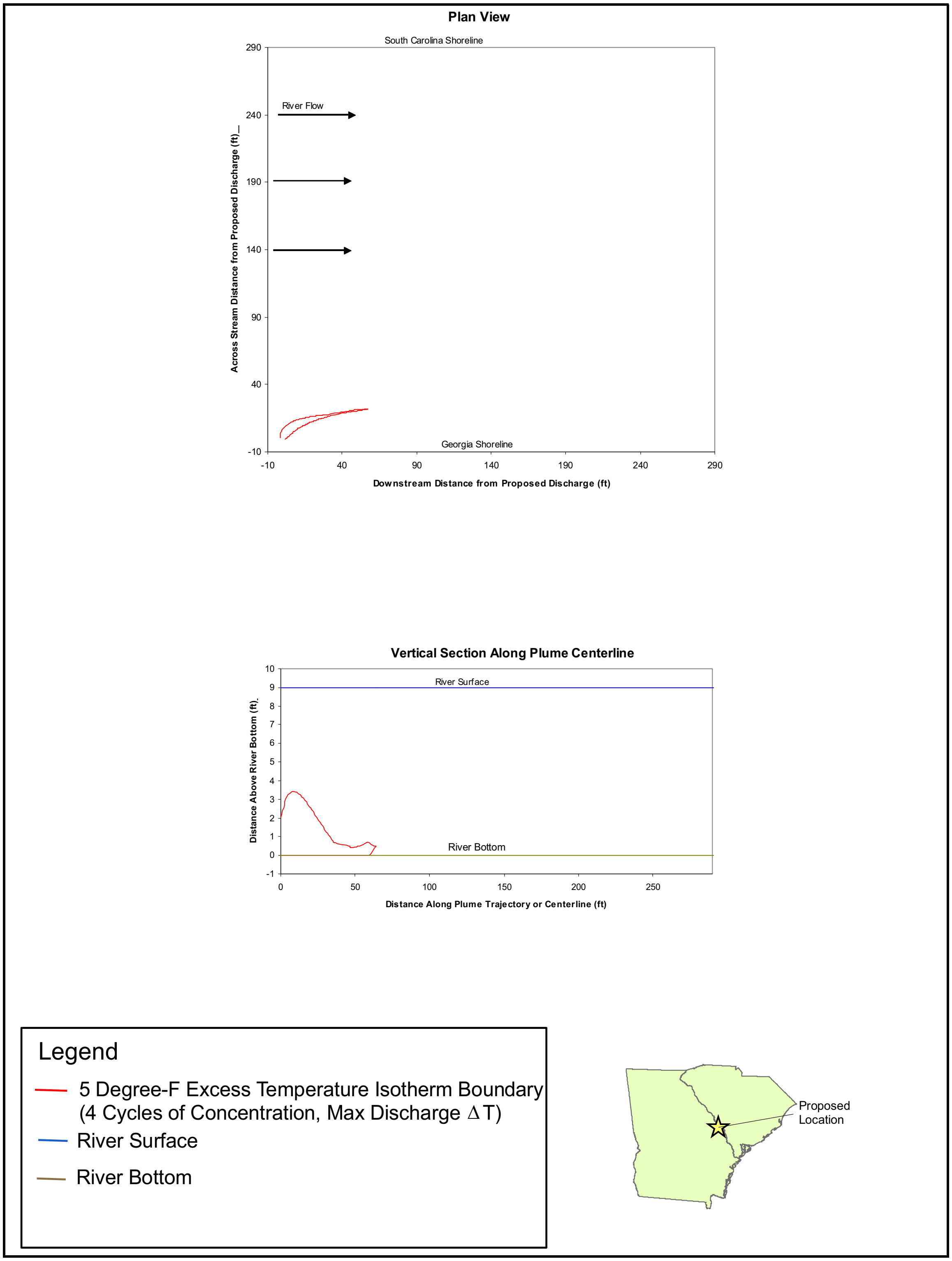

Figure 5.2-3 Mixing Zone for 4 Cycles of Concentration and Maximum Discharge ΔT

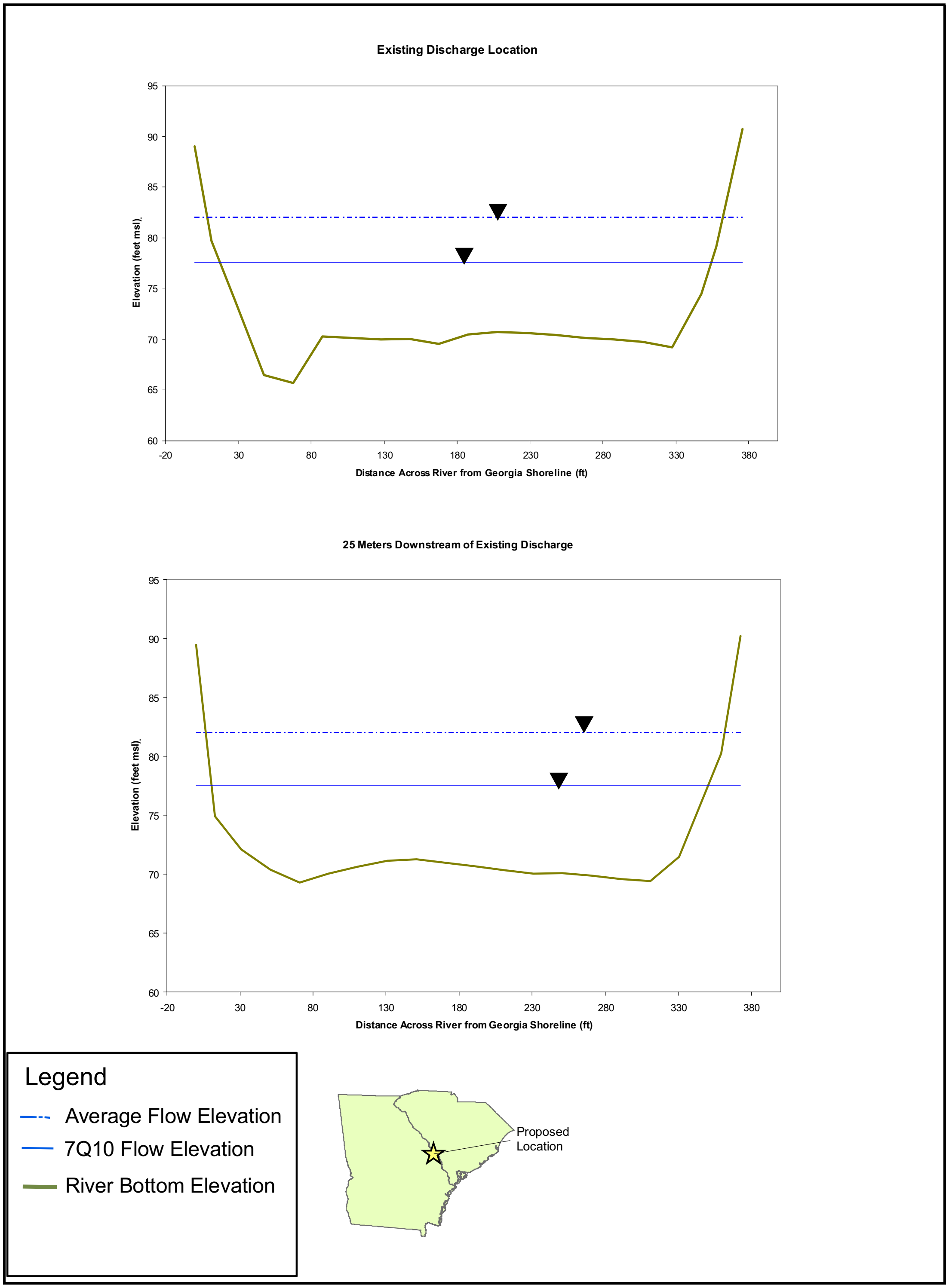

Figure 5.2-4 River Cross Sections at Existing Discharge Location

Section 5.2 References

(CORMIX 2006a) CORMIX Mixing Zone Applications, found on the internet at: http://www.cormix.info/applications.php.

(CORMIX 2006b) Independent CORMIX Validation Studies, found on the internet at: http://www.cormix.info/validations.php.

(DNR 2004) Georgia Department of Natural Resources, Rules and Regulations for Water Quality Control, Chapter 391-3-6, Environmental Protection Division, Atlanta, Georgia, revised November 2004, found on the internet at: http://www.state.ga.us/dnr/environ//rules_files/exist_files/391-3-6.pdf.

(Jirka, Doneker and Hinton 1996) User's Manual For Cormix: A Hydrodynamic Mixing Zone Model and Decision Support System for Pollutant Discharges into Surface Waters, Office of Science and Technology, U.S. EPA, Washington, D.C., September 1996.

(SNC 2000a) Southern Nuclear Company, Groundwater Use Report — September 1999 to February 2000.

(SNC 2000b) Southern Nuclear Company, Groundwater Use Report — March 2000 to August 2000.

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(SNC 2002b) Southern Nuclear Company, Groundwater Use Report — March 2002 to August 2002.

(SNC 2002c) Southern Nuclear Company, Groundwater Use Report — July 2002 to December 2002.

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(SNC 2004b) Southern Nuclear Company, Groundwater Use Report — July 2004 to December 2004.

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(USACE undated) U.S. Army Corps of Engineers, Savannah River Basin Fact Sheet - Water Users, found at http://www.sas.usace.army.mil/drought/sheet9.pdf.

(USACE 1999) U.S. Army Corps of Engineers, Savannah River Basin Comprehensive Reconnaissance Study, found at http://www.sas.usace.army.mil/srb/reconrpt.htm.

(USGS 2006) U.S. Geological Survey, National Water Information System, NWIS Rating for Savannah River near Waynesboro, Ga., found on the internet at: http://nwis.waterdata.usgs.gov/nwisweb/data/exsa_rat/021973269.rdb.

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5.3 Cooling System Impacts

5.3.1 Intake System

Section 3.4.2.1 describes the proposed intake system and the following sections describe its impact on physical and biological systems in the Savannah River.

5.3.1.1 Hydrodynamic Descriptions and Physical Impacts

Nuclear power plants that use closed-cycle, re-circulating cooling systems (cooling towers) withdraw significantly less water for condenser cooling than open-cycle or once-through units. Depending on the type of cooling tower installed and the quality of the makeup water, power plants with closed-cycle, re-circulating (versus "helper") cooling towers withdraw only 5 to 10 percent as much water as plants of the same size with once-through cooling systems.

As discussed in Chapter 3, makeup water will be withdrawn directly from the Savannah River. The new facility will withdraw 28,892 gpm if one unit and three makeup pumps are operating and 57,784 gpm if both units and all six makeup pumps are operating. Although specific design details have not been worked out, the basic design of the intake structure has been formulated (see Section 3.4, Figures 3.4-2 and 3.4-3). The Cooling Water Intake Structure (CWIS) will incorporate a number of design features that will reduce impingement and entrainment of aquatic organisms. These include (1) the basic orientation of the cooling water intake structure and canal, perpendicular to the river and its flow, (2) extremely low current velocities along the length of the intake canal, and correspondingly low approach velocities at the traveling screens to the makeup water pumps, and (3) a submerged weir across the intake canal. The CWIS proposed for the new units at VEGP will be in compliance with Section 316(b) of the Clean Water Act by virtue of its closed-cycle design, which incorporates these measures to mitigate impacts to aquatic biota. As a result, SNC has evaluated the impacts and technical analysis EPA developed in promulgating the Section 316(b) rules and has applied those assessments to the proposed Vogtle cooling system as discussed in the following sections.

5.3.1.2 Aquatic Ecosystems

The EPA's Final Regulations to Establish Requirements for Cooling Water Intake Structures at Phase II Existing Facilities (69 FR 131, July 9, 2004) note (page 41601) that "reducing the cooling water intake structure's [water withdrawal] capacity is one of the most effective means of reducing entrainment (and impingement)" and go on to say that facilities located in freshwater areas with closed-cycle, re-circulating cooling water systems can..."reduce water use by 96 to 98 percent from the amount they will use if they had once-through cooling." Regulations at 40 CFR 125.94(a)(1)(i) indicate that if a facility's flow is commensurate with a closed-cycle recirculating system, the facility has met the applicable performance standards. Power plants with closed-cycle, re-circulating cooling systems, such as the systems proposed for the new units at VEGP, meet the rule's performance standards because they are "deemed to satisfy any applicable impingement mortality and entrainment standard for all waterbodies." The design of the new cooling water intake system (CWIS) will be compliant with the EPA's regulation for Cooling Water Intake Structures (and, by extension, represents the "Best Available Technology" for reducing impacts to aquatic communities). Vogtle participated in the EPA survey to characterize cooling systems in the Steam Electric Generating Plant source category by providing details on the design and operation of the Vogtle cooling water intake structure. The design and operation of the Vogtle cooling water intake structure meets EPA's definition of closed cycle cooling.

The NRC evaluated entrainment at the existing intake structure in the FES for operation of the existing units at VEGP, assuming (1) the drift community was uniformly distributed; (2) two percent of the flow of the Savannah River will pass through the plant, and (3) 100 percent mortality of entrained organisms. The NRC's most conservative analysis assumed a maximum withdrawal rate 120 cfs (53,860 gpm) for cooling tower makeup and a "minimum guaranteed" river flow of 5,800 cfs (2,603,214 gpm). Actual withdrawal rates are significantly lower. The NRC staff concluded that the loss of two percent of the drift community in the VEGP cooling system will not have a significant impact on resident fishes and suggested that anadromous fishes also will be largely unaffected because no important spawning areas were found in the area of the plant. With respect to impingement, the NRC noted that a number of modifications had been made in the original design of the intake structure to protect adult and juvenile fish and concluded that there will be no significant effects on Savannah River fishes as a result of impingement. The NRC, in the FES for the existing units, noted that modifications had been made to the design of the intake structure that would result in minimal impacts to the biota of the Savannah River from entrainment and impingement **(NRC 1985)**. The new intake structure will incorporate similar design features, including a recessed intake, and a weir system consistent with currently available technology to minimize velocity and ensure a uniform flow in the intake canal.

Importantly, the analysis in the ER is even more conservative because SNC has assumed only a 7Q10 river flow of 3828 cfs. This low flow occurs during the Fall of the year. Variations in river flow would affect the relative impact because present aquatic species, including the drift community, would become, on balance, more diffused. Thus, by focusing on low flow instances, the analysis here bounds the impacts. Additionally, the lower 7Q10 flow occurs during a time of year outside of the spawning period for most species in the Savannah River. This ER relies on the same methodology utilized by the NRC in the 1985 FES but applies a more conservative flow regime, resulting in a more conservative assessment of the impacts.

Accordingly, the hydrological analysis in the previous section (Section 5.2.1) uses updated, site-specific flow data and more conservative values (7Q10 flows) than the 1985 NRC analysis, producing a slightly higher estimate (up to 3.1 percent) of river flow that will pass through the new units during low-discharge periods. During spring (March-April), when important anadromous species such as American shad, hickory shad, and blueback herring ascend the Savannah River to spawn, the monthly river flows are higher such that approximately 0.9 to 1.2 percent of the river's average flow and 2.7 to 2.8 percent of the river's 7Q10 flow will pass through the new units. In late spring and summer, when many Lepomids (bluegill, redbreast, redear sunfish) and Ictalurids (white catfish, channel catfish) popular with local fishermen, spawn approximately 1.5 to 1.7 percent of the river's average flow and 3.0 to 3.1 percent of the river's 7Q10 flow will pass through the new units. The proportion of Savannah River flow diverted for cooling tower makeup during peak spawning periods is therefore expected to range from 0.9 to 1.7 percent in most years, and will theoretically approach 3.1 percent approximately once per decade. A comprehensive discussion of all aquatic species likely to inhabit this reach of the Savannah River is included in Section 2.4 and the impacts above are generally representative of all of these species. Since most species spawn in the Spring to early Summer, the use of 7Q10 flows overstates the impacts to these species and provides additional conservatism to the evaluation.

Basing entrainment estimates on cooling water withdrawal rates (and assuming uniform distribution of eggs and larvae) almost certainly overstates the rate of entrainment because the reproductive habits of many species of fish make it less likely that their eggs and larvae will be entrained. Some species spawn in sloughs and backwater areas rather than in the main river channel, making their eggs and young less vulnerable to entrainment. Other species spawn in the main river channel but have eggs that are heavier than water, so they sink to the bottom where they are less likely to be entrained. Still other species have adhesive eggs that attach to logs, sticks, debris, and aquatic vegetation until they hatch. Species that broadcast eggs in the main channels of rivers and expend no energy on "parental care" have eggs and young more vulnerable to entrainment than species that build and guard nests in areas removed from the main channel of the river, such as bluegill, largemouth bass and other centrarchids. Consequently, the assumption of uniform drift is reasonably accurate for some species who provide no "parental care", and otherwise completely bounds the potential impact to the drift community of other species. In either event, the assumption is valid for purposes of characterizing the bounded level of potential impact.

While no impingement or entrainment sampling has been conducted specifically in the VEGP intake structure, several studies have been performed just upstream of VEGP at the SRS intake structures. In 1977, McFarlane et al. completed a detailed assessment of the fish communities and ichthyoplankton in the Savannah River, the impacts associated with impingement and entrainment at the SRS intake structures, and the thermal impacts associated with the discharge of cooling water from the SRS reactors. At the time, SRS operated three once-through cooling water intake systems with a combined capacity to pump over 750,000 gpm from the Savannah River with an estimated average though-screen velocity of 1.25 fps. Even at those high volumes and screen velocities, the average impingement rate for the combined SRS intake structures averaged 7.3 fish per day (predominantly shad). Entrainment was highly seasonal, occurring primarily from March until June with approximately 9.1 to 9.5% of the river's susceptible ichthyoplankton entrained at the three intake structures supporting SRS. **(McFarlane et al. 1978)**

In 1982, GPC published its pre-operational biological study of the VEGP site, including the Savannah River. GPC characterized numerous aquatic communities including resident and anadromous fish, larval fish and plankton **(Wiltz 1982)**. From 1983 to 1985, Paller, et al., performed numerous studies characterizing the fish and ichthyoplankton populations on the Savannah River at SRS. These works also focused on impingement and entrainment rates and impacts at the three SRS intake structures. In 1987, the Comprehensive Cooling Water Study described resident fish and ichthyoplankton populations in the Savannah River in the vicinity of the SRS (and VEGP). The study evaluated the impingement and entrainment rates and thermal impacts associated with the three intake and discharge systems at SRS. **(Du Pont 1987)**. It relied heavily on the data of Paller et al., from 12 stations on the Savannah River, including 3 at the VEGP site. Rates of impingement at the 3 SRS structures averaged 18 fish per day in 1984 and 7.7 fish per day in 1985. SRS entrainment rates were calculated at approximately 8.3% and 12.1% of the total susceptible ichthyoplankton entrained in 1984 and 1985, respectively **(Du Point 1987)**. The SRS intakes are long canals with significant in-canal and across-screen velocities operating at once-through flow rates of up to 750,000 gpm. The VEGP intake is an approximately 200 foot long canal with a weir system designed to protect adult and juvenile fish. A simple ratio of flow rates would predict a reduction in potential for impingement to less than one fish per day. All of these studies make it appropriate to rely on the conclusions reached by NRC in its FES. The only revisions to the assumptions makes the current analysis of the proposed units even more conservative.

Thus, based on the facts that (1) the proposed cooling-tower-based heat dissipation system will withdraw small amounts of Savannah River water (28,892 gpm), (2) the design of the new CWIS incorporates a number of features that, according to EPA's detailed technical evaluation, will reduce impingement and entrainment; and, (3) twenty years of operating experience indicating essentially no impingement of fish resulting from operation of the intake screens; and, over 50 years of aquatic community data collected from field studies in the immediate vicinity of the VEGP and SRS intakes suggest that Savannah River fish populations and the general aquatic community have not been adversely affected by operation of the existing VEGP units. SNC concludes that cooling water system intake impacts will be SMALL and will not warrant mitigation measures beyond the design features previously discussed.

5.3.2 Discharge Systems

This discussion is limited to the new units. Cumulative impacts of four units are discussed in Section 10.5.

5.3.2.1 Thermal Discharges and Other Physical Impacts

Cooling tower blowdown from the new facility will be discharged directly into the Savannah River by means of a new discharge structure that will be constructed approximately 400 feet down-river of the existing discharge. The new discharge structure will be approximately 2,500 feet downstream of the intake, meaning that recirculation of heated effluent to the intake will not be an issue.

Cooling tower blowdown temperatures were modeled by applying cooling tower manufacturer's information (tower design curves) to site meteorology. Simulations used five years of site-specific meteorological data and ten years of river temperature data that were synthesized from monitoring data collected up- and down-stream of VEGP (see Section 5.2.2.1). Based on the CORMIX simulations, the maximum blowdown temperature, 91.5°F, is expected in July. Blowdown temperatures are expected to exceed 90°F for less than seven hours each year. The maximum ΔT (blowdown temperature minus river temperature) of 30.9°F is expected to occur in January. As expected, simulated ΔT values were highest in winter months, when river temperatures are lowest and cooling tower efficiencies are at their highest.

In addition to simulating end-of-pipe blowdown temperatures, SNC conducted a thermal plume analysis, focusing on the portion of the discharge area with temperatures five or more degrees Fahrenheit higher than ambient temperatures. SNC selected a 5°F ΔT value to define the thermal plume because the Georgia water quality standard (Rules and Regulations of the State of Georgia, Chapter 391-3-6, Rules and Regulations for Water Quality Control) limits water temperature increases in "fishing waters" to 5°F. The modeling assumed worst-case conditions: maximum ΔT, maximum discharge flows, and minimum (7Q10) Savannah River flow.

Discharge effects were evaluated in terms of both maximum allowable temperature (the 90°F State of Georgia Water Quality Standard) and maximum allowable temperature increase (the 5°F State of Georgia Water Quality Standard). The CORMIX simulation indicated that the >90°F plume will occupy a surface area of 57.0 square feet (0.001 acre) and a cross-sectional area of 25.4 square feet when cooling towers are employing two cycles of concentration, and a surface area of 33.1 square feet and a cross-sectional area of 13.0 square feet when cooling towers are employing four cycles of concentration. The corresponding volume of heated water for the two cases will be 62 and 34 cubic feet, respectively. The CORMIX simulation indicated that the >5°F maximum ΔT plume will occupy a surface area of 295.9 square feet (0.006 acre) and a cross-sectional area of 114.7 square feet when cooling towers are employing two cycles of concentration and a surface area of 197.4 square feet (0.004 acre) and a cross-sectional area of 47.9 square feet when cooling towers are employing four cycles of concentration. The corresponding volume of heated water for the two cases will be 782 and 375 cubic feet, respectively. As discussed previously in Section 5.2.2, the two-cycle, maximum ΔT case corresponds to the maximum heat discharge to the river and produced the largest thermal plume.

As illustrated in Figures 5.2-2 and 5.2-3, the thermal plume is expected to extend only a short distance across the Savannah River, which is approximately 300 feet wide at the VEGP site. Under two cycles of concentration the maximum ΔT case, the thermal plume extends 37.3 feet across the river and 32.5 feet downstream of the discharge structure. Even for this case, the thermal plume is very small: less than 20 percent of the river's width is involved. Under the maximum temperature case, the thermal plume extends 20.9 feet across the river and 11.2 feet downstream.

When operating at four cycles of concentration, the discharge velocity will be in the range of 3.1 to 6.7 feet per second (fps). These velocities are slightly higher than the average river velocity of 2.3 fps. Because of these relatively low discharge velocities and rapid plume dilution, only minor scouring of the river bottom is expected. During infrequent periods of two-cycle operation, discharge velocities will range from 9.4 to 20.1 fps and somewhat more scouring could be expected.

As discussed in Section 5.2.3 (and illustrated in Figure 5.2-4), a bathymetric study conducted by SNC in 2006 revealed a shallow (3-to-5-foot-deep) trough immediately downstream of the existing discharge structure that is presumed to have been caused by scouring of the river bottom. There was no evidence of this depression 75 feet further downstream, however, indicating that the scouring was restricted to a very small area in the immediate area of the discharge opening.

5.3.2.2 Aquatic Ecosystems

5.3.2.2.1 Thermal Effects

The CORMIX simulation indicates that the heated discharge (cooling tower blowdown) from the proposed new units will affect a small part of the river in the immediate area of the discharge port. Because most of the water column is unaffected by the blowdown, even under extreme (worst-case) conditions, the thermal plume will not create a barrier to upstream or downstream movement of important migrating fish species, including American shad, hickory shad, blueback herring, striped bass, Atlantic sturgeon, shortnose sturgeon, and American eel. There will be no thermal impacts beyond some thermally-sensitive species possibly avoiding the immediate area of the discharge opening. The extremely small cross section of the thermal plume limits the exposure of the drift community to elevated temperature and results in only minimal impact. Impacts to aquatic communities will be SMALL and will not warrant mitigation.

5.3.2.2.2 Chemical Impacts

As discussed in Section 5.2.2, operation of the new cooling towers will be based on four cycles of concentration, meaning that solids and chemical constituents in makeup water will be concentrated four times before being discharged. As a result, levels of solids and organics in cooling tower blowdown will be approximately four times higher than ambient or upstream concentrations. Because the blowdown stream will be very small relative to the flow of the Savannah River concentrations of solids and chemicals used in cooling tower water treatment will return to ambient levels almost immediately downstream of the discharge pipe. The projected maximum blowdown flow of 28,880 gpm is 0.45 to 0.91 percent of the average flow and 1.34 to 1.55 percent of the 7Q10 flow estimated for the VEGP site. This equates to a dilution factor of 60 to 120, depending on the time of year. The normal blowdown flow of 9300 gpm results in an even larger range of dilution factors The discharge will be permitted by Georgia

DNR and comply with applicable state water quality standards (Chapter 391-3-6 of the Rules and Regulations of the State of Georgia, “Rules and Regulations for Water Quality Control”). Any impacts to aquatic biota will be SMALL and will not warrant mitigation.

5.3.2.2.3 Physical Impacts

Based on predicted discharge velocities (see previous section), some localized bottom scouring is expected in the immediate vicinity of the discharge opening. Assuming the degree/extent of bottom scouring associated with operation of the new discharge is similar to that associated with operation of the existing discharge, an area of several hundred square feet could be rendered unsuitable for benthic organisms, including larval aquatic insects and mussels. Other than a local reduction in numbers of benthic organisms, there will be no effect on Savannah River macrobenthos or fish. No important aquatic species or its habitat will be affected. Physical impacts to aquatic communities will therefore be SMALL and will not warrant mitigation.

5.3.3 Heat Dissipation Systems

5.3.3.1 Heat Dissipation to the Atmosphere

SNC will use a single natural draft cooling tower for each AP1000 unit to remove excess heat from the circulating water system (CWS). Cooling towers evaporate water to dissipate heat to the atmosphere. The evaporation is followed by partial recondensation which creates a visible mist or plume. In addition to evaporation small water droplets drift out of the tops of the cooling towers. The plume creates the potential for shadowing, fogging, icing, localized increases in humidity, and possibly water deposition. The drift of water droplets can deposit dissolved solids on vegetation or equipment.

The Final Environmental Statement for construction of the existing VEGP units **(AEC 1974)** examined fogging and solids deposition for the four cooling towers proposed at that time. The AEC analysis determined that there would be no measurable increase in ground-level fogging in the area and that the effect of solids deposition will be negligible. In the FES for operation **(NRC 1985)**, NRC concluded that for the two units then under construction, increases in ground-level fogging, precipitation, icing, cloud formation, and shading would be inconsequential. Drift deposition was examined in detail and determined to be negligible.

For the proposed new units, SNC modeled the impacts from fogging, icing, shadowing, and drift deposition using the Electric Power Research Institute’s Seasonal/Annual Cooling Tower Impact (SACTI) prediction code. This code incorporates the modeling concepts presented by Policastro et al. (1993), which were endorsed by NRC in NUREG-1555. The model provides predictions of seasonal, monthly, and annual cooling tower impacts from mechanical or natural draft cooling towers. It predicts average plume length, rise, drift deposition, fogging, icing, and shadowing, providing results that have been validated with experimental data **(Policastro et al. 1993)**. SNC prepared a calculation package supporting this analysis.

Engineering data for the AP1000 was used to develop input to the SACTI model. The model assumed two identical cooling towers, each with a heat rejection rate of 7.54×10^9 BTU/hr and circulating water flows of 600,000 gallons per minute. The tower height was set at 600 feet. Four cycles of concentration were assumed for normal operations. The meteorological data was from the VEGP meteorological tower for the year 1999, which had the most complete data set.

5.3.3.1.1 Length and Frequency of Elevated Plumes

The SACTI code calculated the expected plume lengths by season and direction for the combined effect of two natural draft cooling towers. The longest plume lengths will occur in the winter months and the shortest in the summer. The plumes will occur in all compass directions. No impacts other than aesthetic will result from the plumes. Although visible from offsite, the plumes resemble clouds and will not disrupt the aesthetic view (see Section 5.8.1.4).

Modeled plumes from proposed cooling towers will be as follows:

	Winter	**Summer**
Median plume length (miles)	0.25	0.19
Predominant direction	N, NE, ENE, E	N, NNE. W
Longest plume length (miles)	6.0	6.0
Frequency of longest plume (percent)	3.9	0.5

5.3.3.1.2 Ground-Level Fogging and Icing

Fogging from the natural draft cooling towers is not expected due to their height. Icing will not occur from these towers. The existing cooling towers at VEGP, which are 550 feet high; do not produce ground-level fogging or icing. As reported in Section 2.7.4.1.4, natural fogging occurs approximately 35 days per year. Impacts from fogging or icing will be SMALL and not warrant mitigation.

5.3.3.1.3 Solids Deposition

Water droplets drifting from the cooling towers will have the same concentration of dissolved and suspended solids as the water in the cooling tower basin. The water in the cooling tower basin is assumed to have solid concentrations four times that of the Savannah River, the source of cooling water makeup. Therefore, as these droplets evaporate, either in the air or on vegetation or equipment, they deposit these solids.

The maximum predicted solids deposition rate from a single tower will be as follows:

Maximum pounds per acre per month	3.6
Feet to maximum deposition	1,600
Direction to maximum deposition	North

The maximum predicted solids deposition from both towers (7.2 pounds per acre per month) is below the NUREG-1555 significance level of 8.9 pounds per acre per month.

Impact from salt deposition from the new towers will be SMALL and will not require mitigation. Cumulative impacts of salt deposition from the four towers are discussed in Section 10.5.

5.3.3.1.4 Cloud Shadowing and Additional Precipitation

Vapor from cooling towers can create clouds or contribute to existing clouds. Rain and snow from vapor plumes are known to have occurred. The SACTI code predicted the precipitation expected from the proposed cooling towers. The towers will produce a maximum of less than one inch (0.00003 inches) of precipitation per year at 0.4 miles east of the towers. This value is very small compared to the annual precipitation of 33 inches from the year of meteorological data used in this analysis, which was a year of low rainfall. The 30-year average rainfall at Augusta is 45 inches and at Waynesboro is 47 inches (1971-2000) **(NOAA 2002)**. Impacts will be SMALL and will not require mitigation.

5.3.3.1.5 Interaction with Existing Pollution Sources

The extent of influence of the proposed cooling towers is limited. No other sources of pollution occur in the vicinity except the existing VEGP cooling towers. The centroid of the proposed cooling towers is approximately 4,000 feet from the centroid of the existing towers. Given this distance, cumulative effects will occur only when the wind is in the approximate direction of the line connecting these two points. The cumulative effect will be SMALL and transitory and will not require mitigation.

5.3.3.1.6 Ground-Level Humidity Increase

The potential for increases in absolute and relative humidity exist where there are visible plumes, however, the increase will be SMALL and mitigation will not be warranted.

5.3.3.2 Terrestrial Ecosystems

Heat dissipation systems associated with nuclear power plants have the potential to impact terrestrial ecosystems through salt drift, vapor plumes, icing, precipitation modifications, noise, and bird collisions with structures (e.g., cooling towers). Each of these topics is discussed below.

No important terrestrial species or important habitats exist within the vicinity of the proposed project (see Sections 2.4.1.1 and 4.3.1).

5.3.3.2.1 Salt Drift

Vegetation near the cooling towers could be subjected to salt deposition attributable to drift from the towers. Salt deposition could potentially cause vegetation stress, either directly by deposition of salts onto foliage or indirectly from accumulation of salts in the soil.

An order-of-magnitude approach is typically used to evaluate salt deposition on plants, since some plant species are more sensitive to salt deposition than others, and tolerance levels of most species are not known with precision. In this approach, deposition of sodium chloride at rates of approximately 1 to 2 pounds/acre/month is generally not damaging to plants, while deposition rates approaching or exceeding 9 pounds/acre/month in any month during the growing season could cause leaf damage in many species (NUREG-1555); NRC presented this data in metric units which SNC converted to American standards for this discussion). An alternate approach for evaluating salt deposition is to use 9 to 18 pounds/acre/month of sodium chloride deposited on leaves during the growing season as a general threshold for visible leaf damage (NUREG-1555).

As presented in Section 5.3.3.1.3, the maximum expected salt deposition rate will be 7.2 pounds/acre/month. This conservative maximum rate is less than the 9 pounds/acre/month rate that is considered a threshold for leaf damage in many species. Even if both towers deposited the maximum expected concentration on the same area the total is less than 9lb/acre/mo. Any impacts from salt drift on the local terrestrial ecosystems will therefore be SMALL and not warrant mitigation. Cumulative impacts are discussed in Section 10.5.

5.3.3.2.2 Vapor Plumes and Icing

As concluded in Section 5.3.3.1.1, the expected longest plumes will be 6.2 miles, but will occur only about 3.9 percent of the time. As discussed in Section 5.3.3.1.2, ground level fogging and icing do not occur at VEGP towers, therefore the impacts of fogging and icing on terrestrial ecosystems will be SMALL and not warrant mitigation.

5.3.3.2.3 Precipitation Modifications

As discussed in Section 5.3.3.1.4, the predicted maximum precipitation from the cooling towers will be less than one inch of rain per year within 0.4 mile of the towers. This amount is very small compared to the average annual precipitation of approximately 33 inches from the year of meteorological data used in this analysis, which was a year of low rain fall. The 30-year average rainfall at Augusta is 45 inches and at Waynesboro is 47 inches (1971-2000) **(NOAA 2002)**. Thus, additional precipitation resulting from operation of the proposed units on local terrestrial ecosystems will be SMALL and will not warrant mitigation.

5.3.3.2.4 Noise

As presented in Section 5.3.4.2. Noise from the operation of the new cooling towers will be similar to background and to current noise levels to which local species are adapted. Therefore, noise impacts to terrestrial ecosystems will be SMALL and will not warrant mitigation.

5.3.3.2.5 Avian Collisions

The natural draft cooling towers associated with the AP1000 will be 600 feet high. Existing natural draft cooling towers at VEGP are 550 feet high, and SNC has observed occasional, incidental occurrences of bird collisions with the towers. Because collisions with existing VEGP cooling towers are rare, it is likely that bird collisions with the new towers will be minimal. In addition, the NRC concluded in NUREG-1437, The *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS), that effects of bird collisions with existing cooling towers are minimal. Therefore, impacts to bird species from collisions with the cooling towers will be SMALL and will not warrant mitigation.

5.3.4 Impacts to Members of the Public

This section describes the potential health impacts associated with the cooling system for the new units. Specifically, impacts to human health from thermophilic microorganisms and from noise resulting from operation of the cooling system are addressed.

As described in Section 3.4, a closed-cycle cooling system will be used for the new units, similar to the existing units' cooling systems. Because the system will use natural draft cooling towers, thermal discharges will be to the atmosphere.

5.3.4.1 Thermophilic Microorganism Impacts

Consideration of the impacts of thermophilic microorganisms on public health are important for facilities using cooling ponds, lakes, canals, or small rivers, because use of such water bodies may significantly increase the presence and numbers of thermophilic microorganisms. These microorganisms are the causative agents of potentially serious human infections, the most serious of which is attributed to *Naegleria fowleri*.

Naegleria fowleri is a free-living ameba that occurs worldwide. It is present in soil and virtually all natural surface waters such as lakes, ponds, and rivers. *Naegleria fowleri* grows and reproduces well at high temperatures (104° to 113°F) and has been isolated from waters with temperatures as low as 79.7°F.

Section 5.2.3 describes the thermal plume expected from cooling tower blowdown to the Savannah River. Theoretically, thermal additions to the Savannah River from cooling tower blowdown could support *Naegleria fowleri* and other thermophilic microorganisms. However, the thermal plume will have maximum temperatures in the range of 91°F with a very small mixing zone, thus limiting the conditions necessary for optimal growth. The maximum recorded temperature in the Savannah River in 2003 was 78.3ºF (Table 2.3.3-2). Savannah River temperatures are not optimal for *Naegleria fowleri* reproduction. Therefore SNC determined the risk to public health from thermophilic microorganisms will be SMALL and will not warrant mitigation.

5.3.4.2 Noise Impacts

The new units will produce noise from the operation of pumps, cooling towers, transformers, turbines, generators, switchyard equipment and loudspeakers. NUREG-1555 notes that the principal sources of noise include natural draft cooling towers and pumps that supply the cooling water. As described in Section 4.4.1, neither Georgia nor Burke County has noise regulations. Additionally, neither the state nor the county provides guidelines or limitations for impulse noise like a sharp sound pressure peak occurring in a short interval of time. The nearest residence is approximately two-thirds of a mile from the site boundary or approximately one mile from the site of the new units, and distance and vegetation will attenuate any noise. SNC has not received complaints about the noise of the existing units.

Most equipment will be located inside structures, reducing the outdoor noise level. Except in the case of the river water pumps, which fishermen, canoeists and kayakers on the Savannah River will hear, noise will be further attenuated by distance to the site boundary. The cooling towers and diesel generators (which will operate intermittently) could have noise emissions as high as 55 dBa at distances of 1,000 feet **(Westinghouse 2005)**. The nearest boundary is about 1,500 feet away from the planned cooling towers location.

As reported in NUREG-1437, and referenced in NUREG-1555, noise levels below 60 to 65 dBA are considered of small significance. Therefore, the noise impact at the nearest residence will be SMALL and no mitigation will be warranted.

Commuter traffic will be controlled by speed limits. The access road to the VEGP site is paved. Good road conditions and appropriate speed limits will minimize the noise level generated by the work force commuting to the VEGP site.

Section 2.7 of Regulatory Guide 4.2 (RG 4.2) suggests an assessment of the ambient noise level within 5 miles of the proposed site; particularly noises associated with high voltage transmission lines. No noise assessment has been done due to the rural character of the area. However, as presented in Section 5.6.3.3 SNC has not received any reports of nuisance noise from the existing transmission lines. It is unlikely any new lines will generate more noise than existing lines.

Section 5.3 References

(AEC 1974) Atomic Energy Commission 1974, Final Environmental Statement related to the proposed Alvin W. Vogtle Nuclear Plant, Units 1, 2, 3, and 4, Georgia Power Company, Directorate of Licensing, Washington, D.C., March.

(Du Pont 1987) E. I. du Pont de Nemours & Co, Comprehensive Cooling Water Study, Volume V: Aquatic Ecology DP-1739-5, W. L. Specht, Editor and Compiler, Savannah River Laboratory, Aiken, SC.

(McFarlane et al. 1978) McFarlane, R.W., R.F. Frietsche and R.D. Miracle. 1978. Impingement and Entrainment of Fishes at the Savannah River Plant: An NPDES 316(b) Demonstration. U.S. Department of Energy. Report DP-1494, E.I. du Pont de Nemours and Company, Aiken, SC.

(NOAA 2002) National Oceanic and Atmospheric Administration, Monthly Station Normals of Temperature, Precipitation and Heating and Cooling Degree Days 1971-2000, Georgia, Climatography of the United States No. 81, National Climate Data Center, Asheville, NC.

(NRC 1985) U.S. Nuclear Regulatory Commission 1985, Final Environmental Statement Related to the Operation of Vogtle Electric Generating Plant, Units 1 and 2, NUREG-1087, Office of Nuclear Reactor Regulation, Washington, D.C., March.

(Policastro et al. 1993) Policastro, A. J., W. E. Dunn, and R. A. Carhart, A Model for Seasonal and Annual Cooling Tower Impacts, Atmospheric Environment Vol. 28, No. 3, pp. 379-395, Elsevier Science Ltd, Great Britain.

(Westinghouse 2005) Westinghouse Electric Company, LLC. AP1000 Siting Guide: Site Information for an Early Site Permit Application, APP-0000-XI-001, Revision 3, April 24.

(Wiltz 1982) Wiltz, J. W. Vogtle Electric Generating Plant Beaverdam Creek Resident Fish Study, Burke County, Georgia, from January 1977 through December 1978, Operating License State Environmental Report Technical Document, Georgia Power Company Environmental Affairs Center, Atlanta.

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5.4 Radiological Impacts of Normal Operation

This section describes the radiological impacts of normal plant operation on members of the public, plant workers, and biota. Section 5.4.1 describes the exposure pathways by which radiation and radioactive effluents could be transmitted from Units 3 and 4 to organisms living near the plant. Section 5.4.2 estimates the maximum doses to the public from the operation of one new unit. Section 5.4.3 evaluates the impacts of these doses by comparing them to regulatory limits for one unit. In addition, the impact of two new units in conjunction with the existing units is compared to the corresponding regulatory limit. Section 5.4.4 considers the impact to non-human biota. Section 5.4.5 describes the radiation doses to plant workers from the new units.

5.4.1 Exposure Pathways

Small quantities of radioactive liquids and gases would be discharged to the environment during normal operation of Units 3 and 4. The impact of these releases and any direct radiation to individuals, population groups, and biota in the vicinity of the new units was evaluated by considering the most important pathways from the release to the receptors of interest. The major pathways are those that could yield the highest radiological doses for a given receptor. The relative importance of a pathway is based on the type and amount of radioactivity released, the environmental transport mechanism, and the consumption or usage factors of the receptor.

The exposure pathways considered and the analytical methods used to estimate doses to the maximally exposed individual (MEI) and to the population surrounding the new units are based on NRC Regulatory Guide 1.109, *Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR 50*, Appendix I (Rev.1, October 1977) (RG 1.109) and NRC Regulatory Guide 1.111, Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors (Revision 1, July 1977) (RG 1.111). An MEI is a member of the public located to receive the maximum possible calculated dose. The MEI allows dose comparisons with established criteria for the public.

5.4.1.1 Liquid Pathways

Units 3 and 4 would release effluents to the Savannah River. The NRC-endorsed LADTAP II computer program **(NRC 1986)** was used to calculate these doses, with parameters specific to the river and downstream locations. This program implements the radiological exposure models described in Reg. Guide 1.109 for radioactivity releases in liquid effluent. The following important exposure pathways are considered in LADTAP II:

- Ingestion of aquatic organisms as food
- Ingestion of drinking water

Although less important, the shoreline, swimming and boating exposure pathways are also considered in LADTAP II. The input parameters for the liquid pathway are presented in Tables 5.4-1. The discharge is assumed fully mixed with the river flow.

5.4.1.2 Gaseous Pathways

The GASPAR II computer program was used to calculate the doses to offsite receptors from the new units. This program implements the radiological exposure models described in NRC Reg. Guide 1.109 (NRC 1977) to estimate the doses resulting from radioactive releases in gaseous effluent. The atmospheric dispersion component of the analysis was calculated with the NRC-sponsored program, XOQDOQ **(NRC 1982)**. Dispersion and deposition factors, shown in Section 2.7, were calculated from onsite meteorological parameters (wind speed, wind direction, stability class) for 1998-2002.

The following exposure pathways are considered in GASPAR II:

- External exposure to contaminated ground
- External exposure to gases in air
- Inhalation of airborne activity
- Ingestion of contaminated meat and milk
- Ingestion of contaminated garden vegetables

The input parameters for the gaseous pathway are presented in Table 5.4-2, and the receptor locations of maximum exposure, determined from GASPAR calculations, are shown in Table 5.4-3.

5.4.1.3 Direct Radiation from Units 3 and 4

Contained sources of radiation at the new units will be shielded. The AP1000 is expected to provide shielding that is at least as effective as existing light water reactors (LWR). An evaluation of all operating plants by the NRC states that:

> *"…because the primary coolant of an LWR is contained in a heavily shielded area, dose rates in the vicinity of light water reactors are generally undetectable and are less than 1 mrem/year at the site boundary. Some plants [mostly BWRs] do not have completely shielded secondary systems and may contribute some measurable off-site dose." (NRC 1996 Section 4.6.1.2)*

Thus, the direct radiation from normal operation would result in small contributions at site boundaries. Therefore, direct dose contribution from the new units would be SMALL and would not warrant additional mitigation. No further consideration of direct radiation is provided.

5.4.2 Radiation Doses to Members of the Public

In this section, doses to MEIs from liquid and gaseous effluents from one new unit are estimated using the methodologies and parameters specified in Section 5.4.1.

5.4.2.1 Liquid Pathway Doses

Based on the parameters shown in Table 5.4-1, the LADTAP II computer program was used to calculate the important doses to the MEI via the following activities:

- Eating fish caught in the Savannah River
- Drinking water from the Savannah River

Doses from shoreline activities were also calculated but found to be much smaller than those from fish ingestion and drinking water. The liquid activity releases (source terms) for each radionuclide are shown in Table 3.5-1. The calculated annual doses to the total body, the thyroid, and the maximally exposed organ are presented in Table 5.4-5. The maximum annual organ dose from liquid releases of 0.021 millirem per unit would be to the liver of the maximally exposed child.

5.4.2.2 Gaseous Pathway Doses

Based on the parameters in Table 5.4-2 and Table 5.4-3, the GASPAR II computer program was used to calculate doses to the maximally exposed individual child (MEI), who represents the bounding age group for total body and all organs. The location of this individual is given in Table 5.4-4. This location was conservatively chosen as the distance to the nearest offsite receptor (0.67 miles) in the maximum exposure direction (chosen from among the 16 compass directions encircling the site). The gaseous activity releases (source terms) for each radionuclide are shown in Table 3.5-2. The calculated annual pathway components for the total body, thyroid, and other organ doses for this individual are presented (for two new units) in Table 5.4-6. The total body MEI (annual total body dose of 1.12 mrem per unit) is represented by a nearby child resident that would be exposed through plume, ground, inhalation, and ingestion of locally grown meat and vegetables pathways; milk consumption was not considered because no milk animals are located within 5 miles of the plant. The maximum annual thyroid dose to this same individual is 6.16 mrem per unit. Based on experience at the existing unit, these calculations are conservative and do not represent actual doses to individuals near the Vogtle site.

5.4.3 Impacts to Members of the Public

In this section, the radiological impacts to individuals and population groups from liquid and gaseous effluents are presented using the methodologies and parameters specified in Section 5.4.1. Table 5.4-7 estimates the single-unit total body and organ doses to the MEI from liquid effluents and gaseous releases from the new units for analytical endpoints prescribed in 10 CFR 50, Appendix I. As the table indicates, the single-unit doses are below Appendix I limits.

The total liquid and gaseous effluent doses from existing Units 1 and 2 plus proposed Units 3 and 4 would be well within the regulatory limits of 40 CFR 190 (Table 5.4-8). As indicated in NUREG-1555, demonstration of compliance with the limits of 40 CFR 190 is considered to be in compliance with the 0.1 rem limit of 10 CFR 20.1301. Table 5.4-9 shows the collective total body dose to the population within 50 miles of the VCSNS site that would be attributable to the new units. Impacts to members of the public from operation of the new units would be SMALL and would not warrant additional mitigation.

5.4.4 Impacts to Biota Other than Members of the Public

Radiation exposure pathways to biota were examined to determine if the pathways could result in doses to biota significantly greater than those predicted for humans. This assessment used species that provide representative information about the various dose pathways potentially affecting broader classes of living organisms. The liquid pathway doses to these species are calculated by the LADTAP II computer program. The gaseous pathway doses were taken as equivalent to adult human doses for the inhalation, vegetation ingestion, plume, and twice the ground pathways; neither muskrats nor heron normally ingest terrestrial vegetation and that pathway was deleted for those species. The doubling of doses from ground deposition reflects the closer proximity of these organisms to the ground.

Doses to biota from liquid and gaseous effluents are shown in Table 5.4-10. The total body dose is taken as the sum of the internal and external dose. Annual doses to all of the surrogates meet the requirements of 40 CFR 190 (Table 5.4-10).

Use of exposure guidelines, such as 40 CFR 190, which apply to members of the public in unrestricted areas, is considered very conservative when evaluating calculated doses to biota. The International Council on Radiation Protection states that “...if man is adequately protected then other living things are also likely to be sufficiently protected,” and uses human protection to infer environmental protection from the effects of ionizing radiation **(ICRP 1977, 1991)**. This assumption is appropriate in cases where humans and other biota inhabit the same environment and have common routes of exposure. It is less appropriate in cases where human access is restricted or pathways exist that are much more important for biota than for humans. Conversely, it is also known that biota with the same environment and exposure pathways as man can experience higher doses without adverse effects.

Species in most ecosystems experience dramatically higher mortality rates from natural causes than man. From an ecological viewpoint, population stability is considered more important to the survival of the species than the survival of individual organisms. Thus, higher dose limits could be permitted. In addition, no biotas have been discovered that show significant changes in morbidity or mortality due to radiation exposures predicted from nuclear power plants.

An international consensus has been developing with respect to permissible dose exposures to biota. The International Atomic Energy Agency **(IAEA 1992)** evaluated available evidence including the *Recommendations of the International Commission on Radiological Protection* **(ICRP 1977)**. The IAEA found that appreciable effects in aquatic populations will not be expected at doses lower than 1 rad per day and that limiting the dose to the maximally exposed individual organisms to less than 1 rad per day will provide adequate protection of the population. The IAEA also concluded that chronic dose rates of 0.1 rad per day or less do not appear to cause observable changes in terrestrial animal populations. The assumed lower threshold occurs for terrestrial rather than for aquatic animals primarily because some species of mammals and reptiles are considered more radiosensitive than aquatic organisms. The permissible dose rates are considered screening levels and higher species-specific dose rates could be acceptable with additional study or data.

The calculated total body doses in Table 5.4-10 can be compared to the 1 rad per day dose criteria evaluated in the *Effects of Ionizing Radiation on Plants and Animals at Levels Implied by Current Radiation Protection Standards* **(IAEA 1992)**. The biota doses meet the dose guidelines by a large margin. In these cases, the annual dose to biota is much less than the daily allowable doses to aquatic and terrestrial organisms. Impacts to biota other than members of the public from exposure to sources of radiation would be SMALL and would not warrant mitigation.

5.4.5 Occupational Radiation Doses

Based on the available data on the AP1000 design, the maximum annual occupational dose is estimated to be similar to or less than that for Units 1 and 2. For 2005, the collective radiation dose to workers at Units 1 and 2 was 151 person-rem **(NRC 2006)**. The total body dose to a Unit 4 construction worker from operation of proposed Unit 3, based on all releases being from ground level, would be less than 0.83 mrem/yr, with a maximum organ dose (to the skin) of less than 3.26 mrem/yr. The impacts to workers from occupational radiation doses would be SMALL and would not warrant additional mitigation.

Table 5.4-1 Liquid Pathway Parameters

Parameter	Value
Release source terms	Table 3.5-1
Discharge rate (River flow)[a]	9229 cubic feet per second[a]
Dilution factor for discharge	1[a]
Transit time to receptor	0.1 hours, 16 hours[b]
Impoundment reconcentration model	None[c]
50-mile population	674,101[d]
50-mile sport fishing	35,000 kg/yr[e]
50-mile shoreline usage	960,000 person-hours/yr[e]
50-mile swimming usage	160,000 person-hours/yr[e]
50-mile boating usage	1,100,000 person-hours/yr[e]
Fish Consumption	21 kilograms per year[f]
Drinking water consumption	730 liters per year[f]

a. Liquid discharge assumed fully mixed with annual average river flow at Vogtle.
b. 0.1 hours assumed for MEI. 16 hours is average transit time halfway down 50-mile stretch.
c. Completely mixed model used for Savannah River.
d. Table 2.5.1-1.
e. **WSRC (2006)**.
f. Adult MEI. 6.9 kilograms per year average (adult population) fish consumption (NRC 1986).

Table 5.4-2 Gaseous Pathway Parameters

Parameter	Value
Release Source Terms	Table 3.5-2
Population distribution	Table 2.5.1-1
Dispersion and deposition factors (X/q and d/q)	Section 2.7
50-mile milk production (l/yr)	6.37E7[a]
50-mile meat production (kg/yr)	1.03 E7[a]
50-mile vegetable production (kg/yr)	6.57 E7[a]

a. Animal and vegetable production from 2002 National Census of Agriculture. Production converted to food products using average conversion factors: 17,050 lb milk/cow; 377 lb beef /cow, calf; 81.2 lb meat/hog, pig; 95.8 lb meat/sheep, and 8,090 kg vegetables/acre

Table 5.4-3 Gaseous Pathway Consumption Factors for Maximally Exposed Individual

	Annual Rate			
Consumption Factor	**Infant**	**Child**	**Teen**	**Adult**
Milk consumption (l/yr)	330	330	400	310
Meat consumption (kg/yr)	0	41	65	110
Leafy vegetable consumption (kg/yr)	0	26	42	64
Vegetable consumption (kg/yr)	0	520	630	520

Source: NRC (1987). Leafy vegetables are assumed grown in the MEI's garden for 58% of the year; the garden is assumed to supply 76% of the other vegetables ingested annually. Average population consumption of milk, meat and vegetables is 131 l/yr, 81 kg/yr, and 197 kg/yr, respectively.

Table 5.4-4 Gaseous Pathway Receptor Locations

Receptor	Direction	Distance (miles)
Site boundary	NE	0.50
Maximally exposed individual (MEI)	NE	0.67

Table 5.4-5 Liquid Pathway Doses for Maximally Exposed Individual (1 Unit)(millirem per year)

Skin	Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI
0.000073	0.012	0.021	0.017	0.015	0.012	0.0090	0.0086

GI-LLI = Gastrointestinal-lining of lower intestine. Child receptor, except total body is adult and skin is teen, and thyroid is infant.

Table 5.4-6 Gaseous Pathway Doses for Total Body Maximally Exposed Individual — Two Units (millirem per year)

PATHWAY	T.BODY	GI-TRACT	BONE	LIVER	KIDNEY	THYROID	LUNG	SKIN
PLUME	5.11E-01	5.11E-01	5.11E-01	5.11E-01	5.11E-01	5.11E-01	5.45E-01	2.56E+00
GROUND	1.75E-01	1.75E-01	1.75E-01	1.75E-01	1.75E-01	1.75E-01	1.75E-01	2.05E-01
VEGET								
ADULT	4.09E-01	4.16E-01	1.97E+00	4.09E-01	3.92E-01	4.00E+00	3.65E-01	3.61E-01
TEEN	6.08E-01	6.16E-01	3.11E+00	6.30E-01	6.02E-01	5.38E+00	5.62E-01	5.55E-01
CHILD	1.33E+00	1.30E+00	7.25E+00	1.38E+00	1.33E+00	1.05E+01	1.27E+00	1.25E+00
MEAT								
ADULT	1.25E-01	1.51E-01	5.41E-01	1.25E-01	1.22E-01	3.08E-01	1.20E-01	1.20E-01
TEEN	1.00E-01	1.15E-01	4.56E-01	1.02E-01	9.98E-02	2.34E-01	9.82E-02	9.78E-02
CHILD	1.81E-01	1.88E-01	8.55E-01	1.83E-01	1.81E-01	3.84E-01	1.79E-01	1.78E-01
COW MILK								
ADULT	1.84E-01	1.58E-01	6.46E-01	2.00E-01	1.89E-01	5.46E+00	1.52E-01	1.49E-01
TEEN	2.97E-01	2.69E-01	1.18E+00	3.46E-01	3.27E-01	8.67E+00	2.64E-01	2.56E-01
CHILD	6.42E-01	6.01E-01	2.87E+00	7.44E-01	7.09E-01	1.73E+01	6.03E-01	5.92E-01
INFANT	1.27E+00	1.21E+00	5.51E+00	1.52E+00	1.40E+00	4.18E+01	1.22E+00	1.20E+00
GOAT MILK								
ADULT	2.71E-01	1.94E-01	7.29E-01	3.06E-01	2.52E-01	6.56E+00	1.94E-01	1.83E-01
TEEN	3.94E-01	3.15E-01	1.32E+00	5.16E-01	4.21E-01	1.04E+01	3.24E-01	3.01E-01
CHILD	7.55E-01	6.74E-01	3.19E+00	1.03E+00	8.61E-01	2.07E+01	6.97E-01	6.63E-01
INFANT	1.43E+00	1.32E+00	5.96E+00	2.03E+00	1.63E+00	5.00E+01	1.37E+00	1.31E+00
INHAL								
ADULT	5.59E-02	5.65E-02	8.57E-03	5.71E-02	5.81E-02	5.19E-01	7.22E-02	5.42E-02
TEEN	5.65E-02	5.70E-02	1.04E-02	5.87E-02	6.00E-02	6.48E-01	8.18E-02	5.47E-02
CHILD	5.00E-02	4.93E-02	1.26E-02	5.22E-02	5.33E-02	7.56E-01	7.08E-02	4.83E-02
INFANT	2.89E-02	2.82E-02	6.36E-03	3.12E-02	3.11E-02	6.78E-01	4.34E-02	2.78E-02
SUM OF VIABLE PATHWAYS (CHILD)	**2.25E+00**	**2.22E+00**	**8.80E+00**	**2.30E+00**	**2.25E+00**	**1.23E+01**	**2.24E+00**	**4.24E+00**

Note: Maximally exposed individual is child resident. Adult, teen and infant doses are presented as additional information. Cow milk and goat milk pathway doses are hypothetical for this location and are presented as additional information only. Ground level releases assumed.

Table 5.4-7 Comparison of Annual Maximally Exposed Individual Doses with 10 CFR 50, Appendix I Criteria

		Annual Dose	
Type of Dose	Location	AP1000 (per unit)	Limit
Liquid effluent[a]			
Total body (mrem)	Savannah River	0.017	3
Maximum organ — liver (mrem)	Savannah River	0.021	10
Gaseous effluent[b]			
Gamma air (mrad)	Site boundary	0.68	10
Beta air (mrad)	Site boundary	2.84	20
Total external body (mrem)	Site boundary	0.56	5
Skin (mrem)	Site boundary	2.30	15
Iodines and particulates[c] (gaseous effluents)			
Maximum organ – thyroid (mrem)	MEI	5.91[d]	15

a. Total body is adult using Savannah River. Liver is child using Savannah River.
b. Northeast site boundary. Ground level releases assumed.
c. Includes tritium and carbon-14 terrestrial food chain dose (and inhalation dose for calculation ease and conservatism), consistent with Table 1 of **NRC (1977)**
d. Child eating home grown meat and vegetables. Difference between Table 5.4-7 and 5.4-8 thyroid dose is 0.51 millirem from noble gases in the plume.

Table 5.4-8 Comparison of Maximally Exposed Individual Doses with 40 CFR 190 Criteria — (millirem per year to child)

	Units 3 and 4			Units 1 and 2			Site	Regulatory
	Liquid	Gaseous[a]	Total	Liquid[b]	Gaseous[b]	Total	Total	Limit
Total body	0.020	2.25	2.27	0.091	0.0017	0.092	2.36	25
Thyroid	0.027	12.30	12.33	0.061	0.0012	0.062	12.39	75
Other organ — bone	0.024[c]	8.80	8.82	0.054[d]	0.0017[e]	0.055	8.88	25

a. Residence with meat animal and vegetable garden, dose to child, 0.67miles NE of new units (MEI).
b. From doses due to 2001 releases (SNC, 2002), the year of maximum MEI total body dose of years 2001–2004. Air pathway receptor is child eating home grown meat and vegetables, 4.7 miles SSW of the existing units.
c. Maximum other organ dose for Units 3 and 4 liquid pathway is 0.043 to the liver of a child.
d. Maximum other organ dose for Units 1 and 2 liquid pathway is 0.15 to the GI-LLI.
e. Maximum other organ doses for units 1 and 2 gaseous pathways are to the liver, kidney, lung, and GI/LLI.

Table 5.4-9 Collective Total Body Doses within 50 Miles (person-rem per year)

	Units 3 and 4		Units 1 and 2	
	Liquid	Gaseous	Liquid	Gaseous
Noble gases	0	0.57	0	0.001
Iodines and particulates	0.037	0.14	0.0075	0.16
Tritium and C-14	0.00050	1.10	0.00037	0.049
Total[a]	0.037	1.80	0.0078	0.21
Natural background[b]	2.43E5		2.43E5	

a. Difference between sum of components and total is due to rounding.
b. Natural background dose is based on a dose rate of 360 mrem/person/yr and a population of 674,101 (Table 2.5.1-1).
Source: Unit 1 source terms from **SNC (2003)** for gaseous releases and **SNC (2002)** for liquid releases.

Table 5.4-10 Doses to Biota from Liquid and Gaseous Effluents

	Dose (millirad per yr)		
Biota	Liquid effluents[a]	Gaseous effluents[b]	Total
Fish	0.16	0	0.16
Muskrat	0.47	1.51	1.98
Raccoon	0.19	2.18	2.37
Heron	2.15	1.51	3.66
Duck	0.45	2.18	2.63

a. Using Savannah River water in vicinity of release.
b. Assumed residing at site boundary. Adult pathway doses from GASPAR for plume, vegetation ingestion (except herons and muskrats) and inhalation; ground exposure taken as twice adult. RBE equal one.

Section 5.4 References

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5.5 Environmental Impact of Waste

This section describes the environmental impacts that could result from the operation of the non-radioactive waste system and from storage and disposal of mixed wastes, and radioactive wastes.

5.5.1 Non-radioactive Waste System Impacts

Descriptions of the existing units' waste systems for non-radioactive wastes are presented in Section 3.6.

All non-radioactive wastes generated at the VEGP site, including those from the new units (i.e., solid wastes, liquid wastes, air emissions) will be managed in accordance with applicable federal, state and local laws and regulations, and permit requirements as they are now. Management practices will be the same as for the existing units and will include the following:

- Non-radioactive solid waste (e.g., office waste, recyclables) will be collected and stored temporarily on the VEGP site and disposed or recycled locally.
- Organic debris collected on trash racks and screens at the water intake structures will be disposed of onsite.
- Scrap metal, universal wastes, used oil and antifreeze will be collected and stored temporarily on the VEGP site and recycled or recovered at an offsite permitted recycling or recovery facility, as appropriate.
- Water from cooling and auxiliary systems will be discharged to the Savannah River through permitted outfalls.
- Wastewater treatment sludge will be disposed in an offsite permitted industrial waste landfill.
- Sewage sludge will be transported to the Burke County water works for disposal.

No site-specific waste disposal activities will be unique to the new units.

5.5.1.1 Impacts of Discharges to Water

Non-radioactive wastewater discharges to surface water from the new units will include cooling water blowdown, permitted wastewater from the new units' auxiliary systems, and storm water runoff from impervious surfaces. Table 3.6-1 lists water treatment chemicals that could be used in the new units. VEGP maintains engineering controls that prevent or minimize the release of harmful levels of constituents to the Savannah River. Concentrations of constituents in the cooling water discharge will be limited by NPDES requirements and will be minimal or non-detectable in the river (see Section 5.2.3).

Smaller-volume discharges associated with plant auxiliary systems will be discharged in accordance with applicable NPDES requirements. Therefore, potential impacts from constituents in the cooling water and plant auxiliary systems' discharges from the new units will be SMALL and will not warrant mitigation.

SNC will revise the existing VEGP Storm Water Pollution Prevention Plan, which prevents or minimizes the discharge of harmful quantities of pollutants with the storm water discharge, to reflect the addition of new paved areas and facilities and changes in drainage patterns. Impacts from increases in volume or pollutants in the storm water discharge will be SMALL and will not warrant mitigation.

5.5.1.2 Impacts of Discharges to Land

Operation of the new units will result in an increase in the total volume of non-radioactive solid waste generated at the VEGP site. Anticipated volumes of non-radioactive wastes are presented in Table 3.6-3. However, there will be no fundamental change in the characteristics of these wastes or the way in which they are managed currently at VEGP. All applicable federal, state, and local requirements and standards will be met for handling, transporting, and disposing of the solid waste. All solid waste will be reused or recycled to the extent possible. Solid wastes appropriate for recycling or reclamation (e.g., used oil, antifreeze, scrap metal, universal wastes) will be managed using approved and licensed contractors. All non-radioactive solid waste destined for offsite land disposal will be disposed of at approved and licensed offsite commercial waste disposal site(s). Therefore, potential impacts from land disposal of non-radioactive solid wastes will be SMALL and will not warrant mitigation.

5.5.1.3 Impacts of Discharges to Air

Operation of the new units will increase gaseous emissions to the air by a small amount, primarily from equipment associated with plant auxiliary systems (e.g., auxiliary boilers, emergency diesel generators). Emissions from the diesel-fueled equipment are provided in Table 3.6-3. Cooling tower impacts on terrestrial ecosystems are addressed in Section 5.3.3.2.

All air emission sources associated with the new units will be managed in accordance with federal, state, and local air quality control laws and regulations. Impacts to air quality will be SMALL and will not require mitigation.

5.5.1.4 Sanitary Waste

The existing facility's sanitary waste treatment system (see Section 3.6) will be expanded to accommodate the increases in sanitary wastes associated with the larger workforce. Sanitary wastes will be managed on site and disposed of off site in compliance with applicable laws, regulations, and permit conditions imposed by federal, state, and local agencies.

Potential impacts associated with increases in sanitary waste from operation of the new units will be SMALL and will not warrant mitigation.

5.5.2 Mixed Waste Impacts

The term “mixed waste” refers specifically to waste that is regulated as both radioactive and hazardous waste. As defined in the Atomic Energy Act (AEA) of 1954, as amended, (42 USC 2011 et seq.), mixed waste contains hazardous waste and a low-level radioactive source, special nuclear material, or byproduct material. Radioactive materials at nuclear power plants are regulated by the NRC under the AEA. Hazardous wastes are regulated by the state of Georgia as an EPA-authorized state under the Resource Conservation and Recovery Act (RCRA; 42 USC 6901 et seq.).

Nuclear power plants are not large generators of mixed waste. Proper chemical handling techniques and pre-job planning ensures that only small quantities of mixed waste will be generated by the new units.

The specific types and quantities of mixed waste that could be generated in new operating reactors are not available. However, each AP1000 reactor is estimated by the manufacturer to generate a maximum of 5,759 ft^3 per year of solid low-level radioactive waste (Table 3.0-1) before compaction. The two existing VEGP units generate approximately 1,730 ft^3 annually of low-level radioactive waste (from Table 2.9-1). NUREG-1437 estimates that the volume of mixed wastes produced at nuclear power plants accounts for less than 3 percent by volume of the annual solid low level waste generated at these plants. Therefore, to be conservative, SNC has assumed that the non-compacted volume of mixed waste generated by the two AP1000 units will be approximately 346 ft^3 annually, but, from VEGP experience the non-compacted mixed waste volume will more likely be approximately 52 ft^3.

SNC will handle mixed wastes generated at the new facilities in accord with existing procedures.

SNC has in place for the existing units contingency plans, emergency preparedness plans, and spill prevention procedures that will be implemented in the unlikely event of a mixed waste spill. Personnel who are designated to handle mixed waste or to respond to mixed waste emergency spills have appropriate training to enable them to perform their work properly and safely. The existing emergency procedures will limit any onsite impacts.

SNC believes that any impacts from the treatment, storage and disposal of mixed wastes generated by the new units will be SMALL and will not warrant mitigation beyond what has been described in the previous paragraphs.

5.5.3 Waste Minimization Plan

VEGP’s existing pollution prevention and waste minimization program will apply to the new units. The previous sections have incorporated components of the waste minimization program in their discussions.

5.5.4 Radioactive Waste

Low-level radioactive waste (LLW) is described in Section 3.5. Westinghouse estimates that one AP1000 will generate approximately 5,759 ft^3 of non-compacted LLW annually. Compaction could reduce the volume by 50 percent or more.

LLW is normally stored on site on an interim basis before being shipped off site for permanent disposal. On-site storage facilities are designed to minimize personnel exposures. High-dose-rate LLW is isolated in a shielded storage area and is easily retrievable. The lower-dose-rate LLW is stacked or stored to maximize packing efficiencies. NRC requirements and guidelines ensure that LLW is stored in facilities that are designed and operated properly and that public health and safety and the environment are adequately protected. The requirements and guidelines include the following:

- The amount of material allowed in a storage facility and the shielding used should be controlled by dose rate criteria for both the site boundary and any adjacent off-site areas. Direct radiation and effluent limits are restricted by 10 CFR Part 20 and 40 CFR Part 190. The exposure limits given in 10 CFR 20.1301 apply to unrestricted areas.
- Containers and their waste forms should be compatible to prevent significant corrosion within the container. After a period of storage, the subsequent transportation and disposal should not cause a container breach.
- Gases generated from organic materials in waste packages should be evaluated periodically with respect to container breach. After a period of storage, the subsequent transportation and disposal should not cause a container breach.
- Gases generated from organic materials in waste packages should be evaluated periodically with respect to container breach. High-activity resins should not be stored more than 1 year unless they are in containers with special vents.
- A program of at least quarterly visual inspection should be established.
- A liquid drainage collection and monitoring system should be in place. Routing of the drain should be to a radwaste processing system.

Commercial low-level waste disposal facilities are sited and operated consistent with 10 CFR 61 and other appropriate regulations, ensuring minimal environmental impact. Waste generators must meet the waste acceptance criteria established for the facility and adhere to packaging requirements. VEGP currently sends wastes to Envirocare in Utah and the Barnwell Low-level Waste Radioactive Management Disposal Facility in South Carolina. Barnwell will no longer accept wastes from Georgia after June 30, 2008. SNC is currently developing alternate disposal plans if the Barnwell facility is no longer available.

VEGP maintains procedures for shipping and handling LLW. SNC determined that the environmental impacts of LLW generation by the new units will be SMALL and not warrant mitigation.

The environmental impacts of on-site LLW management activities, including interim storage, at existing nuclear plants are described in NUREG-1437. Any impacts will result principally from exposure to radioactivity. Workers receive external doses from exposure to radiation while handling and packaging the waste materials and from periodic inspections of the packaged materials and any other handling operations required during interim storage. Such doses account for a small fraction of the total radiation dose commitment to workers and, as discussed in Section 5.4, the total dose commitment is well within regulatory limits. Radiation doses to off-site individuals and biota from interim LLW storage will be SMALL.

5.5.5 Conclusions

Minimal chemical constituents will be discharged to the water or air from operation of the new units. Waste minimization programs will reduce the amount of wastes, including mixed wastes, generated by operation of the new units. All radioactive wastes will be managed according to established laws, regulations, and exposure limits. No new waste streams will be generated. Therefore, impacts of waste generation will be SMALL and will not warrant mitigation.

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5.6 Transmission System Impacts

This section discusses the environmental impacts of the transmission system during operation of the new units. As discussed in Section 3.7, SNC has not finalized the transmission system design for the proposed new generating capacity. However, the proposed new units will require changes to the currently configured transmission and distribution system. Section 3.7.2 describes the proposed new transmission line route.

Current corridor maintenance activities for the VEGP lines are the responsibility of Georgia Power Company (GPC) and are in compliance with applicable federal, state, and local laws and regulations and applicable permit requirements. Maintenance activities on any new transmission line likewise will be the responsibility of GPC and in compliance with all requirements. Section 5.6.1 and Section 5.6.2 discuss the terrestrial and aquatic impacts associated with maintenance activities. Section 5.6.3 discusses the potential impacts to members of the public.

5.6.1 Terrestrial Ecosystems

Section 2.4.1.2 describes the terrestrial ecology along the existing transmission corridors. Impacts of building, operating, and maintaining the existing transmission facilities for Units 1 and 2 were assessed in the FESs for construction **(AEC 1974)** and operation **(NRC 1985)** of the existing units.

GPC has established maintenance procedures summarized below. In addition to the various practices and procedures GPC uses to minimize impacts of transmission facility maintenance across its transmission system, GPC has made a number of commitments to the NRC concerning the maintenance of transmission corridors associated with VEGP. These commitments are part of the existing units' operating licenses, and thus are binding in the manner of the Technical Specifications. Commitments include, but are not limited to, keeping records of herbicide usage that must be readily available to the NRC upon request and reporting unusual occurrences (or mortality) of a federally endangered or threatened species to the GPC Environmental Affairs Department within 24 hours of the discovery.

GPC performs aerial inspections, typically by helicopter, five times each year to support routine maintenance activities. Noise from the fly-overs may startle and temporarily displace local fauna. These impacts are short-term and limited to a localized area. Impacts associated with aerial inspections will be SMALL.

The transmission corridors are managed to prevent woody growth from encroaching on the transmission lines and potentially causing disruption in service or becoming a general safety hazard. Most transmission corridors are recleared on a 5-year maintenance cycle. This cycle may vary depending on public concerns, local ordinances, line maintenance, or environmental considerations. As part of the maintenance cycle, transmission lines and corridors are inspected from the ground and monitored for clearance. Corridor vegetation management involves the use of light equipment (e.g., saws, mowers), herbicides, and hand tools. Mowing is the primary method for maintaining the corridors. Hand cutting and/or herbicides are used in areas where mowing is impractical or undesirable. Herbicides are handled and applied by specialty contractors in accordance with manufacturer specifications and guidance from jurisdictional regulatory agencies. Contractors are appropriately trained and licensed to perform such work.

The use of light equipment (e.g., pick-up trucks, tractors with mower attachments, small-engine hand tools) in transmission corridors could result in incidental spills of fuel and/or lubricants. Whenever these materials are taken into the field, adequate spill response materials are available for immediate clean-up of any spills. Additionally, personnel are trained in how to respond to, clean-up, and report a spill. Contaminated material is managed and disposed of in accordance with federal and state laws and regulations.

Keeping the corridors free of woody vegetation can create suitable habitat for protected plant species (e.g., rare, threatened, endangered) that depend on open conditions. GPC cooperates with the Georgia DNR Natural Heritage Program in management of sensitive sites within transmission corridors.

These same vegetation management practices will be applied to new corridors.

No areas designated by the U.S. Fish and Wildlife Service (USFWS) as “critical habitat” for endangered species exist on or adjacent to existing VEGP transmission lines. The transmission corridors do not cross state or federal parks. Approximately 4.4 miles of the Scherer transmission corridor passes through the Oconee National Forest. Approximately 0.4 miles of the Thallman transmission corridor passes through the Ebenezer Creek Swamp, a privately-owned National Natural Landmark. GPC procedures specifically address corridor and transmission line maintenance in this swamp in accordance with the VEGP Environmental Protection Plan. For example, routine maintenance involving tree trimming is done by hand in this area. The Thallman transmission corridor also crosses the Yuchi Wildlife Management Area, which is adjacent to VEGP, and the Tuckahoe Wildlife Management Area, approximately 30 miles south of VEGP.

Although almost all portions of the VEGP transmission corridors are located in Georgia, approximately 17 miles of the 21.5-mile South Carolina Electric & Gas Company (SCE&G) transmission corridor are in South Carolina. This portion of the corridor is maintained by SCE&G which has its own set of transmission line maintenance procedures that are protective of the environment.

Potential impacts associated with corridor maintenance activities will be SMALL.

The proposed new 500 kV transmission line is discussed in Section 3.7. The macro-corridor study conducted in January 2007 provided information to support the NRC NEPA review (**Photoscience 2007).** Impacts of transmission lines on terrestrial resources during operations will be SMALL and will not warrant mitigation.

Transmission line corridor management was evaluated in NUREG-1437. The impacts were found to be of small significance at operating nuclear power plants. Based on GPC procedures and the NRC analysis of the impacts of corridor management, SNC concludes that the effects of transmission corridor maintenance on the new transmission line corridor will be SMALL.

The effects of transmission line maintenance and vegetation management on floodplains and wetlands were evaluated in NUREG-1437. The impacts were found to be of small significance at operating nuclear power plants. Based on GPC procedures and the NRC analysis, SNC concludes that the effects of new transmission corridor maintenance on floodplains and wetlands will be SMALL.

Transmission line and corridor maintenance personnel have not reported dead birds from collisions or contact with VEGP transmission lines. GPC has an Avian Protection Plan in place to monitor and address the impacts of transmission lines or structures on birds. All issues are coordinated with the U.S. Fish and Wildlife Service as provided for in the Avian Protection Plan. Any additional transmission line will not be expected to cause significant avian mortality, and overall impacts will be SMALL.

5.6.2 Aquatic Ecosystems

This section discusses potential impacts of operation and maintenance of the transmission system on important aquatic habitats and species. Impacts of building, operating, and maintaining the existing transmission facilities for Units 1 and 2 were assessed in the FESs for construction **(AEC 1974)** and operation **(NRC 1985)** of the existing units. Section 4.1.2 discusses the proposed new transmission line. The proposed new line route will cross Burke, Jefferson, Warren, and McDuffie counties.

GPC has issued guidelines and procedures to its transmission engineering and delivery personnel to ensure that transmission lines are maintained and transmission rights-of-way are managed in such a way that important aquatic habitats are preserved and important aquatic species are protected. For example, the company's Routine Line Inspection and Maintenance Procedures require Transmission Delivery personnel to check transmission corridors at least three times a year for encroachment, erosion problems, or evidence of unauthorized logging or construction activity adjacent to the lines. Correcting erosion problems and curtailing unauthorized logging and construction serve to benefit aquatic communities in down-gradient streams and wetlands.

In addition to inspections intended to identify and correct problems, GPC has adopted practices and procedures for mitigating environmental impacts from maintenance of transmission lines. GPC requires line crews engaged in operation and maintenance of transmission lines crossing waterways to:

- Keep vegetative disturbance to a minimum

- Grade and grass disturbed areas to prevent erosion and sedimentation
- Avoid environmentally sensitive areas including National Wild and Scenic Rivers, waterfowl nesting areas, water supply intakes, "concentrated" shellfish spawning areas, and endangered species habitats
- Build crossings so as to minimize placement of fill material in the waterway or adjacent wetland
- Remove (temporary) fill material in its entirety and restore the area to its original elevation

Among the maintenance commitments memorialized in the VEGP operating license, GPC has agreed that maintenance within designated wetland areas must be conducted so as to not disturb the bottom substrate. When necessary, board roads or mats will be employed to prevent substrate damage. No dredge or fill activities that will result in a discharge of sediment within the wetland areas is allowed without a USACE permit.

5.6.2.1 Important Habitats

The proposed 500 kV transmission line is unlikely to cross any state parks, national parks, state conservation areas, state or national wildlife refuges, or critical habitat for any federally listed species because Georgia can require that types of protected areas to be avoided if possible. The proposed new line will be routed northwest from the VEGP site, and could cross perennial or intermittent streams and associated floodplains or wetlands. Programs in place for the current transmission lines associated with VEGP provide controls to ensure protection of threatened and endangered species, wetlands, and cultural resources. These programs or similar programs will be utilized for the new transmission line and will provide an equivalent level of protection for ecological and cultural resources. Impacts of transmission lines on ecological resources during operations will be SMALL and will not warrant mitigation.

5.6.2.2 Important Species

Only two listed aquatic species, the shortnose sturgeon and the Atlantic pigtoe mussel, are known to occur in the counties crossed by the proposed transmission line. As noted in Section 2.4.2, shortnose sturgeons spawn in the Savannah River. Brier Creek, a major tributary of the Savannah River, will likely be crossed by the proposed transmission line. Because shortnose sturgeon do not leave the Savannah River during spawning runs to enter tributary streams, operation and maintenance of this line will have no effect on spawning shortnose sturgeon.

As discussed in Section 2.4.2, the Atlantic pigtoe mussel is found in a tributary of the Ogeechee River (Willamson Swamp Creek) in Jefferson County. The new line could pass within two miles of the creek. Because of the distance, transmission line maintenance associated with the new line will have no effect on Williamson Swamp Creek, thus no effect on the creek's Atlantic pigtoe mussels.

As discussed throughout this section, GPC has procedures in place to ensure that erosion and sedimentation are controlled and herbicides are used sparingly. Because GPC has adopted practices and procedures to prevent impacts to surface waters and wetlands, impacts to aquatic ecosystems from operation and maintenance of transmission lines will be SMALL and will not warrant mitigation measures beyond the commitments already identified in this section.

5.6.3 Impacts to Members of the Public

5.6.3.1 Electrical Shock

Objects located near transmission lines can become electrically charged due to their immersion in the lines' electric field. This charge results in a current that flows through the object to the ground. The current is called "induced" because there is no direct connection between the line and the object. The induced current can also flow to the ground through the body of a person who touches the object. An object that is insulated from the ground can actually store an electrical charge, becoming what is called "capacitively charged." A person standing on the ground and touching a vehicle or a fence receives an electrical shock due to the sudden discharge of the capacitive charge through the person's body to the ground. After the initial discharge, a steady-state current can develop, the magnitude of which depends on several factors, including the following:

- the strength of the electric field which, in turn, depends on the voltage of the transmission line as well as its height and geometry
- the size of the object on the ground
- the extent to which the object is grounded.

The National Electrical Safety Code (NESC) has a provision that describes how to establish minimum vertical clearances to the ground for electric lines having voltages exceeding 98 kilovolts. The clearance must limit the induced current due to electrostatic effects to 5 milliamperes if the largest anticipated truck, vehicle, or equipment were short-circuited to ground. By way of comparison, the setting of ground fault circuit interrupters used in residential wiring (special breakers for outside circuits or those with outlets around water pipes) is 4 to 6 milliamperes.

As described in Section 3.7, two 500-kilovolt lines are proposed to service new generation considered for the Vogtle site, which may be configured in any combination of existing and potential new transmission lines. To determine the impacts of these lines on induced current shock, SNC analyzed a hypothetical span of a 500-kilovolt line originating at VEGP. The hypothetical case is for a ruling span that represents a template for the design of all the spans. The analyzed case is the most extreme condition expected on the line, given that the design standard for 500-kilovolt lines requires a minimum clearance of 45 feet to ground.

SNC calculated electric field strength and induced current using a computer code called ACDCLINE, produced by the Electric Power Research Institute. The results of this computer program have been field-verified through actual electrostatic field measurements by several utilities. The input parameters included the design features of the ruling span at the point of lowest clearance, the NESC requirement that line sag be determined at 120ºF conductor temperature, and the maximum vehicle size under the lines (a tractor-trailer).

The analysis determined that 500-kilovolt lines that connect to VEGP have the capacity to induce up to 3.8 milliamperes in a vehicle parked beneath the line. Should a new transmission line be constructed in the same corridor as an existing line, it is possible that the induced current beneath the two lines could exceed the 3.8 milliamp value calculated for a single line alone. Due to vector summing, the cumulative impact could also be less. SNC commits to design any new transmission lines to ensure compliance with the 5-milliamp standard for the two lines acting in concert. Consequently, impacts will be SMALL.

5.6.3.2 Electromagnetic Field Exposure

In 1992, the U.S. Congress established a research and educational program designed to determine if exposure to extremely low frequency electric and magnetic fields (ELF-EMF) was harmful to humans. The research and information compilation effort was conducted by the National Institute of Environmental Health Sciences (NIEHS), the National Institutes of Health, and the Department of Energy. Their findings **(NIEHS 1999)** state, “The scientific evidence suggesting that ELF-EMF exposures pose any health risk is weak.” Nevertheless, NIEHS concluded that such exposure could not be ruled as entirely safe, but that the evidence was insufficient to warrant aggressive regulatory concern. SNC concurs with this finding, but nonetheless continues to monitor industry research on this subject.

5.6.3.3 Noise

High-voltage transmission lines can emit noise when the electric field strength surrounding them is greater than the breakdown threshold of the surrounding air, creating a discharge of energy. This energy loss, known as corona discharge, is affected by ambient weather conditions such as humidity, air density, wind, and precipitation and by irregularities on the energized surfaces. GPC transmission lines are designed and constructed with hardware and conductors with features to eliminate corona discharge. Nevertheless, during wet weather, the potential for corona loss increases, and nuisance noise could be present if insulators or other hardware have any defects. Corona-induced noise along the existing transmission lines is very low or inaudible, except possibly directly below the line on a quiet, humid day. Such noise does not pose a risk to humans. In its Environmental Protection Plan **(SNC 1989)**, SNC committed to monitor complaints on transmission line noise and report them to NRC; SNC has not received any reports of nuisance noise from members of the public. Accordingly, SNC does not expect complaints on nuisance noise from the proposed ESP transmission lines and concludes impacts will be SMALL.

5.6.3.4 Radio and Television Interference

GPC very seldom receives complaints on electromagnetic interference with radio or television reception. In those few cases, the cause was from corona discharge from defective insulators or hardware. GPC replaced the defective component to correct the problem. As described in section 5.6.3.3, GPC transmission lines are designed to be corona-free up to their maximum operating voltage. A 1974 study on radio noise around GPC 500-kilovolt lines near Atlanta indicated that radio noise outside a 150-foot corridor is minimal. SNC expects that radio and television interference from any new lines will be SMALL.

5.6.3.5 Visual Impacts

Should new transmission lines be constructed for new generation at the Vogtle site, they will be sited in accordance with long-standing procedures that take into consideration environmental and visual values. SNC will attempt to maintain important viewscapes. Where possible natural vegetation will be retained at road crossings to help minimize ground-level visual impacts. Contractors performing routine vegetation control on the transmission lines will be instructed to maintain a screen of natural vegetation in the right-of-way on each side of major highways and rivers, unless engineering requirements dictate otherwise. Accordingly, the visual impacts to members of the public from the transmission system will be SMALL.

Section 5.6 References

(AEC 1974) U.S. Atomic Energy Commission, Final Environmental Statement related to the proposed Alvin W. Vogtle Nuclear Plant Units 1, 2, 3, and 4, Directorate of Licensing, Washington, DC, March.

(NIEHS 1999) "NEIHS Report on Health Effects from Exposure to Power-Line Frequency Electric and Magnetic Fields," Publication No. 99-4493, Research Triangle Park, North Carolina, 1999.

(NRC 1985) U.S. Nuclear Regulatory Commission, Final Environmental Statement related to the operation of Vogtle Electric Generating Plant, Units 1 and 2, Office of Nuclear Reactor Regulation, Washington, DC, March.

(Photoscience 2007) Photoscience, Corridor Study: Thompson – Vogtle 500 kV Transmission Project. Prepared for Georgia Power Company. January 2007.

(SNC 1989) Appendix B to Facility Operating License No. NPF-68 and Facility Operating License No. NPF-81, Vogtle Electric Generating Plant Units 1 and 2, Docket Nos. 50-424 and 50-425, Environmental Protection Plan (Nonradiological), Birmingham, Alabama, March 31, 1989.

5.7 Uranium Fuel Cycle Impacts

This section discusses the environmental impacts from the uranium fuel cycle for the AP1000. The uranium fuel cycle is defined as the total of those operations and processes associated with provision, utilization, and ultimate disposal of fuel for nuclear power reactors.

The regulations in 10 CFR 51.51(a) state that

> *Every environmental report prepared for the construction permit stage of a light-water-cooled nuclear power reactor, and submitted on or after September 4, 1979, shall take Table S-3, Table of Uranium Fuel Cycle Environmental Data, as the basis for evaluating the contribution of the environmental effects of uranium mining and milling, the production of uranium hexafluoride, isotopic enrichment, fuel fabrication, reprocessing of irradiated fuel, transportation of radioactive materials and management of low level wastes and high level wastes related to uranium fuel cycle activities to the environmental costs of licensing the nuclear power reactor. Table S-3 shall be included in the environmental report and may be supplemented by a discussion of the environmental significance of the data set forth in the table as weighed in the analysis for the proposed facility.*

Table S-3 is used to assess environmental impacts. Its values are normalized for a reference 1000-MWe LWR at an 80-percent capacity factor. The 10 CFR 51.51(a) Table S-3 values are reproduced as the “Reference Reactor” column in Table 5.7-1. SNC has analyzed an AP1000 unit operating at 93 percent capacity factor in this ESP application. The results of this analysis are also included in Table 5.7-1.

Specific categories of natural resource use are included in Table S-3 (and duplicated in Table 5.7-1). These categories relate to land use, water consumption and thermal effluents, radioactive releases, burial of transuranic and high-level and low-level wastes, and radiation doses from transportation and occupational exposure. In developing Table S-3, the NRC considered two fuel cycle options, which differed in the treatment of spent fuel removed from a reactor. “No recycle” treats all spent fuel as waste to be stored at a Federal waste repository; “uranium only recycle” involves reprocessing spent fuel to recover unused uranium and return it to the system. Neither cycle involves the recovery of plutonium. The contributions in Table S-3 resulting from reprocessing, waste management, and transportation of wastes are maximized for both of the two fuel cycles (uranium only and no recycle); that is, the identified environmental impacts are based on the cycle that results in the greater impact.

Because the United States does not currently reprocess spent fuel, only the no-recycle option is considered here. Natural uranium is mined from either open-pit or underground mines or by an in-situ leach solution process. In situ leach mining, the primary form used in the United States today, involves injecting a lixiviant solution into the uranium ore body to dissolve uranium and then pumping the solution to the surface for further processing. The ore in in-situ leach solution is transferred to mills where it is processed to produce uranium oxide (UO_2) or “yellowcake”. A conversion facility prepares the uranium oxide from the mills for enrichment by converting it to uranium hexafluoride, which is then processed to separate the relatively nonfissile isotope uranium-238 from the more fissile isotope uranium-235. At a fuel-fabrication facility, the enriched uranium, which is approximately 5 percent uranium-235, is converted to UO_2. The UO_2 is pelletized, sintered, and inserted into tubes to form fuel assemblies. The fuel assemblies are placed in the reactor to heat water to steam which turns turbines which produce power. The nuclear reaction reduces the amount of uranium-235 in the fuel. When the uranium-235 content of the fuel reaches a point where the nuclear reaction becomes inefficient, the fuel assemblies are withdrawn from the reactor. After onsite storage for a time sufficient to allow the short-lived fission products to decay thus reducing the heat generation rate, the fuel assemblies will be transferred to a permanent waste disposal facility for internment. Disposal of spent fuel elements in a repository constitutes the final step in the no-recycle option.

The following assessment of the environmental impacts of the fuel cycle for an AP1000 at VEGP is based on the values in Table S-3 and the NRC’s analysis of the radiological impacts from radon-222 and technetium-99 in NUREG-1437 which SNC has reviewed and updated for this analysis. NUREG-1437 and Addendum 1 to the GEIS **(NRC 1999)**, provide a detailed analysis of the environmental impacts from the uranium fuel cycle. Although NUREG-1437 is specific to impacts related to license renewal, the information is relevant to this review because the advanced LWR designs considered here use the same type of fuel.

The fuel impacts in Table S-3 are based on a reference 1000-MWe LWR operating at an annual capacity factor of 80 percent for a net electric output of 800 MWe. SNC is considering operating two AP1000 at VEGP. The standard configuration (a single unit) will be used to evaluate uranium fuel cycle impacts relative to the reference reactor. In the following evaluation of the environmental impacts of the fuel cycle, SNC conservatively assumed a gross electrical output of 1,150 MWe **(Westinghouse 2003)** and a capacity factor of 93 percent for a total gross electric output of approximately 1,070 MWe for the AP1000, the AP1000 output is approximately one and one third times the output used to estimate impact values in Table S-3 (reproduced here as the first column of Table 5.7-1) for the reference reactor. Analyses presented here are scaled from the 1000-MWe reference reactor impacts to reflect the output of one AP1000.

Recent changes in the fuel cycle may have some bearing on environmental impacts; however, as discussed below, SNC is confident that the contemporary fuel cycle impacts are bounded by values in Table S-3. The NRC calculated the values in Table S-3 from industry averages for the performance of each type of facility or operation associated with the fuel cycle. NRC chose assumptions so that the calculated values will not be under-estimated. This approach was intended to ensure that the actual values will be less than the quantities shown in Table S-3 for all LWR nuclear power plants within the widest range of operating conditions. Since Table S-3 was promulgated changes in the fuel cycle and reactor operations have occurred. For example, the estimate of the quantity of fuel required for a year’s operation of a nuclear power plant can now reasonably be calculated assuming a 60-year lifetime (40 years of initial operation plus a 20-year license renewal term). This was done in NUREG-1437 for both BWR and PWRs, and the highest annual requirement (35 metric tonnes [MT] of uranium made into fuel for a BWR) was used in NUREG-1437 as the basis for the reference reactor year. A number of fuel management improvements have been adopted by nuclear power plants to achieve higher performance and to reduce fuel and enrichment requirements, reducing annual fuel requirements. For example, an AP1000 requires about 23 MTU per year. Therefore, Table S-3 remains a conservative estimate of the environmental impacts of the fuel cycle fueling nuclear power reactors operating today.

Another change is the elimination of the U.S. restrictions on the importation of foreign uranium. The economic conditions of the uranium market now and in the foreseeable future favor full utilization of foreign uranium at the expense of the domestic uranium industry. These market conditions have forced the closing of most U.S. uranium mines and mills, substantially reducing the environmental impacts in the United States from these activities. However, the Table S-3 estimates have not been adjusted accordingly so as to ensure that these impacts, which will have been experienced in the past and may be fully experienced in the future, are considered. Factoring in changes to the fuel cycle suggests that the environmental impacts of mining and tail millings could drop to levels below those in Table S-3. Section 6.2 of NUREG-1437 discusses the sensitivity of these changes in the fuel cycle on the environmental impacts.

Finally, the no-recycle option might not always be the only option for spent fuel disposition in this country. The Energy Policy Act of 2005 (Pub. L. No. 109-58) directs the U. S. Department of Energy (DOE) to conduct an advanced fuel recycling technology research, development, and demonstration program to evaluate proliferation-resistant fuel recycling and transmutation technologies. DOE has reported to Congress on a plan to begin limited recycling of fuel with current reactors by 2025, and transitional recycling with current reactors by 2040 **(DOE 2005)**. Thus, during the 40-year term of the licenses to operate VEGP, it is possible that spent fuel recycling becomes available. However, many actions on the part of DOE will be necessary before this research and development concept becomes a technological reality. For this reason, SNC has concluded that this option is too speculative to warrant further consideration for VEGP.

5.7.1 Land Use

The total annual land requirements for the fuel cycle supporting an AP1000 will be about 150 acres. Approximately 17 acres will be permanently committed land, and 130 acres will be temporarily committed. A “temporary” land commitment is a commitment for the life of the specific fuel cycle plant (e.g., a mill, enrichment plant, or succeeding plants). Following decommissioning the land could be released for unrestricted use. “Permanent” commitments represent land that may not be released for use after decommissioning because decommissioning does not result in the removal of sufficient radioactive material to meet the limits of 10 CFR 20, Subpart E for release of an area for unrestricted use.

In comparison, a coal-fired plant with the same MW(e) output as the AP1000 using strip-mined coal requires the disturbance of about 270 acres per year for fuel alone. The impacts on land use will be SMALL and will not warrant mitigation.

5.7.2 Water Use

Principal water use for the fuel cycle supporting this ESP application will be that required to remove waste heat from the power stations supplying electricity to the enrichment process. Scaling from Table S-3, of the total annual water use of 1.52×10^{10} gallons for the AP1000 fuel cycle, about 1.48×10^{10} will be required for the removal of waste heat. Evaporative losses from fuel cycle process cooling will be about 2.1×10^{8} gallons per year and mine drainage will account for 1.7×10^{8} gallons per year. Impacts on water use will be SMALL and not warrant mitigation.

5.7.3 Fossil Fuel Impacts

Electric energy and process heat are required during various phases of the fuel cycle process. The electric energy is usually produced by the combustion of fossil fuel at conventional power plants. Electric energy associated with the fuel cycle represents about 5 percent of the annual electric power production of the reference 1000-MWe LWR. Process heat is primarily generated by the combustion of natural gas. This gas consumption, if used to generate electricity, will be less that 0.4 percent of the electrical output from the reference reactor. The direct and indirect consumption of electrical energy for fuel cycle operations will be small relative to the power production of the proposed units.

5.7.4 Chemical Effluents

The quantities of liquid, gaseous and particulate discharges associated with the fuel cycle processes are given in Table S-3 (Table 5.7-1) for the reference 1000-MWe LWR. The quantities of effluents for an AP1000 will be approximately one and one-third times greater than those in Table S-3 (Table 5.7-1). The principal effluents are SO_x, NO_x, and particulates. Based on the U.S. Environmental Protection Agency National Air Pollutant Emissions Estimates for 2000 **(EPA 2005)**, these emissions constitute less than 0.1 percent of all SO_2 emissions in 2000, and 0.01 percent of all NO_X emissions in 2000.

Liquid chemical effluents produced in the fuel cycle processes are related to fuel enrichment and fabrication and may be released to receiving waters. All liquid discharges into navigable waters of the United States from facilities associated with fuel cycle operations are subject to requirements and limitations set by an appropriate federal, state, regional, local or Tribal regulatory agency. Tailing solutions and solids are generated during the milling process and are not released in quantities sufficient to have a significant impact on the environment. Impacts from chemical effluents will be SMALL and will not warrant mitigation.

5.7.5 Radioactive Effluents

Radioactive gaseous effluents estimated to be released to the environment from waste management activities and certain other phases of the fuel cycle are set forth in Table S-3 (Table 5.7-1). From these data the 100-year environmental dose commitment to the U.S. population was calculated for one year of the fuel cycle for the AP1000 in this ESP application (excluding reactor releases and dose commitments due to radon-222 and technetium-99). The dose commitment to the U.S. population will be approximately 5.3 person-Sv (530 person-rem) per year of operation of the AP1000.

The additional whole body dose commitment to the U.S. population from radioactive liquid wastes effluents due to all fuel cycle operations other than reactor operation will be approximately 2.7 person-Sv (270 person-rem) per year of operation. Thus the estimated 100-year environmental dose commitment to the U.S. population from the fuel cycle is approximately 8 person-Sv (800 person-rem) to the whole body per reactor-year for the AP1000.

The radiological impacts of radon-222 and technetium-99 releases are not included in Table S-3. Principal radon releases occur during mining and milling operations and as emissions from mill tailings. Principal technetium-99 releases occur as releases from the gaseous diffusion enrichment process. NRC provided an evaluation of these technetium-99 and radon-222 releases in NUREG-1437. SNC has reviewed the evaluation, considers it reasonable, and has provided it as part of this ESP application.

Section 6.2 of NUREG-1437 estimates radon-222 releases from mining and milling operations and from mill tailings for a year of operation of the reference 1000-MWe LWR. The estimated releases of radon-222 for one AP1000 reactor year are 6,900 Ci. Of this total, about 78 percent will be from mining, 15 percent from milling, and 7 percent from inactive tails before stabilization. Radon releases from stabilized tailings were estimated to be 1.5 Ci per year for the AP1000; that is one and one-third times the NUREG-1437 estimate for the reference reactor year. The major risks from radon-222 are from exposure to the bone and lung, although there is a small risk from exposure to the whole body. The organ-specific dose weighting factors from 10 CFR 20 were applied to the bone and lung doses to estimate the 100-year dose commitment from radon-222 to the whole body. The 100-year estimated dose commitment from mining, milling and tailings before stabilization for the AP1000 will be approximately 12 person-Sv (1,200 person-rem) to the whole body. From stabilized tailing piles, the same estimated 100-year environmental dose commitment will be approximately 0.23 person-Sv (23 person-rem) to the whole body.

NUREG-1437 considered the potential health effects associated with the releases of technetium-99. The estimated releases for the AP1000 will be 0.0094 Ci from chemical processing of recycled uranium hexafluoride before it enters the isotope enrichment cascade and 0.0067 Ci into groundwater from a high-level-waste repository. The major risks from technetium are from exposure of the gastrointestinal tract and kidneys, and a small risk from whole-body exposure. Applying the organ-specific dose-weighting factors from 10 CFR 20 to the gastrointestinal tract and kidney doses, the total-body 100-year dose commitment from technetium-99 is estimated to be 1.3 person-Sv (130 person-rem) for the AP1000.

Although radiation can cause cancer at high doses and high dose rates, no data unequivocally establish a relationship between cancer and low doses or low dose rates, below about 100 mSv (10,000 mrem). However, to be conservative radiation protection experts assume that any amount of radiation may pose some risk of cancer, or a severe hereditary effect, and that higher radiation exposures create higher risks. Therefore, a linear, no-threshold dose response relationship is used to describe the relationship between radiation dose and detrimental effects. Based on this model, risk to the public from radiation exposure can be estimated using the nominal probability coefficient (730 fatal cancers, non-fatal cancers or severe hereditary effects per 10,000 person-Sv [1,000,000 person-rem]) from the International Commission on Radiation Protection Publication 60 **(ICRP 1991)**. This coefficient, multiplied by the sum of the estimated whole-body population doses estimated above for the AP1000, approximately 22 person-Sv per year (2,200 person-rem per year), estimates that the U.S. population could incur a total of approximately 1.6 fatal cancers, non-fatal cancers or severe hereditary effects from the annual fuel cycle for the AP1000. This risk is small compared to the number of fatal cancers, non-fatal cancers and severe hereditary effects that will be estimated to occur in the U.S. population annually from exposure to natural sources of radiation using the same risk estimation methods.

Based on these analyses, SNC concludes that the environmental impacts of radioactive effluents from the fuel cycle will be SMALL and will not warrant mitigation.

Table 5.7-1 10 CFR 51.51 Table S-3 of Uranium Fuel Cycle Environmental Data (normalized to model LWR annual fuel requirement [WASH-1248] or reference reactor year [NUREG-0116])[1] compared to proposed AP1000 configuration

	Ref. Reactor	AP1000
MWe	1000	1150
Capacity	0.8	0.93
MWe	800	1070
Environmental Considerations		
Natural Resource Use		
Land (acres)		
Temporarily committed[2]	100	130
Undisturbed area	79	110
Disturbed area	22	29
Permanently committed	13	17
Overburden moved (million of MT)	2.8	3.7
Water (millions of gallons)		
Discharged to air	160	210
Discharged to water bodies	11,090	15,000
Discharged to ground	127	170
Total	11,377	15,000
Fossil fuel		
Electrical energy (thousands of MW-hour)	323	430
Equivalent coal (thousands of MT)	118	160
Natural gas (millions of scf)	135	180
Effluents — Chemicals (MT)		
Gases (including entrainment)[3]		
SO_x	4400	5,900
NO_x[4]	1190	1,600
hydrocarbons	14	19
CO	29.6	40
particulates	1154	1,500
Other gases		
F	0.67	0.90
HCl	0.014	0.019

Table 5.7-1 (cont.) 10 CFR 51.51 Table S-3 of Uranium Fuel Cycle Environmental Data (normalized to model LWR annual fuel requirement [WASH-1248] or reference reactor year [NUREG-0116])[1] compared to proposed AP1000 configuration

		Ref. Reactor	AP1000
	Environmental Considerations		
Liquids			
	SO^{4-}	9.9	13
	NO^{3-}	25.8	34
	fluoride	12.9	17
	Ca^{++}	5.4	7.2
	Cl^{-}	8.5	11
	Na^{+}	12.1	16
	NH_3	10	13
	Fe	0.4	0.53
	Tailings solutions (thousands of MT)	240	320
Solids		91,000	120,000
	Effluents — radiological (curies)		
Gases			
	$Rn^{222(5)}$		
	Ra^{226}	0.02	0.027
	Th^{230}	0.02	0.027
	U	0.034	0.045
	H^3 (thousands)	18.1	24
	C^{14}	24	32
	Kr^{85} (thousands)	400	530
	Ru^{106}	0.14	0.19
	I^{129}	1.3	1.7
	I^{131}	0.83	1.1
	$Tc^{99(5)}$		
	Fission products and TRU	0.203	0.27
Liquids			
	U and daughters	2.1	2.8
	Ra^{226}	0.0034	0.0045
	Th^{230}	0.0015	0.0020
	Th^{234}	0.01	0.013
	fission and activation	5.90E-06	7.9E-06

Table 5.7-1 (cont.) 10 CFR 51.51 Table S-3 of Uranium Fuel Cycle Environmental Data (normalized to model LWR annual fuel requirement [WASH-1248] or reference reactor year [NUREG-0116])[1] compared to proposed AP1000 configuration

	Ref. Reactor	AP1000
Environmental Considerations		
Solids buried		
not HLW (shallow)	11,300	15,000
TRU and HLW (deep)	1.10E+07	1.5E+07
Effluents – thermal (Billions of Btu)	4063	5400
Transportation (person rem)		
exposure of workers and the general public	2.5	3.3
occupational exposure	22.6	30

TRU transuranic
HLW high level waste

1 In some cases where no entry appears in Table S-3 it is clear from the background documents that the matter was addressed and that, in effect, the table should be read as if a specific zero entry had been made. However, there are other areas that are not addressed at all in the table. Table S-3 does not include health effects from the effluents described in the table, or estimates of releases of radon-222 from the uranium fuel cycle or estimates of technetium-99 released from waste management or reprocessing activities. Radiological impacts of these two radionuclides are addressed in NUREG-1437, "Generic Environmental Impact Statement for License Renewal of Nuclear Plants, (1996) and it was concluded that the health effects from these two radionuclides posed a small significance.
Data supporting Table S-3 are given in the "Environmental Survey of the Uranium Fuel Cycle", WASH-1248 (April 1974); the "Environmental Survey of Reprocessing and Waste Management Portion of the LWR Fuel Cycle," NUREG-0116 (Supplement 1 to WASH-1248); the "Public Comments and Task Force Responses Regarding the Environmental Survey of the Reprocessing and Waste Management Portions of the LWR Fuel Cycle," NUREG-0216 (Supp. 2 to WASH-1248); and in the record of final rule making pertaining to "Uranium Fuel Cycle Impacts from Spent Fuel Reprocessing and Radioactive Waste Management, Docket RM-50-3." The contributions from reprocessing, waste management and transportation of wastes are maximized for either of the two fuel cycles (uranium only and fuel recycle). The contribution from transportation excluded transportation of cold fuel to a reactor and of irradiated fuel and radioactive wastes from a reactor which are considered in Table S-4 of § 51.20(g). The contributions from the other steps of the fuel cycle are given in columns A-E of Table S-3A of WASH-1248.

2 The contributions to temporarily committed land from reprocessing are not prorated over 30 years, since the complete temporary impact accrues regardless of whether the plant services one reactor for one year or 57 reactors for 30 years.

3 Estimated effluents based upon combustion of coal for equivalent power generation.

4 1.2 percent from natural gas use and processes.

5 Radiological impacts of radon-222 and technetium-99 are addressed in NUREG-1437, "Generic Environmental Impact Statement for License Renewal of Nuclear Plants," (May 1996). The GEIS concluded that the health effects from these two radionuclides pose a small risk.

Section 5.7 References

(DOE 2005) U.S. Department of Energy, 2005, Report to Congress: Advanced Fuel Cycle Initiative Objectives, Approach and Technology Summary. Executive Summary, Office of Nuclear Energy, Science and Technology, Washington, D.C. May.

(EPA 2005) U.S. Environmental Protection Agency, Air Emission Trends – Continued Program through 2004, available at http://www.epa.gov/cgi-bin/epaprintonly.cgi. Accessed August 30, 2005

(ICRP 1991) 1990 Recommendations of the International Commission of Radiological Protection, ICRP Publication 60, Annals of the ICRP 21(1-3), Pergammon Press, New York, New York, 1991.

(NRC 1999) U.S. Nuclear Regulatory Commission, 1996, Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Section 6.3, “Transportation,” and Table 9-1, “Summary of findings on NEPA issues for license renewal of nuclear power plants,” NUREG-1437, Volume 1, Addendum 1, Office of Nuclear Regulatory Research, Washington D.C., August.

(Westinghouse 2003) Westinghouse Electric Company, LLC, AP1000 Siting Guide: Site Information for an Early Site Permit Application, APP-0000-X1-001, Revision 3, April 24.

5.8 Socioeconomic Impacts

5.8.1 Physical Impacts of Station Operation

This section assesses the potential physical impacts due to operation of the new units on the nearby communities or residences. Potential impacts include noise, odors, exhausts, thermal emissions, and visual intrusions. These physical impacts will be managed to comply with applicable federal, state and local environmental regulations and will not significantly affect the VEGP site and its vicinity.

There are no residential areas located within the site boundary. The area within 10 miles of the VEGP site is estimated to be populated by approximately 3,500 people (see Section 2.5). This area is predominately rural and characterized by farmland and wooded tracts. No significant industrial or commercial facilities other than VEGP exist or are planned for this area. Population distribution details are given in Section 2.5.1.1.

5.8.1.1 Air

Burke County is part of the Augusta-Aiken Interstate Air Quality Control Region (AQCR) (40 CFR 81.114). All areas within the Augusta-Aiken AQCR are classified as achieving attainment with the National Ambient Air Quality Standards (NAAQS) (40 CFR 81.311 and 40 CFR 81.341). The NAAQS define ambient concentration criteria for sulfur dioxide (SO_2), particulate matter with aerodynamic diameters of 10 microns or less (PM_{10}), particulate matter with aerodynamic diameters of 2.5 microns or less ($PM_{2.5}$), carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), and lead (Pb). These pollutants are generally referred to as “criteria pollutants.” Areas of the United States having air quality as good as or better than the NAAQS are designated by the U.S. Environmental Protection Agency (EPA) as attainment areas. Areas with air quality that is worse than the NAAQS are designated by EPA as non-attainment areas. The nearest non-attainment area to VEGP is the Columbia, South Carolina metropolitan area, a non-attainment area under the 8-hour ozone standard, which is located approximately 80 miles northeast of the plant.

The new units will have standby diesel generators and auxiliary power systems. Emissions from those sources are described in Section 3.6.3. Certificates to operate these pieces of equipment will ensure that air emissions comply with regulations. The generators and auxiliary boilers will be operated periodically on a limited short-term basis. The impact of the operation of the new units on air quality will be SMALL, and will not warrant mitigation.

Good access roads and appropriate speed limits will minimize the amount of dust generated by the commuting work force.

During normal plant operation, the new units will not use chemicals in amounts that will generate odors exceeding the odor threshold value.

5.8.1.2 Thermal Emissions

Heat dissipation to the atmosphere from operation of the cooling towers is described in Section 5.3.3.1. Because there is no residential area within the site boundary, there will be no heat impacts on nearby communities.

5.8.1.3 Visual Intrusions

The nearest residence is more than one mile from the site of the proposed new units and is shielded by forested land. Given this distance, residents will not have a clear view of the new units. The intake structure will be clearly visible from the Savannah River, and the towers and top of the containment domes likely will be glimpsed from some locations on the river. However, the viewscape will be similar to the existing viewscape.

The visual impacts of the operation of the cooling towers will be the towers themselves and plumes resembling lines of clouds. Modeling indicated that the plumes will be most noticeable in the winter months. A plume could extend 5 to 6 miles from the VEGP site. The longest plume will occur 1 percent of the time or less in each direction.

Figure 5.8-1 depicts the amount of time that the modeled visible plume heads in each direction during the winter months. The length of the bars represents the frequency of a plume in each direction. The modeled plume heads towards the Savannah River Site (SRS) 47 percent of the time. The next most predominant frequencies are to the west-southwest and north-northwest.

Figure 5.8-2 depicts the maximum modeled plume length by direction and the frequency that the plume reaches the maximum length during the winter months. Many of the maximum modeled plume lengths are from 5 to 6 miles long, but none has a frequency greater than 1 percent.

Figures 5.8-3 and 5.8-4 depict the same information modeled for the summer months. The modeled plume heads towards the SRS 42 percent of the time. The next most predominant frequencies for the plume direction are to the south and west. The modeled maximum plume lengths are typically much shorter during the summer months and do not travel much farther than the VEGP site boundary except for less than one percent of the time, when the plume may reach 5 to 6 miles long. The predominant plume directions are to the north-northwest, northwest, and towards SRS.

5.8.1.4 Other Impacts

Roads within the vicinity of the VEGP site will experience a temporary increase in traffic at the beginning and the end of the workday. However, the current road network has sufficient capacity to accommodate the increase, as detailed in Section 5.8.2.2. Therefore, no significant traffic congestion will result from operation of the new units.

5.8.1.5 Conclusion

Physical impacts to the surrounding population as a result of operation of the new units will be SMALL and will not warrant mitigation.

5.8.2 Social and Economic Impacts

This section evaluates the demographic, economic, infrastructure, and community impacts to the region as a result of operating two AP1000 nuclear units at the VEGP site. The evaluation assesses impacts of operation and of demands placed by the workforce on the region. Operation of the new nuclear units could continue for 60 years (a potential 40-year initial operating license, plus 20 additional years of operation under a renewed license). A two-unit facility will require approximately 660 onsite employees.

It is likely that operation of the new units will overlap for a time with the continued operation of the existing units, which employ 890 onsite staff. The Units 1 and 2 VEGP refueling outages last approximately 4 to 6 weeks and require approximately 800 additional workers. For the new units, refueling outages will last 3 to 5 weeks and employ as many as 1000 additional workers.

5.8.2.1 Demography

The 2000 population within the 50-mile radius of the region was approximately 670,000 and is projected to grow to approximately 4.5 million by 2090, for an average annual growth rate over the 90-year period of 2.1 percent (see Table 2.5.1-1). SNC anticipates employing 660 operations workers at the new units. To be conservative, SNC assumes that all of the new units' employees will migrate into the region, and that each operations worker will bring a family. The average household size in Georgia and South Carolina are 2.65 and 2.53, respectively. To be conservative, SNC used the Georgia household size of 2.65 to estimate the increase in population in the 50-mile region. An operational workforce of 660 will increase the population in the 50-mile region by approximately 1,750 people.

Seventy-nine percent of the current VEGP workforce is distributed across Burke (20 percent), Richmond (26 percent), and Columbia (34 percent) Counties, and 20 percent is distributed across 25 other counties in the two-state region. SNC assumes that the new units' workforces' residential distribution will resemble that of the current VEGP workforce. Therefore, approximately 350 people will live in Burke County, 460 will live in Richmond County, and 590 will live in Columbia County. These numbers constitute 1.6 percent, 0.2 percent, and 0.7 percent of the 2000 populations of Burke, Richmond, and Columbia Counties, respectively.

The remaining employees and their families will be scattered throughout the other 25 counties within the 50-mile radius of VEGP. The operations workers and their families will represent a very small percent of the existing population.

Additional jobs in the region will result from the multiplier effect attributable to the new operations workforce. In the multiplier effect, each dollar spent on goods and services by an operations worker becomes income to the recipient who saves some but re-spends the rest. The recipient re-spending becomes income to someone else, who in turn saves part and re-spends the rest. The number of times the final increase in consumption exceeds the initial dollar spent is called the “multiplier.” The U.S. Department of Commerce Bureau of Economic Analysis Economics and Statistics Division provide multipliers for industry jobs and earnings **(BEA 2005)**. The economic model, RIMS II, incorporates buying and selling linkages among regional industries and was used to estimate the impact of new nuclear plant-related expenditure of money in the region of interest. For every operations job at the new units, an estimated additional 1.41 jobs will be created in the 50-mile region, which means that 660 direct jobs will result in an additional 930 indirect jobs for a total of approximately 1,600 new jobs in the region. Since most indirect jobs are service-related and not highly specialized, SNC assumes that most, if not all, indirect jobs will be filled by the existing workforce within the 50-mile region.

5.8.2.2 Impacts to the Community

5.8.2.2.1 Economy

The impacts of the new units’ operation on the local and regional economy depend on the region’s current and projected economy and population. The economic impacts of a potential 60-year period of operation are discussed below.

SNC assumes, conservatively, that all new operating personnel would come from outside of the 50-mile region. The employment of the operations workforce for such an extended period of time would have economic and social impacts on the surrounding region. Burke County will be the most affected county in the 50-mile region (i.e., the relationship of the net economic benefits of new nuclear units to the total economy of a county will be greatest in Burke County) because it is the most rural of the three counties that will be most affected, and because it will receive property tax revenues assessed on the new units, in addition to tax revenues generated by the operations workforce that will settle in the county.

The wages and salaries of the operating workforce will have a multiplier effect that could result in an increase in business activity, particularly in the retail and service industries. As stated previously (Section 5.8.2.1), for every new operations job an estimated additional 1.41 indirect jobs would be created, which means that the 660 direct jobs would result in an additional 930 jobs for a total of 1,600 jobs. SNC assumes that 132 direct operations workers (20 percent) would relocate to Burke County and 186 indirect workers (20 percent) would already reside in Burke County. SNC estimates that most indirect jobs would be service-related, not highly specialized, and filled by the existing workforce within the 50-mile region, particularly the three counties of interest. There are currently 7,800 unemployed workers in the three counties and 936 in Burke County. SNC anticipates that some or all of the indirect jobs created by the operations workforce will be filled by unemployed workers in these counties, especially Burke County. This will have a positive impact on the economy by providing new business and job opportunities for local residents. In addition, these businesses and employees will generate additional profits, wages, and salaries, upon which taxes will be paid.

SNC concludes that the impacts of Units 3 and 4 operations on the economy will be beneficial and SMALL everywhere in the region except Burke County, where the impacts will be beneficial and MODERATE, and that mitigation will not be warranted.

5.8.2.2.2 Taxes

Personal and Corporate Income Taxes

Georgia has a personal and corporate income tax. Employees of VEGP's new nuclear units will pay taxes on their wages and salaries to Georgia if (1) their residence is in Georgia, (2) they are nonresidents working in Georgia and filing a federal return which will include income from sources in Georgia that exceeds five percent of income from all sources, or (3) they have income that is subject to Georgia tax that is not subject to federal income tax.

GPC will pay Georgia a corporate income tax on the profits received from the sale of electricity generated by the new units. While the exact amount of tax payable to Georgia is not known, it could be substantial over the potential 60-year life of the plant. Although the taxes collected over the potential lifetime of the project could be large in absolute amounts, they will be small when compared to the total amount of taxes Georgia collects in any given year or over the 60-year period.

New businesses will pay income taxes, and will hire workers who will be taxed on wages and salaries. Thus, the tax base in the region will expand, particularly in the three counties most affected by the influx of new workers.

Sales and Use Taxes

Georgia, South Carolina, and the counties surrounding the VEGP site will experience an increase in the amount of sales and use taxes collected. Additional sales and use taxes will be generated by retail expenditures of the operating workforce.

Currently, it is difficult to assess which counties and local jurisdictions will be most impacted by sales and use taxes collected from the new workforce. Burke County is rural with limited shopping or entertainment options, although this will likely change over the estimated 60-year life of the new units. The retail center of the 50-mile region is the Augusta metropolitan area, so it is likely that the Augusta metropolitan area will realize the greatest increase in and derive the greatest benefit from sales and use taxes.

In absolute terms, the amount of sales and use taxes collected over a potential 60-year operating period could be large, but small when compared to the total amount of taxes collected by Georgia and South Carolina, and the affected counties.

Property Taxes

One of the main sources of economic impact related to the operation of new units will be property taxes assessed on the facility. Currently VEGP's tax payments represent 80-82 percent of the total property taxes received by Burke County (see Table 2.5.2-8). Property taxes that will be paid by the co-owners for the new units during operations depend on many factors, most of which are unknown at this time, including millage rates and the percent ownership of each co-owner. In order to provide some sense of the impacts of tax revenues, SNC made simplifying assumptions to develop an estimate of tax payments. For example, SNC has assumed that, beginning with the first year of construction, the new units will be valued annually by the Georgia Department of Revenue. A construction start date and operations schedule was assumed only to support this analysis and may be considerably different in actuality. Tax payments are calculated using different methodologies for investor-owned utilities and municipally-owned utilities or electric cooperatives, so for purposes of this analysis, SNC estimated property taxes by disregarding any joint ownership arrangements and assuming that the units will be subject to the ad valorem tax in Burke County as though owned by a single entity filing on a non-unit basis. Some percent of the new units will be exempt from the ad valorem property tax. Because the actual percent is not known, SNC made a preliminary assumption based on other generating facilities in Georgia. Neither the value of the Allowance for Funds Used During Construction (AFUDC; the cost of money), nor how much of AFUDC will be allowed to be recouped in the rate base is known. Therefore, SNC used generic assumptions. SNC based costs on reasonable assumptions supported by several independent studies **(MIT 2003, UC 2004, EIA 2004, OECD 2005)** and the company's own analyses.

Table 5.8.2-1 provides SNC estimates of property taxes that the new nuclear units could provide annually to Burke County during the 40-year period of operation. This estimated range is based on the range of estimated costs of the new units generated by information provided by GPC to the Georgia Public Service Commission (which has not been publicly disclosed) and costs taken from the studies mentioned above. The table shows decreasing tax payments over time due to the affect of depreciation.

The second source of property taxes will be on housing owned by the new workforce. To be conservative, SNC anticipates that the entire operations workforce will relocate from outside the region. New workers could construct new housing or increase the demand for existing housing, which could increase housing prices, increasing home values and property tax assessments. In the larger municipalities in the region, the increase in property taxes paid, though important and large when aggregated over time, will be insignificant compared to the total property taxes collected. In the less populated jurisdictions, such as Burke County, the effects could be more significant. For example, local planners consider Burke County fire-fighting capabilities to be under-staffed and under-funded. Increased tax revenues could be used to upgrade the Burke County fire-fighting capabilities.

Summary of Tax Impacts

SNC believes that the impact of additional taxes will be SMALL in the 50-mile region, except for Burke County where they will be MODERATE to LARGE and mitigation will not be warranted.

5.8.2.2.3 Land Use

NUREG-1437 presents an analysis of offsite land use during license renewal (i.e., operations) that is based on (1) the size of plant-related population growth compared to the area's total population, (2) the size of the plant's tax payments relative to the community's total revenue, (3) the nature of the community's existing land-use pattern, and (4) the extent to which the community already has public services in place to support and guide development. In the same document, NRC presents an analysis of offsite land use during refurbishment (i.e. large construction activities) that is based on population changes caused by refurbishment activities. SNC reviewed the criteria and methodology in NUREG-1437 and determined that NRC's criteria and methodology are appropriate to evaluate socioeconomic impacts of operation of new units.

Burke County is the focus of the land use analysis because the new units and a percentage of the workforce will reside there. A larger percentage of the workforce will live in Richmond and Columbia Counties, but those counties are heavily populated and land use changes there are influenced by a variety of other socioeconomic forces. Those forces will significantly dilute potential land use impacts created by the operation of the new units.

Based on the case-study analysis of refurbishment, in NUREG-1437 NRC concluded that all new land-use changes at nuclear plants will be:

SMALL	if population growth results in very little new residential or commercial development compared with existing conditions and if the limited development results only in minimal changes in the area's basic land use pattern.
MODERATE	if plant-related population growth results in considerable new residential and commercial development and the development results in some changes to an area's basic land use pattern.
LARGE	if population growth results in large-scale new residential or commercial development and the development results in major changes in an area's basic land-use pattern.

Second, NRC defined the magnitude of refurbishment-related population changes as follows:

SMALL	if plant-related population growth is less than five percent of the study area's total population, especially if the study area has established patterns of residential and commercial development, a population density of at least 60 persons per square mile, and at least one urban area with a population of 100,000 or more within 50 miles.
MODERATE	if plant-related growth is between five and 20 percent of the study area's total population, especially if the study area has established patterns of residential and commercial development, a population density of 30 to 60 persons per square mile, and one urban area within 50 miles.
LARGE	if plant-related population growth and density is greater than 20 percent of the area's total population is less than 30 persons per square mile.

Third, NRC defined the magnitude of license renewal-related tax impacts as:

SMALL	if the payments are less than 10 percent of revenue.
MODERATE	if the payments are between 10 and 20 percent of revenue.
LARGE	if the payments are greater than 20 percent of revenue.

Finally, NRC determined that, if the plant's tax payments are projected to be a dominant source of the community's total revenue, new tax-driven land-use changes will be large. This would be especially true where the community has no pre-established pattern of development or has not provided adequate public services to support and guide development in the past.

Off-site Land Use in Burke County

Burke County (830 sq mi); **(USCB 2006)** has the second largest land area of any county in Georgia and includes six small incorporated municipalities and a very large unincorporated area. The predominant land uses are agriculture and forestry (76 percent of the unincorporated area in the County in 1990) (Section 2.2). In 1990, developed areas represented approximately 6 to 7 percent of the total land area in the County (Section 2.2). Most industry is related to forestry and manufacturing and no new industries have located in the area as a result of VEGP's presence. Most of the current VEGP workforce does not live in Burke County.

As stated in Sections 2.2 and 2.5.2.4, Burke County and municipalities within the county use comprehensive land use planning, land development codes, zoning, and subdivision regulations to guide development. From 1990 to 2000, the Burke County population grew at an average annual growth rate of 0.8 percent. The County encourages growth in areas where public facilities, such as water and sewer systems, exist or are scheduled to be built in the future. Burke

County promotes the preservation of its communities' natural resources and has no growth control measures. The County is revising its comprehensive plan and developing a zoning plan.

Operations-Related Population Growth

This analysis assumes that 20 percent of the workforce needed to operate the new units will reside in Burke County. As stated in Section 2.5.1, the 2000 population of Burke County was approximately 22,243 with a population density of 27 persons per square mile. Burke County could gain 130 new families and 350 people or 2 percent, of the total 2000 populations of Burke County.

According to NRC guidelines, operations-related population changes will be considered small if plant-related population growth will be less than five percent of the study area's total population, the area has an established pattern of residential and commercial development, a population density of at least 60 persons per square mile, and at least one urban area with a population of 100,000 or more (Augusta: 195,182) within 50 miles. With the exception of population density, Burke County meets the NRC criteria and SNC concludes that changes to the population of Burke County due to VEGP operations will be SMALL. Anticipated population increases attributable to VEGP's workforce would represent 0.2 percent of the 2000 Richmond County population, 0.7 percent of the 2000 Columbia County population and even smaller percentage of the population of other counties in the 50-mile region. SNC concludes that impacts would be SMALL.

Tax Revenue-Related Impacts

VEGP's tax payments represent 80-82 percent of the total property taxes received by Burke County (see Table 2.5.2-8). Using NRC's criteria, SNC's tax payments are of large significance to Burke County. As described in Section 5.8.2.2.2, SNC expects that the new nuclear units will generate similar property tax revenue for Burke County.

Conclusion

Burke County is still predominantly rural, and land in the county will likely continue to be used for agriculture and forestry into the foreseeable future. Commercial and residential development is minimal and has experienced little change over the 20 years of existing plant operations. As stated in Section 2.5.2.6, Burke County has 900 vacant housing units, therefore the influx of operations workers and their families will not spur residential development, particularly since the operations workforce will arrive as the much larger construction workforce is leaving the area. The County's infrastructure and public services are sufficient to support the existing populations and will not be significantly impacted by the in-migration of the new workers and their families.

SNC concludes that Burke County is capable of meeting the needs of the anticipated work force without additional housing, infrastructure or public utilities and that impacts to other counties will be less significant than those in Burke County.

Although SNC property tax payments will continue to be of large significance, the population and land use in Burke County have not changed significantly since the construction of the original VEGP units, indicating that the tax revenues are not leading to significant land use impacts. Tax revenues assist with funding schools, emergency management systems, road maintenance, and county facilities.

Therefore, by NRC criteria, off-site land use changes will be SMALL and will not warrant mitigation.

5.8.2.2.4 Transportation

Impacts of new units' operations on transportation and traffic will be greatest on the rural roads of Burke County, particularly River Road, a two-lane highway which provides the only access to VEGP. Impacts on traffic are determined by four elements: (1) the number of operations workers and their vehicles on the roads; (2) the number of shift changes for the operations workforce; (3) the projected population growth rate in Burke County, and (4) the capacity of the roads.

SNC estimates it will employ an operation workforce of 660 workers at the new units. This analysis conservatively assumes one worker per vehicle. The existing units' workforce of 890 (and outage workforces of up to 1000) also will access VEGP via River Road.

Traffic congestion will be most noticeable during shift-change, which will occur three times a day. To enter the plant, the workforce will use the current access road that has a left turn lane from River Road to allow workers to enter the plant and other traffic to continue on, alleviating congestion.

Georgia Department of Transportation (DOT) assumes road capacity on two lane highways to be 1,700 passenger cars per hour (pc/h) for one direction and 3,200 pc/h for both directions combined **(TRB 2000)**. Traffic on River Road north of VEGP, as measured by the 2004 Average Annual Daily Traffic (AADT) was 1,277 in one direction (see Table 2.5.2-6 and Figure 2.5.2-2; location 33). Most traffic on River Road is related to VEGP, although there is some local traffic.

SNC doubled the 2004 AADT unidirectional count on River Road to arrive at an estimate of 2,554 vehicles on River Road in a single 24-hour period. For purposes of analysis SNC assumed that 100 percent of the 2,554 vehicles are attributable to the current VEGP workforce (60 percent day shift; 30 percent night shift; 10 percent graveyard shift). The AADT does not consider hourly traffic volume. After conservatively assuming that all traffic is due to VEGP workers, SNC assumed that all traffic on River Road occurred during shift change. SNC assumes that the afternoon shift change results in the highest hourly traffic count as approximately 800 day shift workers leave and 400 night shift workers arrive. Therefore, SNC uses 1,200 cars per hour as the basis for predicting the impacts of additional operations traffic.

The 2000 Burke County population was 22,243 (Table 2.5.1-3) and will increase by an estimated 20 percent by 2020, the earliest date SNC estimates operations activities will begin, however because most of the traffic on River Road is plant-related and because of the conservative assumptions SNC has made regarding the timing of VEGP traffic, local traffic was not factored into the analysis.

The capacity of River Road is 3,200 cars per hour, so there is enough capacity for an additional 2,000 passenger cars or equivalent beyond the current 1,200 cars per hour use now. AP1000 operations will increase the existing VEGP workforce by 660 workers, divided into four shifts. There could also be as many as 1,000 outage workers per unit (divided between two shifts) for approximately 1 month annually or semiannually. SNC assumes that the number of new operations workers per shift will be similar, in percentage, to the current operations workforce. Therefore, during the afternoon shift change, approximately 60 percent of the 660 operations workers will leave the VEGP site while 30 percent will arrive, increasing the vehicles on River Road by approximately 600, for a total of 1,800 vehicles. VEGP operations traffic will not exceed road capacity. During outages, assuming 1,000 additional vehicles, the number of vehicles on River Road could be 2,800 per hour, nearing but still less than, capacity.

SNC will stagger outage schedules so only one unit will be down at a time. Therefore, SNC is confident that road capacity will not be exceeded. SNC concludes that impacts to traffic will be SMALL at most times and MODERATE during shift changes during outages and that mitigation is not warranted.

5.8.2.2.5 Aesthetics and Recreation

As with the original units, SNC will work to minimize the visual impact of the structures through use of topography, design, materials and color. People boating on the Savannah River are used to seeing intake canals on that reach of the river, and people who reside in the area are used to the existing towers and plumes. Trees will screen the other plant facilities from view from the river and from River Road. The new towers will be similar in design to the existing towers, and the additional plumes will resemble cumulus clouds when seen from a distance. SNC has determined that impacts of operations on aesthetics will be SMALL and will not warrant mitigation.

The Yuchi WMA and a boat landing on the Savannah River are immediately south of VEGP on River Road. Additional worker traffic on River Road could adversely affect hunters and fishermen using the road to get to these recreation facilities. However, use of the WMA/boat landing is seasonal and not likely to coincide with shift traffic. Because it will be unlikely that hunters and fishermen will be on River Road at the same time as the workers, impacts will be

SMALL and will not warrant mitigation. The operation of new nuclear units at the existing VEGP site will not affect any other recreational facilities in the 50-mile region.

5.8.2.2.6 Housing

While there is no way of accurately estimating the number of available housing units at the commencement of operations, Section 2.5.2.6 reviews the year 2000 availability of housing in the region.

In 2000, there were 4,466 vacant rental units and 1,997 vacant housing units for sale in Burke, Richmond, and Columbia Counties. It is likely adequate housing will be available, especially in the larger metropolitan areas, at the time the workforce was needed. If 20 percent of the new workforce moved to Burke County, about 130 families will move into the county. While there is currently enough housing to accommodate all the new families expected in Burke County, not all housing may be the type sought by the new workforce. Therefore, a percentage of the operations workforce that could be expected to reside in Burke County could choose to live elsewhere in the three-county region or to construct new homes.

In all three counties, the average income of the new workforce will be expected to be higher than the median or average income in the county, therefore, the new workforce could exhaust the high-end housing market and some new construction could result. Burke County is the most likely county for this to happen. However, the availability of high-end housing in the region could mitigate any impacts. The majority of the current VEGP workforce lives in Richmond and Columbia Counties and the Columbia County housing market is rapidly expanding, as is evidenced by its four percent increase in housing between 1990 and 2000 (Table 2.5.2-10).

Refueling outages will occur at least annually, and sometimes semiannually, when the new and existing units are all operational. SNC estimates that the maximum increase in workforce will be 1,000 outage workers. These workers will need temporary (3 to 5 weeks) housing. Most of the outage workers will stay in local extended stay hotels, rent rooms in local homes or bring travel trailers. The outage workforce will not affect the permanent housing market in the region.

SNC concludes that the potential impacts on housing will be SMALL in Richmond and Columbia Counties and the 50-mile region of operations and SMALL to MODERATE in Burke County. Because the lead time for constructing and operating a nuclear facility is several years, and because the community will be aware of this construction project, people will recognize the opportunity for additional housing and construct new homes in anticipation of the arrival of the workforce. Additional mitigation will not be warranted.

5.8.2.2.7 Public Services

Water Supply Facilities

SNC considered both plant demand and plant-related population growth demands on local water resources. Section 2.5.2.7 describes the public water supply systems in the area, their permitted capacities, and current demands. The average per capita water usage in the U.S. is 90 gallons per day per person. Of that, 26 gallons is used for personal use **(EPA 2003)**. The balance is used for bathing, laundry and other household uses.

VEGP does not use water from a municipal system. Onsite wells provide potable water, and will provide the water for the new units as well. Therefore, water usage at the VEGP site, will not impact municipal water suppliers. VEGP is permitted to take an annual average of 5.5 million gallons of groundwater per day (mgd). The VEGP wells provided an average of 1.052 mgd of water between 2001 and 2004 for sanitary water facilities, central water supply, cooling water, process water, and irrigation (Section 4.2.2).

SNC has conservatively assumed that each new worker will require 26 gallons of potable water per day, for a total of 17,160 additional gallons. Impacts to groundwater from the additional workforce will be SMALL and not require mitigation.

Municipal water suppliers in the region have excess capacity (see Table 2.5.2-12). The impact to the local water supply systems from operations-related population growth can be estimated by calculating the amount of water that will be required by these individuals. The average person in the U.S. uses about 90 gallons per day **(EPA 2003)**. The operation-related population increase of 1,750 people could increase consumption by 157,500 gallons per day in an area where the excess public water supply capacity from groundwater in Burke County, alone, is approximately 3,000,000 gallons per day and regional aquifer yields of 2,000 gallons per minute are common. Impacts to municipal water suppliers from the operations related population increase will be SMALL and not warrant mitigation.

Waste Water Treatment Facilities

VEGP has a private wastewater treatment facility sized for the two existing units. As part of the new units' construction project, the facility will be expanded to support the increased capacity of the additional units. Therefore, operations will not impact the VEGP wastewater treatment facility.

Section 2.5.2.7 describes the public waste water treatment systems in the three counties, their permitted capacities, and current demands. Waste water treatment facilities in the three counties have excess capacity (see Table 2.5.2-13). The impact to local waste water treatment systems from operations-related population increases can be determined by calculating the amount of water that will be used and disposed of by these individuals. The average person in the U.S. uses about 90 gallons per day **(EPA 2003)**. To be conservative, SNC estimates that 100 percent of this water will be disposed of through the waste water treatment facilities. The operations-related population increase of 1,750 people could require 157,500 gallons per day of additional waste water treatment capacity in an area where the excess treatment capacity is approximately 19 million gallons per day. Impacts to waste water treatment facilities will be SMALL and not warrant mitigation.

Police Services

In 2001, Burke, Richmond, and Columbia Counties' persons per police officer ratios were 271:1, 998:1, and 992:1, respectively (see Table 2.5.2-14). Ratios are in part, dependent on population density. Fewer officers are necessary for the same population if the population resides in a smaller area. Local planning officials consider the level of police protection in the Central Savannah River Area, that includes the three counties, as adequate for the population **(CSRARDC 2005)**. SNC does now and will continue to employ its own security force at VEGP.

Burke County will see an influx of approximately 350 new residents. Approximately 460 new residents will move into Richmond County, and approximately 590 will move into Columbia County. The rest of the workforce will live in other counties in the 50-mile region. These population increases will increase the persons per police officer ratios (Table 5.8.2-1) by 0.3 and 0.7 percent in Richmond, and Columbia Counties, respectively. Burke County's person per police officer ratio will increase 1.8 percent, but the county will still have the lowest person to officer ratio of the three.

Based on the percentage increase in persons per police officer ratios, operations-related population increases will not adversely affect existing police services in Burke, Richmond or Columbia Counties.

SNC concludes that the potential impacts of new unit operations on police services in Burke, Richmond and Columbia Counties and in the 50-mile region will be SMALL and will not warrant mitigation.

Fire Protection Services

In 2001, Burke, Richmond, and Columbia Counties' persons per firefighter ratios were 890:1, 666:1, and 676:1, respectively (Table 2.5.2-14).

For new unit operations, Burke County will see an influx of approximately 350 new residents. Approximately 460 new residents will move into Richmond County, and approximately 590 will move into Columbia County. The rest of the workforce will live in other counties in the 50-mile region. These population increases will increase the persons per firefighter ratios (Table 5.8.2-2) by 0.2 and 0.7 percent in Richmond, and Columbia Counties, respectively. Burke County's person per firefighter ratio will increase 1.6 percent.

Based on the percentage increase in persons per firefighter ratios, operations-related population increases will not have a significant impact on existing fire protection services in Burke, Richmond, or Columbia Counties.

SNC concludes that the potential impacts of the new reactors' workforce on fire protection services in Burke, Richmond and Columbia Counties and the 50-mile region will be SMALL and mitigation will not be warranted.

Medical Services

Information on medical services in the three-county region is provided in Section 2.5.2.7. Minor injuries to operations workers will be assessed and treated by onsite medical personnel. Other injuries will be treated at one of the hospitals in the three-county region, depending on severity of the injury. SNC has agreements with some local medical providers to support emergencies at VEGP. SNC will revise the agreements to include emergency medical services for the additional workforce. Operation activities are not expected to burden existing medical services.

The medical facilities in the three county region provide medical care to much of the population within the 50-mile region. The operations workforce will increase the population in the 50-mile region by much less than one percent. The potential impacts of operations on medical services will be SMALL and mitigation will not be warranted.

5.8.2.2.8 Social Services

New reactors and the associated population influx likely will economically benefit the disadvantaged population served by the Georgia Department of Human Resources. The additional direct jobs will increase indirect jobs that could be filled by currently unemployed workers, thus removing them from social services client lists. Many of these benefits could accrue to Burke County, where, because of the smaller economic base, they might have a more noticeable impact. Impacts will be SMALL and positive and not require mitigation.

5.8.2.2.9 Education

SNC assumes that the new workforce will relocate to the 50-mile region with their families, increasing the population by approximately 1,750 people. Approximately 20 percent will settle in Burke County, 26 percent in Richmond County, and 34 percent in Columbia County. The remaining 20 percent will be distributed across the 25 other counties within the region.

In Georgia 26.5 percent of the population is under 18 years old **(USCB 2005)**. Therefore, SNC conservatively estimates that in an operations-workforce related population of 1,750, approximately 464 will be school-aged (Table 5.8.2-4).

Burke County will see the largest increase in school-age population of 3 percent. However, when spread over K-12 grades it is unlikely this increase will be noticeable on class size, particularly since these children will attend schools that were losing the children of construction workers.

Increased property and special option sales tax revenues as a result of the increased population, and, in the case of Burke County, property taxes on the new reactors, will fund additional teachers and facilities.

SNC concludes that impacts to the three counties school systems and school systems within the region will be SMALL and will not warrant mitigation.

5.8.3 Environmental Justice

Environmental justice refers to a Federal policy under which each Federal agency identifies and addresses, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority or low-income populations. The NRC has a policy on the treatment of environmental justice matters in licensing actions (69 FR 52040).

SNC evaluated whether the health or welfare of minority and low-income populations could be disproportionately adversely affected by potential impacts.

SNC identified the most likely pathways by which adverse environmental impacts associated with the operation of new units at the VEGP site could affect human populations. In this document, SNC analyzed potential operations impacts on the following resource areas: land use, water, air, socioeconomic, ecological, health and safety, waste, and cultural resources. SNC has identified SMALL impacts in all resources areas in the 50-mile radius, with the exception of Burke County. In Burke County, SMALL impacts were found in all resource areas except:

- Economy — beneficial and MODERATE
- Property tax revenue — beneficial and MODERATE to LARGE
- Transportation — MODERATE at shift change during outages
- Housing — MODERATE

Increased property tax revenues and their boost to the local economy are considered by most people to be beneficial. Moderate increases in traffic will mostly affect people living along or traveling on River Road and 56 spur during morning and afternoon shift change. However, the capacity of the roads will not be exceeded. MODERATE impacts to housing are expected to be mitigated by new housing construction and should not affect homeowners or renters already residing in Burke County.

SNC located minority and low-income populations within the 50-mile radius of VEGP (Figures 2.5.4-1 through 2.5.4-4). VEGP is in a predominantly Black Races census block group, and adjacent census block groups also have predominantly Black Races populations.

SNC also investigated the possibility of subsistence-living populations in the vicinity of VEGP by contacting local government officials, the staff of social welfare agencies, and businesses concerning unusual resource dependencies or practices that could result in potentially disproportionate impacts to minority and low-income populations. SNC asked about minority, low-income, and migrant populations or locations of particular concern, and whether subsistence living conditions were evident. No one contacted reported such dependencies or practices, as subsistence agriculture, hunting, or fishing, through which the populations could be disproportionately adversely affected by the project.

In summary, no operations-related adverse health or environmental effects that will disproportionately affect impacting minority or low-income populations were identified. Therefore, SNC concludes that impacts of operations of new nuclear units at the VEGP site on minority and low-income populations will be SMALL and mitigation will not be warranted.

Table 5.8.2-1 Estimated Property Taxes Generated by VEGP Units 3 and 4

Years of Operation	Range of Average Annual Tax Payments to Burke County for Units 3 and 4	
2015 - 2024	20,000,000	29,000,000
2025 - 2034	16,000,000	23,000,000
2035 - 2044	14,000,000	10,000,000
2045 - 2055	3,500,000	5,000,000

Table 5.8.2-2 Police Protection in the Three Counties, Adjusted for the AP1000 Workforce and Associated Population Increase

County	Total Population	Additional Population Due to New Plant Operations	Total Population	Police Protection in 2001	Estimated Persons per Police Officer Ratio	2001 Person Per Police Officer Ratio	Percent Increase from 2001 Persons per Police Officer Ratio
Burke	22,243	350	22,593	82	276:1	271:1	1.8
Richmond	199,775	460	200,235	200	1,001:1	998:1	0.3
Columbia	89,288	590	89,878	90	999:1	992:1	0.7

Source: **CSRARDC 2005**

Table 5.8.2-3 Fire Protection in the Three Counties, Adjusted for the AP1000 Workforce and Associated Population Increase

County	Total Population	Additional Population Due to New Plant Operations	Total Population	Firefighters (Full time and Volunteer)	Estimated Persons per Firefighter Ratio	2001 Persons Per Firefighter Ratio	Percent Increase from Current Persons per Firefighter Ratio
Burke	22,243	350	22,593	25	904:1	890:1	1.6
Richmond	199,775	460	200,235	300	667:1	666:1	0.2
Columbia	89,288	590	89,878	132	680:1	676:1	0.7

Source: **CSRARDC 2005**

Table 5.8.2-4 Estimated Additional Public School Age Students in the Three Counties as a Result of Operation of the AP1000

County	Population Increase	Population under age 18	Percentage of Additional Public School Children per County
Burke	350	93	2
Richmond	460	122	<1
Columbia	590	156	<1

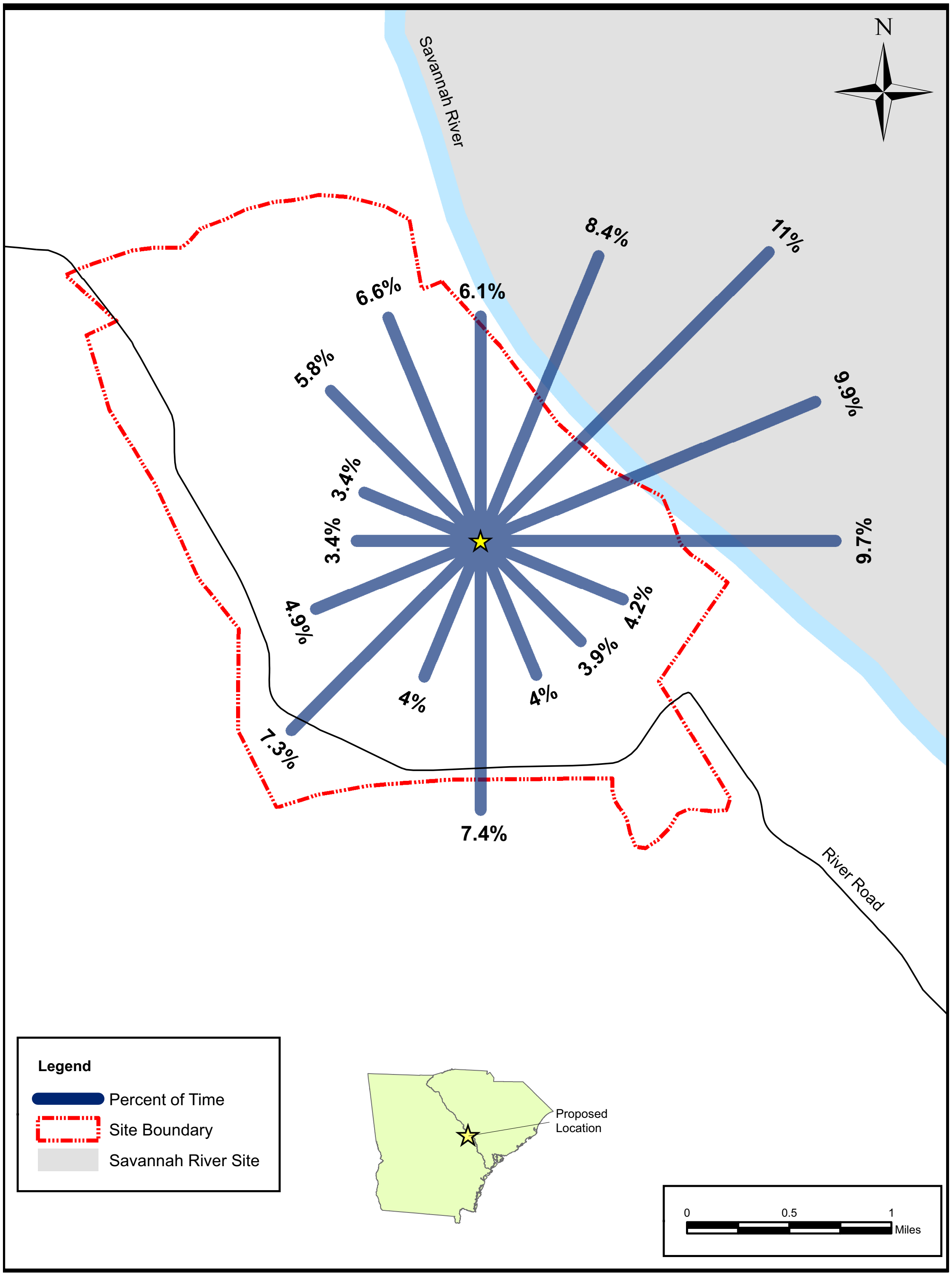

Figure 5.8-1 Modeled Plume Direction During Winter Months

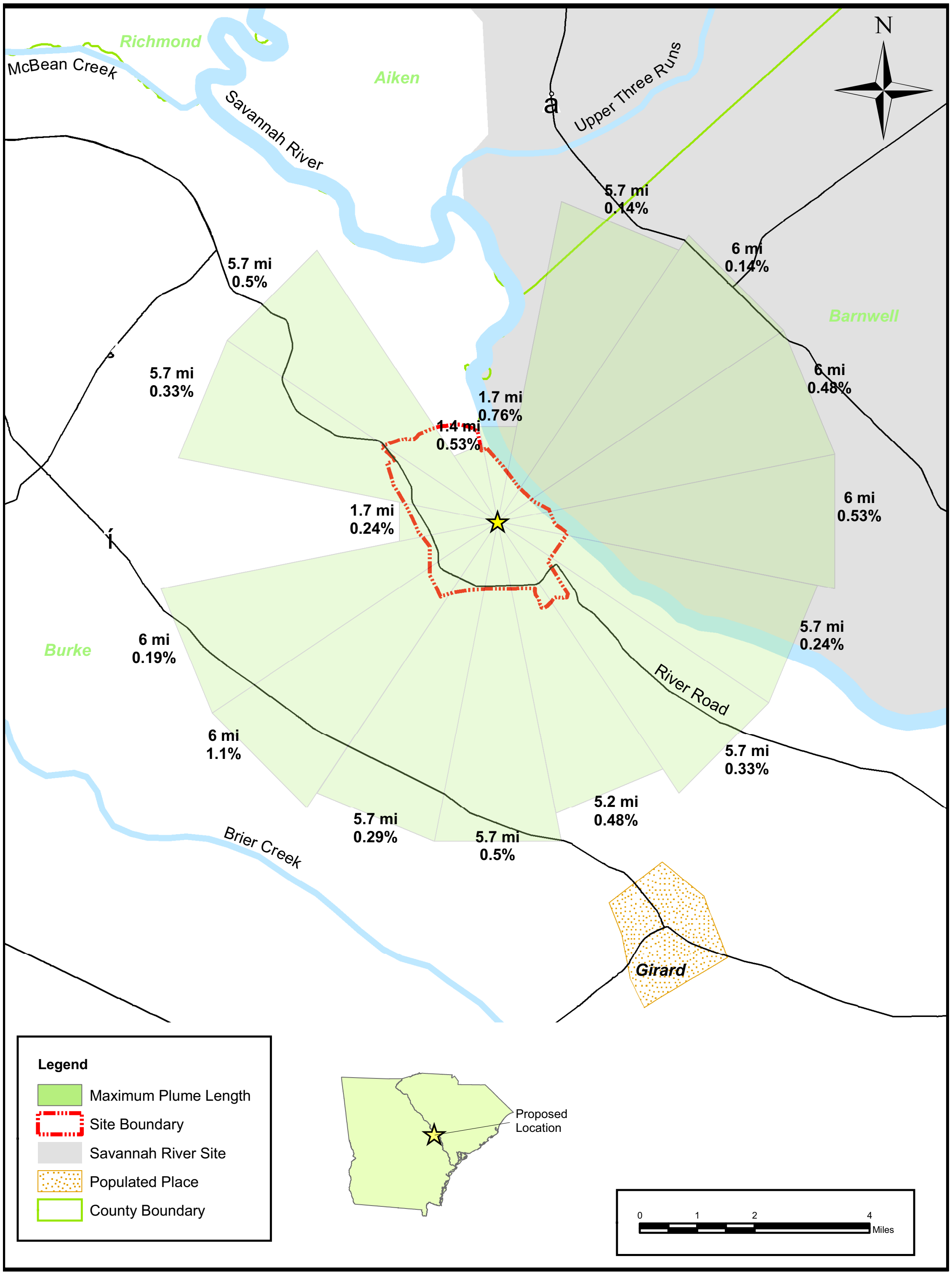

Figure 5.8-2 Maximum Modeled Plume Length and Frequency During Winter Months

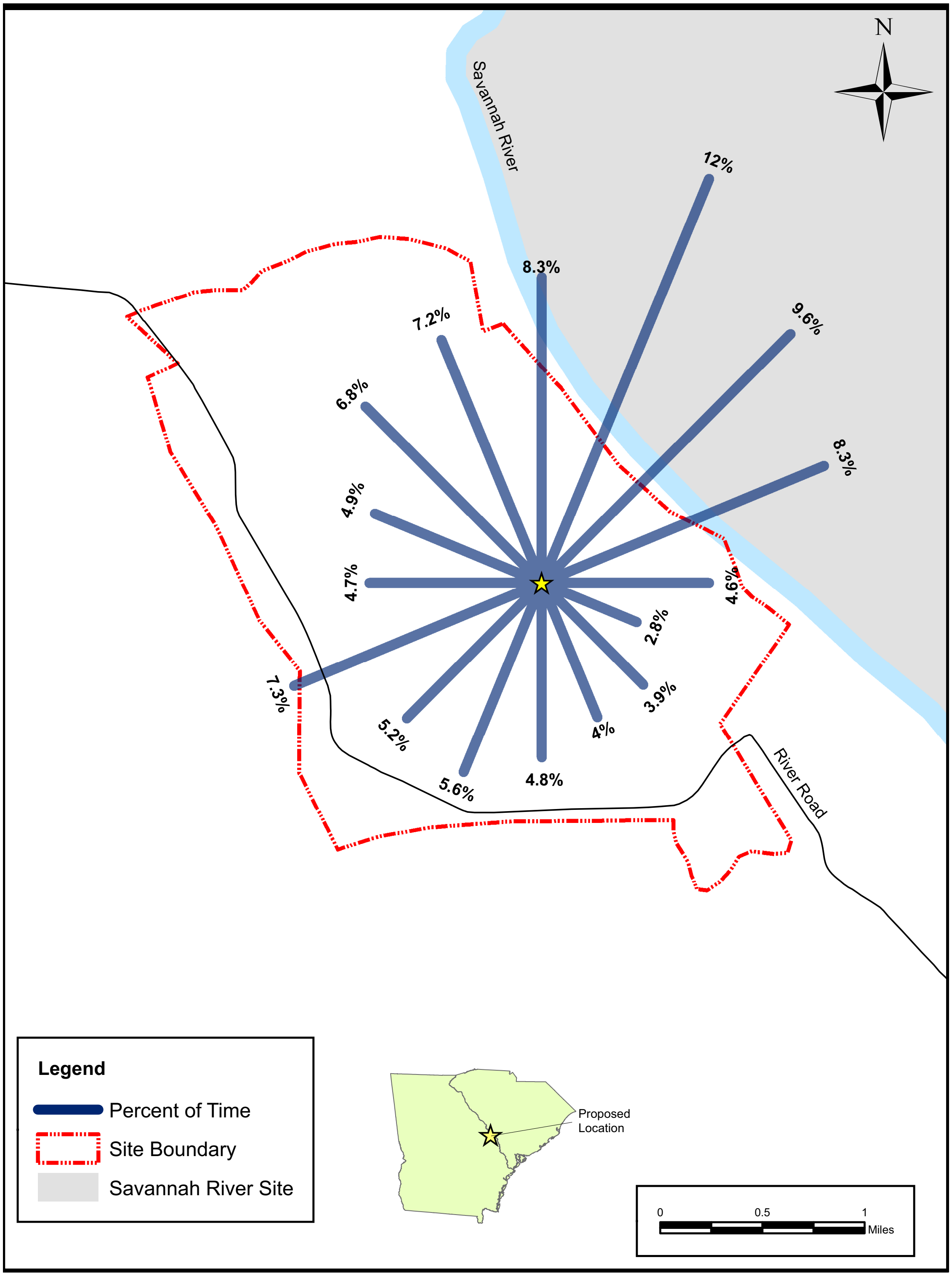

Figure 5.8-3 Modeled Plume Direction during Summer Months

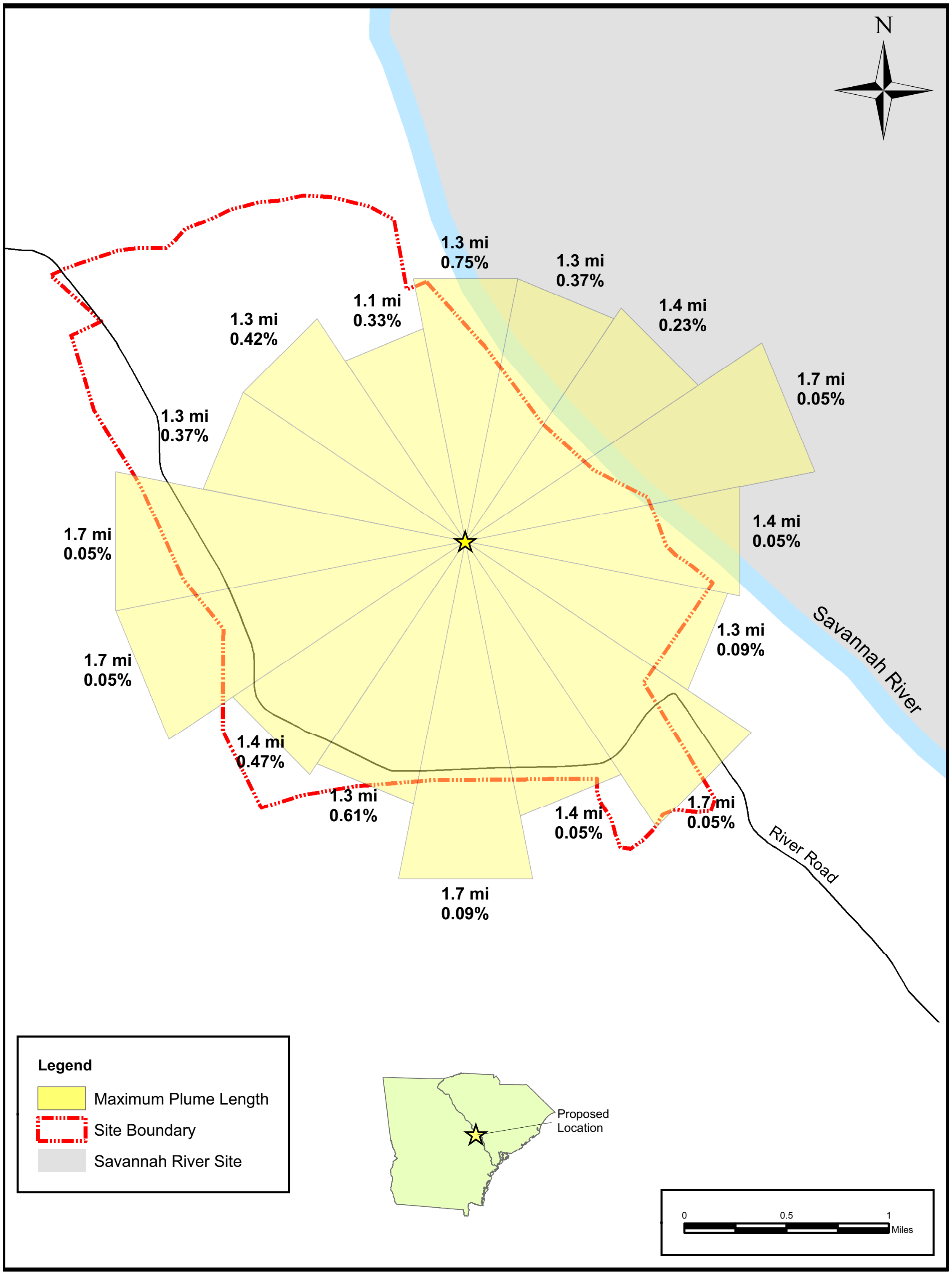

Figure 5.8-4 Maximum Modeled Plume Length and Frequency During Summer Months

Section 5.8 References

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(USCB 2006) U.S. Census Bureau, State and County Quickfacts, Burke County, Georgia, available at http://www.quickfacts.census.gov, accessed July 13, 2006.

5.9 Decommissioning

NRC defines decommissioning as the safe removal of a nuclear facility from service and the reduction of residual radioactivity to a level that permits release of the property and termination of the license (10 CFR 50). NRC regulation 10 CFR 50.82 specifies the regulatory actions that NRC and a licensee must take to decommission a nuclear power facility. NRC regulation 10 CFR 20, Subpart E identifies the radiological criteria that must be met for license termination. These requirements apply to the existing fleet of power reactors and to advanced reactors such as the AP1000.

Decommissioning must occur because NRC regulations do not permit an operating license holder to abandon a facility after ending operations. However, NRC prohibits licensees from performing decommissioning activities that result in significant environmental impacts not previously reviewed [10 CFR 50.82(a)(6)(ii)]. Therefore, NRC has indicated that licensees for existing reactors can rely on the information in a generic environmental impact statement (GEIS) on the environmental impacts of decommissioning the existing fleet of domestic nuclear power reactors **(NRC 2002)**.

The U.S. Department of Energy (DOE) funded a study that compares activities required to decommission existing reactors to those required for advanced reactors, including the AP1000 **(DOE 2004)**. In addition, SNC has prepared a decommissioning cost analysis for the AP1000 at VEGP, which relies on technical information provided in the DOE-funded study and site-specific information for the currently operating units at VEGP. SNC has concluded that the DOE-funded study and the SNC cost analysis form a basis for concluding that the environmental impacts that the decommissioning GEIS identifies are representative of impacts that can be reasonably expected from decommissioning the AP1000. The following sections summarize the decommissioning GEIS, the DOE-funded study, the SNC cost analysis, and the SNC conclusion.

5.9.1 NRC Generic Environmental Impact Statement Regarding Decommissioning

The *Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities* (NUREG-0586, Supplement 1, November 2002) describes decommissioning regulatory requirements, the decommissioning process, and environmental impacts of decommissioning. Prior to presenting impacts, the GEIS describes the NRC process for evaluating impacts. Activities and impacts that NRC considered to be within the scope of the GEIS include:

- Activities performed to remove the facility from service once the licensee certifies that the facility has permanently ceased operations, including organizational changes and removal of fuel from the reactor
- Activities performed in support of radiological decommissioning, including decontamination and dismantlement (D&D) of radioactive structures, systems, and components (SSCs) and any activities required to support the decontamination and dismantlement process such as

isolating the spent fuel pool to reduce the scope of required safeguards and security systems so D&D can proceed on the balance of the facility without affecting the spent fuel

- Activities performed in support of dismantlement of nonradiological SSCs, such as diesel generator buildings and cooling towers
- Activities performed up to license termination and their resulting impacts as provided by the definition of decommissioning, including shipment and processing of radioactive waste
- Nonradiological impacts occurring after license termination from activities conducted during decommissioning
- Activities related to release of the facility
- Human health impacts from radiological and nonradiological decommissioning activities.

According to Section 5.9 of NUREG-1555, studies of social and environmental effects of decommissioning large commercial power generating units have not identified any significant impacts beyond those considered in the final GEIS on decommissioning. The GEIS evaluates the environmental impact of the following three decommissioning methods:

- DECON — The equipment, structures, and portions of the facility and site that contain radioactive contaminants are removed or decontaminated to a level that permits termination of the license shortly after cessation of operations.
- SAFSTOR — The facility is placed in a safe stable condition and maintained in that state (safe storage) until it is subsequently decontaminated and dismantled to levels that permit license termination. During SAFSTOR, a facility is left intact, but the fuel is removed from the reactor vessel and radioactive liquids are drained from systems and components and then processed. Radioactive decay occurs during the SAFSTOR period, thus reducing the quantity of contaminated and radioactive material that must be disposed of during the decontamination and dismantlement of the facility at the end of the storage period.
- ENTOMB — This alternative involves encasing radioactive structures, systems, and components in a structurally long-lived substance, such as concrete. The entombed structure is appropriately maintained, and continued surveillance is carried out until the radioactivity decays to a level that permits termination of the license.

NRC regulations do not require an ESP applicant to select one of these decommissioning alternatives or to prepare definite plans for decommissioning. These plans are required (by 10 CFR 50.82) after a decision has been made to cease operations. The general environmental impacts are summarized in this section, because decommissioning plans and reports (and consequently detailed analyses of alternatives) are not prepared until cessation of operations.

According to the NRC, decommissioning a nuclear facility that has reached the end of its useful life generally has a positive environmental impact. The air quality, water quality, and ecological impacts of decommissioning are expected to be substantially smaller than those of power plant construction or operation because the level of activity and the releases to the environment are expected to be smaller during decommissioning than during construction and operation. The major environmental impact, regardless of the specific decommissioning option selected, is the commitment of small amounts of land for waste burial in exchange for the potential reuse of the land where the facility is located. Socioeconomic impacts of decommissioning will result from the demands on, and contributions to, the community by the workers employed to decommission a power plant. (NUREG-0586)

Experience with decommissioned power plants has shown that the occupational exposures during the decommissioning period are comparable to those associated with refueling and plant maintenance when it is operational (NUREG-0586). Each potential decommissioning alternative will have radiological impacts from the transport of materials to their disposal sites. The expected impact from this transportation activity will not be significantly different from normal operations (NUREG-1555).

5.9.2 DOE-Funded Study on Decommissioning Costs

The total cost of decommissioning depends on many factors, including the sequence and timing of the various stages of the program, location of the facility, current radioactive waste burial costs, and plans for spent fuel storage. So that a lack of funds does not result in delays in or improper conduct of decommissioning that may adversely affect public health and safety, 10 CFR 50.75 requires that operating license applicants and licensees provide reasonable assurance that adequate funds for performing decommissioning will be available at the end of operation. To provide this assurance, the regulation requires that two factors be considered, the amount of funds needed for decommissioning and the method used to provide financial assurance. At its discretion, an applicant may submit a certification based either on the formulas provided in 10 CFR 50.75 or, when a higher funding level is desired, on a facility-specific cost estimate that is equal to or greater than that calculated using the formula in 10 CFR 50.75. (Regulatory Guide 1.159, Revision 1. *Assuring the Availability of Funds for Decommissioning Nuclear Reactors*, October 2005) (RG 1.159)

NRC regulations do not require the establishment of decommissioning financial assurances to support an ESP application (NUREG-1555). However, DOE commissioned the *Study of Construction Technologies and Schedules, O&M Staffing and Cost, and Decommissioning Costs and Funding Requirements for Advanced Reactor Designs* **(DOE 2004)** to support development of advanced reactors for production of electric power and to establish the requirements for providing reasonable assurance that adequate funds for performing decommissioning will be available at the end of plant operations. The study presents estimates of the costs to decommission the advanced reactor designs following a scheduled cessation of plant operations. Four reactor types were evaluated in this report: the Toshiba and General Electric (GE) Advanced Boiling Water Reactor (ABWR), the GE Economic Simplified Boiling Water Reactor (ESBWR), the Westinghouse Advanced Passive pressurized water reactor (AP1000), and the Atomic Energy of Canada, Limited's (AECL) Advanced CANDU Reactor (ACR-700).

The cost analysis described in the study is based upon the prompt decommissioning alternative, or DECON as defined by the NRC. The DECON alternative is also the basis for the NRC funding regulations (10 CFR 50.75) and the use of the DECON alternative for the advanced reactor designs facilitates the comparison with NRC's own estimates and financial provisions.

DECON comprises four distinct periods of effort: (1) preshutdown planning/engineering, (2) plant deactivation and transition (no activities are conducted during this period that will affect the safe operation of the spent fuel pool), (3) Decontamination and dismantlement with concurrent operations in the spent-fuel pool until the pool inventory is zero, and (4) license termination. Each of the decommissioning activities evaluated in the GEIS is performed during one or more of the periods identified above. Because of the delays in development of the federal waste management system, it may be necessary to continue operation of a dry fuel storage facility on the reactor site after the reactor systems have been dismantled and the reactor nuclear license terminated. However, these latter storage costs are considered operations costs under 10 CFR 50.54(b)(b) and are not considered part of decommissioning (NUREG-0586, Supplement 1).

The cost estimates described in the DOE study were developed using the same cost estimating methodology used by NRC and consider the unique features of a generic site located in the Southeast, including the nuclear steam supply systems, power generation systems, support services, site buildings, and ancillary facilities; and are based on numerous fundamental assumptions, including labor costs, low-level radioactive waste disposal costs and practices, regulatory requirements, and project contingencies. The primary cost contributors identified in the study are either labor-related or associated with the management and disposition of the radioactive waste. These are the same primary cost contributors that NRC identified in its *Revised Analysis of Decommissioning for the Reference Pressurized Water Reactor Power Station*, (NUREG/CR-5884; November 1995). Overall, the DOE study concluded that with consistent operating and management assumptions, the total decommissioning costs projected for the advanced reactor designs are comparable to those projected by NRC for operating reactors with appropriate reductions in costs due to reduced physical plant inventories. **(DOE 2004)**

5.9.3 SNC Decommissioning Cost Analysis

Although NRC regulations do not require the establishment of decommissioning financial assurances to support an ESP application (NUREG-1555), SNC commissioned a cost analysis to assess its financial obligations pertaining to the eventual decommissioning of the Westinghouse AP1000 advanced reactor assuming one is constructed on the VEGP site. The cost to decommission the AP1000 was evaluated for the DECON decommissioning alternative; and relies upon technical information from the DOE study and certain site-specific information for the currently operating units at VEGP. The estimate assumes the removal of all contaminated and activated plant components and structural materials such that the owner may then have unrestricted use of the site with no further requirements for an operating license. The estimate also assumes that the spent fuel pool will remain operational for a minimum of five years following cessation of operations. The pool will be isolated and an independent spent fuel island created to allow decommissioning operations to proceed in and around the pool area. The methodology and assumptions for estimating decommissioning costs for the AP1000 at VEGP is the same as that used in the DOE study. Like the NRC and DOE studies, the primary cost contributors identified in the SNC cost analysis are either labor-related or associated with the management and disposition of the radioactive waste.

The SNC projected cost to decommission one AP1000 using the DECON alternative is estimated to be $427.4 million, as reported in 2006 dollars. The minimum certification amounts were calculated using the formula delineated in 10 CFR 50.75(c)(1) and escalation indices provided in NUREG-1307, dated June 2005, for both waste recycling and burial only options. The funding levels calculated for the AP1000, in 2006 dollars, are $340.6 million for the waste recycling option and $664.1 million for the burial only option.

5.9.4 Conclusions

SNC compared the activities analyzed in the GEIS of the environmental impacts of decommissioning the existing fleet of domestic nuclear power reactors (NUREG-0586, Supplement 1) with the activities that form the basis for decommissioning cost estimates prepared by DOE **(DOE 2004)** and SNC for advanced reactor designs and determined that the scope of activities are the same. Projected physical plant inventories associated with advanced reactor designs will generally be less than those for currently operating power reactors due to advances in technology that simplify maintenance, and benefit decommissioning. Based on this comparison, SNC has concluded that the environmental impacts identified in the GEIS are representative of impacts that can be reasonably expected from decommissioning the AP1000.

SNC projected total site-specific decommissioning costs for an AP1000 at VEGP using the same cost estimating methodology and assumptions used by NRC as the basis for decommissioning funding regulations in 10 CFR 50.75. The SNC projected the cost to decommission the AP1000 using the DECON alternative is estimated to be $427.4 million, as reported in 2006 dollars.

Section 5.9 References

(DOE 2004) U.S. Department of Energy, Study of Construction Technologies and Schedules, O&M Staffing and Cost, and Decommissioning Costs and Funding Requirements for Advanced Reactor Designs, prepared by Dominion Energy Inc., Bechtel Power Corporation, TLG, Inc., and MPR Associates for United States Department of Energy Cooperative Agreement DE-FC07-03ID14492, Contract DE-AT01-020NE23476, May 27, 2004.

5.10 Measures and Control to Limit Adverse Impacts During Operations

The following measures and controls would limit adverse environmental impacts of operations:

- Compliance with applicable local, state, and federal, ordinances, laws and regulations intended to prevent or minimize adverse environmental effects.
- Compliance with the applicable requirements of all environmental permits and licenses.
- Compliance with SNC or Georgia Power procedures and processes.

In Table 5.10-1, the significance of potential impacts are identified as (S)mall, (M)oderate or (L)arge, based on the analyses done in this chapter. Mitigation measures briefly describe the types of programs and controls SNC will put in place to ensure that adverse impacts to the environment are minimized.

Table 5.10-1 Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Potential Impact Significance[1, 2]

Section Reference	Noise	Erosion and Sediment	Air Quality	Traffic/Transportation	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Public Health & Safety	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/ Controls
5.1 Land-Use Impacts																	
5.1.1 The Site and Vicinity								S-M				S				• Although Burke County does not have zoning designations, the land use as VEGP will not change from current land use • Some of the workforce may chose to live in the immediate vicinity of the project • Property taxes on new units could provide county with revenues to develop additional land in the county	• No mitigation measures will be required
5.1.2 Transmission Corridors and Offsite Areas								S		S	S					• Possible new corridor could affect land use, terrestrial and aquatic ecosystems	• Maintenance practices will protect sensitive habitats and protected species, including wetlands and water crossings. • Routing decisions would consider protected species and critical habitats

Table 5.10-1 (cont.) Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Potential Impact Significance[1, 2]

Section Reference	Noise	Erosion and Sediment	Air Quality	Traffic/Transportation	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Public Health & Safety	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/ Controls
5.1.3 Historic Properties															S	• No impacts beyond those associated with construction of the proposed new units and transmission corridors	• No mitigation will be required
5.2 Water-Related Impacts																	
5.2.1 Hydrologic Alterations and Plant Water Supply						S	S										
5.2.2 Water-Use Impacts						S	S									• For start time during off-normal operations groundwater withdrawal could exceed permit limits • Maximum consumptive surface water use will be less than 2 percent of 7Q10 flow	• No mitigation will be required
5.2.3 Water Quality Impacts						S	S				S					• Discharges to surface water will be permitted and limited • Maximum thermal plume will have a volume of less than 800 ft3	• No mitigation will be required

Table 5.10-1 (cont.) Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Potential Impact Significance[1, 2]

Section Reference	Noise	Erosion and Sediment	Air Quality	Traffic/Transportation	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Public Health & Safety	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/ Controls
5.2.4 Future Water Use						S	S									• VEGP will not adversely affect future water use	• No mitigation will be required
5.3 Cooling System Impacts																	
5.3.1 Intake System																	
5.3.1.1 Hydrodynamic Descriptions and Physical Impacts																	
5.3.1.2 Aquatic Ecosystems											S					• Intake structure will be constructed using Best Available Technology	• No mitigation will be required
5.3.2 Discharge System																	
5.3.2.1 Thermal Discharges and Other Physical Impacts											S					• Thermal plume will not impede fish passage • Plume will be SMALL and localized	• No mitigation will be required.
5.3.2.2 Aquatic Ecosystems											S						
5.3.3 Heat-Dissipation System																	

Table 5.10-1 (cont.) Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Potential Impact Significance[1, 2]

Section Reference	Noise	Erosion and Sediment	Air Quality	Traffic/Transportation	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Public Health & Safety	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/ Controls
5.3.3.1 Heat Dissipation to the Atmosphere	S		S							S						• Median plume length will be about 0.5 miles long with a maximum plume length of 6.2 miles expected 3.5 percent of the time • Maximum salt deposition will be 2.5 pounds per acre per month per tower, approximately half that which is considered a threshold for leaf damage • Cooling tower noise levels will be undistinguishable from above ground • Potential for bird collisions with towers is low, based on current VEGP operations	• None
5.3.3.2 Terrestrial Ecosystems										S						• No impacts identified	• No mitigation will be required

Table 5.10-1 (cont.) Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Potential Impact Significance[1, 2]

Section Reference	Noise	Erosion and Sediment	Air Quality	Traffic/Transportation	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Public Health & Safety	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/ Controls
5.3.4 Impacts to Members of the Public	S													S		• Offsite noise will be less than 10dB above background • Discharges to the Savannah River will not result in a significant increase in temperature of the river or an increase in thermophilic organisms.	• No mitigation will be required
5.4 Radiological Impacts of Normal Operation																	
5.4.1 Exposure Pathways			S			S			S		S	S	S	S		• Potential for small discharges of radioactive liquids and gases to the environment • Direct dose contribution from the new units will be negligible	• Releases of radiation will be within all regulatory limits
5.4.2 Radiation Doses to Members of the Public													S	S		• See Section 5.4.2 for a discussion of impacts to members of the public	

Table 5.10-1 (cont.) Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Potential Impact Significance[1, 2]

Section Reference	Noise	Erosion and Sediment	Air Quality	Traffic/Transportation	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Public Health & Safety	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/ Controls
5.4.3 Impacts to Members of the Public													S	S		• Potential doses to the public from liquid effluent releases to the Savannah River and gaseous releases to the atmosphere. Calculated doses to the public will be within the design objectives of 10 CFR 50 Appendix I and within regulatory limits of 40 CFR 190.	• No mitigation will be necessary
5.4.4 Impacts to Biota Other than Members of the Public										S	S		S			• Potential doses to biota from liquid and gaseous effluents. Although there are no acceptance criteria specifically for biota, there is no scientific evidence that chronic doses below 100 mrad/ day are harmful to plants or animals. The biota doses are less than 0.1 mrad/day	• No mitigation is required.

Table 5.10-1 (cont.) Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Potential Impact Significance[1, 2]

Section Reference	Noise	Erosion and Sediment	Air Quality	Traffic/Transportation	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Public Health & Safety	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/ Controls
5.5 Environmental Impact of Waste																	
5.5.1 Nonradioactive-Waste-System Impacts					S	S		S			S					• Increased volume of discharged effluents • Increased chemicals and other pollutants in the discharge • Increased stormwater discharge • Increased air emissions • Increase in total volume of sanitary waste generated	• All discharges will comply with Georgia NPDES permit and applicable water quality standards • Revise the existing VEGP Storm Water Pollution Prevention Plan or prepare and implement a new one to avoid/minimize releases of contaminated storm water. • Revise the existing VEGP Spill Prevention Countermeasures and Control Plan or prepare and implement a new one to avoid/ minimize contamination from spills. • Use approved transporters and offsite landfills for disposal of solid wastes. Continue the existing program of waste minimization reuse and recycling. • Operate minor air emission sources in accordance with applicable regulations and certificates. • If necessary, modify the existing sanitary waste treatment system to accommodate increased volume.

Table 5.10-1 (cont.) Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Potential Impact Significance[1, 2]

Section Reference	Noise	Erosion and Sediment	Air Quality	Traffic/Transportation	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Public Health & Safety	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/ Controls
5.5.2 Mixed Waste Impacts					S					S			S		S	• Expected annual generation of 350 ft^3 mixed waste per year. • Potential chemical hazard and occupational exposure to radiological materials during handling and storage • Potential exposure to offsite workers and emergency response • Personnel during accidental releases and cleanup activities	• Limit mixed waste generation through source reduction, recycling, and treatment options • Develop a Waste Minimization Program to address mixed waste inventory management, equipment maintenance, recycling and reuse, segregation, treatment (decay in storage), work planning, waste tracking, and awareness training • Revise the existing VEGP Spill Prevention Countermeasures and Control Plan or prepare and implement a new one to avoid/ minimize contamination from spills.
5.5.3 Waste Minimization					S			S									• Develop a Waste Minimization Program to address mixed waste inventory management, equipment maintenance, recycling and reuse, segregation, treatment (decay in storage), work planning, waste tracking, and awareness training

Table 5.10-1 (cont.) Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Potential Impact Significance[1, 2]

Section Reference	Noise	Erosion and Sediment	Air Quality	Traffic/Transportation	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Public Health & Safety	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/ Controls
5.5.4 Radioactive Waste																• Expected annual generation of uncompacted radioactive waste of 5,759 ft^3.	• Develop a Waste Minimization Program to address mixed waste inventory management, equipment maintenance, recycling and reuse, segregation, treatment (decay in storage), work planning, waste tracking, and awareness training
5.6 Transmission System Impacts																	
5.6.1 Terrestrial Ecosystems	S		S							S						• Exhaust and nuisance noise from aerial surveys of transmission corridors. Current maintenance practices will be continued on any new lines.	• No mitigation is required.
5.6.2 Aquatic Ecosystems											S					• Current maintenance practices will be continued on any new lines	• No mitigation is required.
5.6.3 Impacts to Members of the Public	S													S		• New lines will be built to specifications to minimize noise and electric shock	• No mitigation is required.

Table 5.10-1 (cont.) Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Potential Impact Significance[1, 2]

Section Reference	Noise	Erosion and Sediment	Air Quality	Traffic/Transportation	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Public Health & Safety	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/ Controls
5.7 Uranium Fuel Cycle Impacts																	
5.7 Uranium Fuel Cycle Impacts (i.e., relative to the reference LWR)		S	S	S		S		S	S				S			• Yellowcake production and uranium conversion and mining will affect energy requirements, erosion, emissions, and water • Air emissions from fossil fuel plants supplying the gaseous diffusion plant. • Production of UO2 during fuel fabrication • Radioactive waste management from operations, and decontamination and decommissioning	• Select mining techniques that minimize potential impacts • Consider use of new technology that requires less uranium hexafluoride • Consider use of centrifuge process over gaseous diffusion process, which could significantly reduce energy requirements and environmental impacts • Consider use of new technologies with less fuel loading to reduce energy, emissions and water usage.

Table 5.10-1 (cont.) Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Potential Impact Significance[1, 2]

Section Reference		Noise	Erosion and Sediment	Air Quality	Traffic/Transportation	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Public Health & Safety	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/ Controls
5.8	Socioeconomic Impacts																	
5.8.1	Physical Impacts of station operation	S		S	S											S	• Noise from industrial facility will be below a level considered nuisance to public at nearest residence • Potential impacts from air emissions associated with diesel generators and auxiliary power systems • Potential visual impacts from Savannah River and roadways in the region due to additional cooling towers and new buildings • Local roads will experience increased operations traffic	• Comply with permit limits and regulations for installing and operating air emission sources • Perform view scape study for new structures on site, including cooling towers, as part of final design • Consider staggering outage shifts to reduce plant-associated traffic on local roads during shift changes

Table 5.10-1 (cont.) Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Potential Impact Significance[1, 2]

Section Reference	Noise	Erosion and Sediment	Air Quality	Traffic/Transportation	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Public Health & Safety	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/ Controls
5.8.2 Social and Economic Impacts				S-M								S-L				• Increase the population in the region by as many as 2,600 people. Overall impacts to community services in the surrounding counties will be small. Predicted workforce is a small fraction of the total projected population in the region • Revenue from property taxes paid for the new units will benefit Burke county • The available housing in Burke County may not support influx of operational workers • Increased traffic on highways and roads during shift change	• Lead time will allow developers to construct new homes.

Table 5.10-1 (cont.) Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Potential Impact Significance[1, 2]

Section Reference	Noise	Erosion and Sediment	Air Quality	Traffic/Transportation	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Public Health & Safety	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/ Controls
5.8.3 Environmental Justice				S-M								S-L				• No disproportion nately high impacts on minority or low-income populations resulting from operation of the proposed new units except moderate increases in traffic during shift change	• No mitigation required; traffic volume will not exceed road capacities.
5.9 Decommissioning																	
5.9 Decommissioning					S	S		S					S			• Potential radiation exposure related to decommissioning, including transportation of materials to disposal sites. • Decommissioning methods are expected to produce impacts equivalent to operations	• The significance of impacts is unknown because the decommissioning methods have not been chosen. No mitigation measures or controls are proposed at this time.
5.11 Transportation of Radioactive Materials																	
5.11 Transportation of Radioactive Materials				S									S	S		• Transportation risks are very small, including accidents	• No mitigation is required

Table 5.10-1 (cont.) Summary of Impacts and Measures and Controls to Limit Adverse Impacts During Operations

Potential Impact Significance[1, 2]

Section Reference	Noise	Erosion and Sediment	Air Quality	Traffic/Transportation	Wastes	Surface Water	Groundwater	Land-Use	Water-Use	Terrestrial Ecosystems	Aquatic Ecosystems	Socioeconomic	Radiation Exposure	Public Health & Safety	Other (site-specific)	Impact Description or Activity	Feasible and Adequate Measures/ Controls
5.12 Non-Radiological Health Impacts																	
5.12 Non-Radiological Health Impacts														S		• Incidence rate of recordable cases at VEGP is less than the national average. New units will likely follow the same trend.	• No mitigation required.

[1] The assigned significance levels [(S)mall, (M)oderate, or (L)arge are based on the assumption that for each impact, the associated proposed mitigation measures and controls (or equivalents) will be implemented.

[2] A blank in the elements column denotes “no impact” on that specific element due to the assessed impacts.

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5.11 Transportation of Radioactive Materials

This section addresses radioactive materials transportation associated with operating a new reactor at the VEGP site. The analysis is based on the reactor characteristics described in Section 3.2 and radioactive waste management systems described in Section 3.5. Information regarding preparation and packaging of the radioactive materials for transport offsite can be found in Section 3.8.

5.11.1 Transportation Assessment

The NRC regulations in 10 CFR 51.52 state that:

> *"Every environmental report prepared for the construction permit stage of a light-water-cooled nuclear power reactor, and submitted after February 4, 1975, shall contain a statement concerning transportation of fuel and radioactive wastes to and from the reactor. That statement shall indicate that the reactor and this transportation either meet all of the conditions in paragraph (a) of this section or all of the conditions in paragraph (b) of this section."*

NRC evaluated the environmental effects of transportation of fuel and waste for LWRs in the Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Plants (WASH-1238; AEC 1972) and Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants, Supplement 1 (NUREG-75/038; NRC 1975) and found the impacts to be SMALL. These NRC analyses provided the basis for Table S-4 in 10 CFR 51.52 (see Table 5.11-1), which summarizes the environmental impacts of transportation of fuel and radioactive wastes to and from a reference reactor. The table addresses two categories of environmental considerations: (1) normal conditions of transport and (2) accidents in transport.

To analyze the impacts of transporting AP1000 fuel to Table S-4, the fuel characteristics for the AP1000 were normalized to a reference reactor-year. The reference reactor is an 1100 MWe reactor that has an 80 percent capacity factor, for an electrical output of 880 MWe per year. The advanced LWR technology being considered for VEGP is the AP1000. The proposed configuration for this new plant is two units. The standard configuration (a single unit) for the AP1000 will be used to evaluate transportation impacts relative to the reference reactor.

Subparagraphs 10 CFR 51.52(a)(1) through (5) delineate specific conditions the reactor licensee must meet to use Table S-4 as part of its environmental report. For reactors not meeting all of the conditions in paragraph (a) of 10 CFR 51.52, paragraph (b) of 10 CFR 51.52 requires a further analysis of the transportation effects.

The conditions in paragraph (a) of 10 CFR 51.52 establishing the applicability of Table S-4 are reactor core thermal power, fuel form, fuel enrichment, fuel encapsulation, average fuel irradiation, time after discharge of irradiated fuel before shipment, mode of transport for unirradiated fuel, mode of transport for irradiated fuel, radioactive waste form and packaging, and mode of transport for radioactive waste other than irradiated fuel. The following sections describe the characteristics of the AP1000 relative to the conditions of 10 CFR 51.52 for use of Table S-4. Information for the AP1000 fuel is taken from the AP1000 Design Control Document **(Westinghouse 2005)** and supporting documentation prepared by the Idaho National Engineering and Environmental Laboratory.

5.11.1.1 Reactor Core Thermal Power

Subparagraph 10 CFR 51.52(a)(1) requires that the reactor have a core thermal power level not exceeding 3800 megawatts. The AP1000 has a thermal power rating of 3400 MWt and meets this condition.

The core power level was established as a condition because, for the LWRs being licensed when Table S-4 was promulgated, higher power levels typically indicated the need for more fuel and therefore more fuel shipments than was evaluated for Table S-4. This is not the case for the new LWR designs due to the higher unit capacity and higher burnup for these reactors. The annual fuel reloading for the reference reactor analyzed in WASH-1238 was 30 metric tons of uranium (MTU) while the annual fuel loading for the AP1000 is 23 MTU. When normalized to equivalent electric output, the annual fuel requirement for the AP1000 is approximately 20 MTU or two-thirds that of the reference LWR.

5.11.1.2 Fuel Form

Subparagraph 10 CFR 51.52(a)(2) requires that the reactor fuel be in the form of sintered uranium dioxide (UO_2) pellets. The AP1000 uses a sintered UO_2 pellet fuel form.

5.11.1.3 Fuel Enrichment

Subparagraph 10 CFR 51.52(a)(2) requires that the reactor fuel have a uranium-235 enrichment not exceeding 4 percent by weight. For the AP1000, the enrichment of the initial core varies by region from 2.35 to 4.45 percent and the average for reloads is 4.51 percent (Table 3.0-1). The AP1000 fuel exceeds the 4 percent U-235 condition.

5.11.1.4 Fuel Encapsulation

Subparagraph 10 CFR 51.52(a)(2) requires that the reactor fuel pellets be encapsulated in Zircaloy rods. Paragraph 10 CFR 50.44 also allows use of ZIRLO™. License amendments approving use of ZIRLO™ rather than Zircaloy have not involved a significant increase in the amounts or significant change in the types of any effluents that may be released offsite, or significant increase in individual or cumulative occupational radiation exposure. AP1000 uses either Zircaloy or ZIRLO cladding and meets this subsequent evaluation condition.

5.11.1.5 Average fuel irradiation

Subparagraph 10 CFR 51.52(a)(3) requires that the average burnup not exceed 33,000 megawatt-days per MTU. The average burnup is 48,700 megawatt-days per MTU for the AP1000 (Table 3.0-1), which exceeds this condition.

5.11.1.6 Time after discharge of irradiated fuel before shipment

Subparagraph 10 CFR 51.52(a)(3) requires that no irradiated fuel assembly be shipped until at least 90 days after it is discharged from the reactor. The WASH-1238 for Table S-4 assumes 150 days of decay time prior to shipment of any irradiated fuel assemblies. *Environmental Effects of Extending Fuel Burnup Above 60 Gwd/MTU*, (NUREG/CR-6703, January 31, 2001) updated this analysis to extend Table S-4 to burnups of up to 62,000 megawatt-days per MTU assumes a minimum of five years between removal from the reactor and shipment. Five years is the minimum decay time expected before shipment of irradiated fuel assemblies. The U.S. DOE's contract for acceptance of spent fuel, as set forth in 10 CFR 961, Appendix E, requires a five-year minimum cooling time. In addition, NRC specifies five years as the minimum cooling period when it issues certificates of compliance for casks used for shipment of power reactor fuel (NUREG-1437, Addendum 1). As described in Section 3.5, the new units will have storage capacity exceeding that needed to accommodate five-year cooling of irradiated fuel prior to transport off site.

5.11.1.7 Transportation of unirradiated fuel

Subparagraph 10 CFR 51.52(a)(5) requires that unirradiated fuel be shipped to the reactor site by truck. Fuel is currently transported to the reactors at VEGP by truck. SNC will receive fuel via truck shipments for the AP1000 units being considered for this site.

Table S-4 includes a condition that the truck shipments not exceed 73,000 pounds as governed by federal or state gross vehicle weight restrictions. The fuel shipments to the VEGP site will comply with Federal or state weight restrictions.

5.11.1.8 Transportation of irradiated fuel

Subparagraph 10 CFR 51.52(a)(5) allows for truck, rail, or barge transport of irradiated fuel. This condition will be met for the AP1000. For the impacts analysis described in Section 5.11.2, SNC assumed that all spent fuel shipments will be made using legal weight trucks. DOE is responsible for spent fuel transportation from reactor sites to the repository and will make the decision on transport mode (10 CFR 961.1).

5.11.1.9 Radioactive waste form and packaging

Subparagraph 10 CFR 51.52(a)(4) requires that, with the exception of spent fuel, radioactive waste shipped from the reactor be packaged and in a solid form. As described in Section 3.5.3, SNC will solidify and package the radioactive waste. Additionally, SNC will comply with NRC

(10 CFR 71) and DOT (49 CFR 173 and 178) packaging and transportation regulations for the shipment of radioactive material.

5.11.1.10 Transportation of radioactive waste

Subparagraph 10 CFR 51.52(a)(5) requires that the mode of transport of low-level radioactive waste be either truck or rail. SNC will ship radioactive waste from the new units by truck.

Radioactive waste shipments are subject to a weight limitation of 73,000 pounds per truck and 100 tons per cask per rail car. Radioactive waste from the AP1000 is capable of being shipped in compliance with Federal or state weight restrictions.

5.11.1.11 Number of truck shipments

Table S-4 limits traffic density to less than one truck shipment per day or three rail cars per month. SNC has estimated the number of truck shipments that will be required assuming that all radioactive materials (fuel and waste) are received at the site or transported offsite via truck.

Table 5.11-2 summarizes the number of truck shipments of unirradiated fuel. The table also normalizes the number of shipments to the electrical output for the reference reactor analyzed in WASH-1238. When normalized for electrical output, the number of truck shipments of unirradiated fuel for the AP1000 is less than the number of truck shipments estimated for the reference LWR.

For the AP1000, the initial core load is estimated at 84.5 MTU per unit and the annual reload requirements are estimated at 23 MTU/yr per unit. This equates to about 157 fuel assemblies in the initial core (assuming 0.5383 MTU per fuel assembly) and 43 fuel assemblies per year for refueling. The vendor is designing a transportation container that will accommodate one 14-foot fuel bundle. Due to weight limitations, the number of such containers will be limited to 7 to 8 per truck shipment. For the initial core load, the trucks are assumed to carry 7 containers to allow for shipment of core components along with the fuel assemblies. Truck shipments will be able to accommodate 8 containers per shipment for refueling.

The numbers of spent fuel shipments were estimated as follows. For the reference LWR analyzed in WASH-1238, NRC assumed that 60 shipments per year will be made, each carrying 0.5 MTU of spent fuel. This amount is equivalent to the annual refueling requirement of 30 MTU per year for the reference LWR. For this transportation analysis, SNC assumed that for the AP1000 it will also ship spent fuel at a rate equal to the annual refueling requirement. The shipping cask capacities used to calculate annual spent fuel shipments were assumed to be the same as those for the reference LWR (0.5 MTU per legal weight truck shipment). This results in 46 shipments per year for one AP1000. After normalizing for electrical output, the number of spent fuel shipments is 39 per year for the AP1000. The normalized spent fuel shipments for the AP1000 will be less than the reference reactor that was the basis for Table S-4.

Table 5.11-3 presents estimates of annual waste volumes and numbers of truck shipments. The values are normalized to the reference LWR analyzed in WASH-1238. The normalized annual waste volumes and waste shipments for the AP1000 will be less than the reference reactor that was the basis for Table S-4.

The total numbers of truck shipments of fuel and radioactive waste to and from the reactor are estimated at 65 per year for the AP1000. These radioactive material transportation estimates are well below the one truck shipment per day condition given in 10 CFR 51.52, Table S-4. Doubling the estimated number of truck shipments to account for empty return shipments still results in number of shipments well below the one-shipment-per-day condition.

5.11.1.12 Summary

Table 5.11-4 summarizes the reference conditions in paragraph (a) of 10 CFR 51.52 for use in Table S-4, and the values for the AP1000. The AP1000 does not meet the conditions for average fuel enrichment or average fuel irradiation. Therefore, Sections 5.11.2 and 7.4 present additional analyses of fuel transportation effects for normal conditions and accidents, respectively. Transportation of radioactive waste met the applicable conditions in 10 CFR 51.52 and no further analysis is required.

5.11.2 Incident-Free Transportation Impacts Analysis

Environment impacts of incident-free transportation of fuel are discussed in this section. Transportation accidents are discussed in Section 7.4.

NRC analyzed the transportation of radioactive materials in its assessments of environmental impacts for the proposed ESP sites at North Anna, Clinton, and Grand Gulf. SNC reviewed the NRC analyses for guidance in assessing transportation impacts for the VEGP site.

The NRC assessments included the AP1000 reactor technology being considered for the SNC ESP site. In many cases, the assumptions used by NRC are “generic” (i.e., independent of the reactor technology). For example, the radiation dose rate associated with fuel shipments is based on the regulatory limit rather than the fuel characteristics or packaging. SNC used these same generic assumptions in assessing transportation impacts for unirradiated fuel shipments to the VEGP site.

Although NRC did not consider VEGP as an alternative site, they did assess transportation impacts for the Savannah River Site. SNC reviewed the assumptions and parameters used in NRC’s analysis of transportation impacts for spent fuel shipments from the Savannah River Site described in NUREG-1811 (Section 6.2 and Appendix G). The proposed VEGP site is located directly across the Savannah River from DOE’s Savannah River Site. The truck shipment routes evaluated for the Savannah River Site and VEGP are identical except for approximately 30 miles (about 1 percent of the distance to the repository) from either point of origin.

SNC also reviewed the analysis of transportation impacts for spent fuel shipments from the Savannah River Site and VEGP in DOE's Yucca Mountain EIS. The Savannah River Site-Yucca Mountain truck shipment route used in the NRC analysis is the same route evaluated in the Yucca Mountain EIS. Parameter values used in the NRC analyses (e.g., vehicle speed, traffic count, dose rate, packaging, and attributes associated with vehicle stops) are consistent with those used in the Yucca Mountain EIS and DOE guidance on transportation risk assessment (**DOE 2002a**) and other NRC evaluations of spent fuel shipments **(Sprung et al. 2000)**. The parameter values selected by NRC are commonly used and are considered standard values for RADTRAN applications such as environmental impact statements. Thus they are appropriate to assess transportation impacts of spent fuel shipments from the VEGP site.

Based on its review of the NRC transportation analyses and Yucca Mountain EIS, SNC concluded the transportation impacts associated with spent fuel shipments from the proposed ESP site at VEGP would be nearly identical to and slightly less than those projected in NRC's transportation analysis for the Savannah River Site. SNC analyzed the potential impacts for spent fuel shipments (both incident-free transportation and transportation accidents) based on the results of NRC's assessment for the Savannah River Site.

5.11.2.1 Transportation of Unirradiated Fuel

Table S-4 of 10 CFR 51.52 includes conditions related to radiological doses to transport workers and members of the public along transport routes. These doses, based on calculations in WASH-1238, are a function of the radiation dose rate emitted from the unirradiated fuel shipments, the number of exposed individuals and their locations relative to the shipment, the time of transit (including travel and stop times), and the number of shipments to which the individuals are exposed. In its assessments of environmental impacts for other proposed ESP sites, NRC calculated the radiological dose impacts of unirradiated fuel transportation using the RADTRAN 5 computer code **(NRC 2004, 2005, 2006)**. The RADTRAN 5 calculations estimated worker and public doses associated with annual shipments of unirradiated fuel.

One of the key assumptions in WASH-1238 for the reference LWR unirradiated fuel shipments is that the radiation dose rate at 1 meter from the transport vehicle is about 0.1 millirem per hour. This assumption was also used by NRC to analyze advanced LWR unirradiated fuel shipments for other proposed ESP sites **(NRC 2004, 2005, 2006)**. This assumption is reasonable for all of the advanced LWR types because the fuel materials will all be low-dose-rate uranium radionuclides and will be packaged similarly (inside a metal container that provides little radiation shielding). The per-shipment dose estimates are "generic" (i.e., independent of reactor technology) because they were calculated based on an assumed external radiation dose rate rather than the specific characteristics of the fuel or packaging. Thus, the results can be used to evaluate the impacts for any of the advanced LWR designs. Other input parameters used in the radiation dose analysis for advanced LWR unirradiated fuel shipments are summarized in

Table 5.11-5. The results for this "generic" fresh fuel shipment based on the RADTRAN 5 analyses are as follows:

Population Component	Dose
Transport workers	0.00171 person-rem/shipment
General public (Onlookers — persons at stops and sharing the highway)	0.00665 person-rem/shipment
General public (Along Route — persons living near a highway)	1.61×10^{-4} person-rem/shipment

These unit dose values were used to estimate the impacts of transporting unirradiated fuel to the VEGP site. Based on the parameters used in the analysis, these per-shipment doses are expected to conservatively estimate the impacts for fuel shipments to a site in the SNC region of interest. For example, the average shipping distance of 2000 miles used in the analyses is likely to exceed the shipping distance for fuel deliveries to the VEGP site.

The unit dose values were combined with the average annual shipments of unirradiated fuel to calculate annual doses to the public and workers that can be compared to Table S-4 conditions. The numbers of unirradiated fuel shipments were normalized to the reference reactor analyzed in WASH-1238. The numbers of shipments per year were obtained from Table 5.11-2. The results are presented in Table 5.11-6. As shown, the calculated radiation doses for transporting unirradiated fuel to the SNC ESP site are within the Table S-4 conditions.

Although radiation may cause cancers at high doses and high dose rates, currently there are no data that unequivocally establish the occurrence of cancer following exposures to low doses and dose rates, below about 1E+04 millirem. However, radiation protection experts conservatively assume that any amount of radiation may pose some risk of causing cancer or a severe hereditary effect and that the risk is higher for higher radiation exposures. Therefore, a linear, no-threshold dose response relationship is used to describe the relationship between radiation dose and detriments such as cancer induction. Simply stated, any increase in dose, no matter how small, results in an incremental increase in health risk. This theory is accepted by the NRC as a conservative model for estimating health risks from radiation exposure, recognizing that the model may over-estimate those risks. A recent review by the National Academy of Sciences Committee to Assess Health Risks from Low Levels of Ionizing Radiation supports the linear no-threshold model **(NAS 2005)**.

Based on this model, the risk to the public from radiation exposure is estimated using the nominal probability coefficient for total detriment (730 fatal cancers, nonfatal cancers, and severe hereditary effects per 1×10^6 person-rem) from International Commission on Radiation Protection (ICRP) Publication 60 **(ICRP 1991)**. All the public doses presented in Table 5.11-6 are less than 0.1 person-rem per year; therefore, the total detriment estimates associated with these doses will all be less than 1×10^{-4} fatal cancers, nonfatal cancers, and severe hereditary effects per year. These risks are very small compared to the fatal cancers, nonfatal cancers, and severe hereditary effects that the same population will incur annually from exposure to natural sources of radiation.

5.11.2.2 Transportation of Spent Fuel

This section provides the environmental impacts of transporting spent fuel from the VEGP site to a spent fuel disposal facility using Yucca Mountain, Nevada as a possible location for a geologic repository. The impacts of the transportation of spent fuel to a possible repository in Nevada provides a reasonable bounding estimate of the transportation impacts to a monitored retrievable storage facility because of the distances involved and the representative exposure of members of the public in urban, suburban, and rural areas **(NRC 2004, 2005, 2006)**.

Incident-free transportation refers to transportation activities in which the shipments reach their destination without releasing any radioactive cargo to the environment. Impacts from these shipments will be from the low levels of radiation that penetrate the heavily shielded spent fuel shipping cask. Radiation doses will occur to (1) persons residing along the transportation corridors between the ESP site and the proposed repository; (2) persons in vehicles passing a spent-fuel shipment; (3) persons at vehicle stops for refueling, rest, and vehicle inspections; and (4) transportation crew workers.

This analysis is based on shipment of spent fuel by legal-weight trucks in casks with characteristics similar to casks currently available (i.e., massive, heavily shielded, cylindrical metal pressure vessels). Each shipment is assumed to consist of a single shipping cask loaded on a modified trailer. These assumptions are consistent with assumptions made in evaluating of environmental impacts of spent fuel transportation in Addendum 1 to NUREG-1437. As discussed in NUREG-1437, these assumptions are conservative because the alternative assumptions involve rail transportation or heavy-haul trucks, which will reduce the overall number of spent fuel shipments.

In its assessments of other proposed ESP sites, NRC calculated the environmental impacts of spent fuel transportation using the RADTRAN 5 computer code **(Neuhauser et al. 2003)**. Routing and population data used in the RADTRAN 5 for truck shipments were obtained from the TRAGIS routing code **(Johnson and Michelbaugh 2000)**. The population data in the TRAGIS code were based on the 2000 census.

NRC assumed all spent fuel shipments will be transported by legal weight trucks to the potential Yucca Mountain site over designated highway route-controlled quantity (HRCQ) routes. The routes used for the NRC analyses of other proposed ESP sites are the same as those used in the Yucca Mountain EIS **(DOE 2002b)**.

Although shipping casks have not been designed for the advanced LWR fuels, the advanced LWR fuel designs will not be significantly different from existing LWR designs. Current shipping cask designs were used for analysis.

Radiation doses are a function of many parameters, including vehicle speed, traffic count, dose rate at 1 meter from the vehicle, packaging dimensions, number in the truck crew, stop time, and population density at stops. A listing of the values for the parameters used in the NRC analyses can be found in Appendix G of the *Draft Environmental Impact Statement for an Early Site Permit (ESP) at the North Anna Site* (NUREG-1811; November 2004).

The transportation route selected for a shipment determines the total potentially exposed population and the expected frequency of transportation-related accidents. For truck transportation, the route characteristics most important to the risk assessment include the total shipping distance between each origin-destination pair of sites and the population density along the route.

Representative shipment routes for the VEGP site and alternative sites were identified using the TRAGIS (Version 1.5.4) routing model **(Johnson and Michelhaugh 2000)** for the truck shipments. The Highway data network in TRAGIS is a computerized road atlas that includes a complete description of the interstate highway system and of all U.S. highways. The TRAGIS database version used was Highway Data Network 4.0. The population densities along a route are derived from 2000 census data from the U.S. Bureau of the Census. This transportation route information is summarized in Table 5.11-7 along with the characteristics for the Savannah River Site-Yucca Mountain route.

The VEGP site, is directly across the Savannah River from the DOE's Savannah River Site. The transportation impacts associated with shipments of spent fuel from VEGP will be nearly identical to and slightly less than the NRC transportation analyses for the Savannah River Site because of the proximity of the two sites. As analyzed in the Yucca Mountain EIS **(DOE 2002b)**, the truck shipment routes from the Savannah River Site and VEGP site converge at Interstate 520, a distance of approximately 30 miles from either point of origin or about 1 percent of the total one-way shipping distance to the repository. The remainder of the highway transportation routes to the proposed repository is identical. SNC analyzed potential transportation impacts from VEGP based on the results for spent fuel shipments from the Savannah River Site.

TRAGIS was recently updated to reflect use of the Las Vegas Beltway (Interstate 215/CC-215) as a preferred route for transportation to Yucca Mountain. This change resulted in a decrease of approximately 45,000 in the total exposed population (persons that live within 800 meters of the transportation route) for each transportation route. The total exposed populations within the 800-meter buffer zone are 722,000 for the Hatch site, 764,000 for the VEPG site, and 766,000 for the Farley site. These values are bounded by the total exposed population of greater than 800,000 for the Savannah River Site - Yucca Mountain route.

By using the results for the Savannah River Site-Yucca Mountain transportation route, SNC has conservatively estimated the potential impacts for spent fuel transportation from an ESP site. Based on the transportation route information shown in Table 5.11-7, the impacts of spent fuel shipments originating at the VEGP site are expected to be greater than the impacts for the alternative sites with existing nuclear plants (Farley, Hatch). The impacts of transportation of spent fuel from a green field site located in the SNC region of interest will also be less than the transportation impacts for the VEGP site.

Based on the Savannah River Site-Yucca Mountain transportation route results presented in Table G-6 of NUREG-1811, the radiation dose estimates to the transport workers and the public for spent fuel shipments from VEGP are as follows:

Population	Dose
Transport workers	0.099 person-rem/shipment
General public (Onlookers)	0.35 person-rem/shipment
General public (Along Route)	0.010 person-rem/shipment

These per-shipment dose estimates are independent of reactor technology because they were calculated based on an assumed external radiation dose rate emitted from the cask, which was fixed at the regulatory maximum of 10 millirem per hour at 2 meters. For purpose of this analysis, the transportation crew consists of two drivers. Stop times were assumed to accrue at the rate of 30 minutes per 4-hour driving time.

The numbers of spent fuel shipments for the transportation impacts analysis were derived as described in Section 5.11.1. The normalized annual shipments values and corresponding population dose estimates per reactor-year are presented in Table 5.11-8. The population doses were calculated by multiplying the number of spent fuel shipments per year for the AP1000 by the per-shipment doses. For comparison to Table S-4, the population doses were normalized to the reference LWR analyzed in WASH-1238.

As shown in Table 5.11-8, population doses to the transport crew and the onlookers for both the AP1000 and the reference LWR exceed Table S-4 values. Two key reasons for these higher population doses relative to Table S-4 are the number of spent fuel shipments and the shipping distances assumed for these analyses relative to the assumptions used in WASH-1238.

- The analyses in WASH-1238 used a "typical" distance for a spent fuel shipment of 1,000 miles. The shipping distance used in this assessment is about 2,600 miles.
- The numbers of spent fuel shipments are based on shipping casks designed to transport shorter-cooled fuel (i.e., 150 days out of the reactor). This analysis assumed that the shipping cask capacities are 0.5 MTU per legal-weight truck shipment. Newer cask designs are based on longer-cooled spent fuel (i.e., 5 years out of reactor) and have larger capacities. For example, spent fuel shipping cask capacities used in the Yucca Mountain EIS (**DOE 2002b,** Table J-2) were approximately 1.8 MTU per legal-weight truck shipment. Use of the newer shipping cask designs will reduce the number of spent fuel shipments and decrease the associated environmental impacts (since the dose rates used in the impacts analysis are fixed at the regulatory limit rather than based on the cask design and contents).

If the population doses were adjusted for the longer shipping distance and larger shipping cask capacity, the population doses from incident-free spent fuel transportation from VEGP will fall within Table S-4 requirements.

Other conservative assumptions in the spent fuel transportation impacts calculation include:

- <u>Use of the regulatory maximum dose rate (10 millirem per hour at 2 meters) in the RADTRAN 5 calculations</u>. The shipping casks assumed in the Yucca Mountain EIS **(DOE 2002b)** transportation analyses were designed for spent fuel that has cooled for 5 years. In reality, most spent fuel will have cooled for much longer than 5 years before it is shipped to a possible geologic repository. NRC developed a probabilistic distribution of dose rates based on fuel cooling times that indicates that approximately three-fourths of the spent fuel to be transported to a possible geologic repository will have dose rates less than half of the regulatory limit **(Sprung et al. 2000)**. Consequently, the estimated population doses in Table 5.11-8 could be divided in half if more realistic dose rate projections are used for spent fuel shipments from VEGP.
- <u>Use of 30 minutes as the average time at a truck stop in the calculations</u>. Many stops made for actual spent fuel shipments are short duration stops (i.e., 10 minutes) for brief visual inspections of the cargo (checking the cask tie-downs). These stops typically occur in minimally populated areas, such as an overpass or freeway ramp in an unpopulated area. Based on data for actual truck stops, NRC concluded that the assumption of a 30-minute stop for every 4-hours of driving time used to evaluate other potential ESP sites will overestimate public doses at stops by at least a factor of two **(NRC 2004, 2005, 2006)**. Consequently, the doses to onlookers given in Table 5.11-8 could be reduced by a factor of two to reflect more realistic truck shipping conditions.

Impact of accident free transportation of unirradiated and spent fuel will be SMALL and will not warrant additional mitigation.

Table 5.11-1 Summary of Environmental Impacts of Transportation of Fuel and Waste to and from One LWR, Taken from 10 CFR 51.52 Table S-4[1]

Normal Conditions of Transport			
		Environmental Impact	
Heat (per irradiated fuel cask in transit)		250,000 Btu/hr.	
Weight (governed by Federal or State restrictions)		73,000 lbs. per truck; 100 tons per cask per rail car.	
Traffic density:			
Truck		Less than 1 per day.	
Rail		Less than 3 per month.	
Exposed Population	Estimated Number of Persons Exposed	Range of Doses to Exposed Individuals[2] (per reactor year)	Cumulative Dose to Exposed Population (per reactor year)[3]
Transportation workers	200	0.01 to 300 millirem	4 man-rem.
General public:			
Onlookers	1,100	0.003 to 1.3 millirem	3 man-rem.
Along Route	600,000	0.0001 to 0.06 millirem	
Accidents in Transport			
Types of Effects	**Environmental Risk**		
Radiological effects	Small[4]		
Common (nonradiological) causes	1 fatal injury in 100 reactor years; 1 nonfatal injury in 10 reactor years; $475 property damage per reactor year.		

1 Data supporting this table are given in the Commission's "Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants," WASH-1238, December 1972, and Supp. 1 NUREG-75/038, April 1975.

2 The Federal Radiation Council has recommended that the radiation doses from all sources of radiation other than natural background and medical exposures should be limited to 5,000 millirem per year for individuals as a result of occupational exposure and should be limited to 500 millirem per year for individuals in the general population. The dose to individuals due to average natural background radiation is about 130 millirem per year.

3 Man-rem is an expression for the summation of whole body doses to individuals in a group. Thus, if each member of a population group of 1,000 people were to receive a dose of 0.001 rem (1 millirem), or if 2 people were to receive a dose of 0.5 rem (500 millirem) each, the total man-rem dose in each case will be 1 man-rem.

4 Although the environmental risk of radiological effects stemming from transportation accidents is currently incapable of being numerically quantified, the risk remains small regardless of whether it is being applied to a single reactor or a multi-reactor site.

Table 5.11-2 Number of Truck Shipments of Unirradiated Fuel

Reactor Type	Number of Shipments per Unit: Initial Core[1]	Annual Reload	Total[2]	Unit Electric Generation, MWe[3]	Capacity Factor[3]	Normalized Shipments Total[4]	Normalized Shipments Annual[5]
Reference LWR	18[6]	6.0	252	1100	0.8	252	6.3
AP1000	23	5.3	231	1115	0.93	196	4.9

1 Shipments of the initial core have been rounded up to the next highest whole number.
2 Total shipments of fresh fuel over 40-year plant lifetime (i.e., initial core load plus 39 years of average annual reload quantities).
3 Unit generating capacities from **Westinghouse (2005)** and capacity factors for advanced LWRs from Table 3.0-1. 93 percent used in normalization calculations where >92 percent indicated by Table 3.0-1.
4 Normalized to electric output for WASH-1238 reference plant (i.e., 1100 MWe) plant at 80 percent or an electrical output of 880 MWe).
5 Annual average for 40-year plant lifetime
6 The initial core load for the reference BWR in WASH-1238 was 150 MTU. The initial core load for the reference PWR was 100 MTU. Both types result in 18 truck shipments of fresh fuel per reactor.

Table 5.11-3 Number of Radioactive Waste Shipments

Reactor Type	Waste Generation, ft^3/yr, per unit	Annual Waste Volume, ft^3/ yr, per site	Electrical Output, MWe, per site	Capacity Factor	Normalized Waste Generation Rate, ft^3/ reactor-year[1]	Normalized Shipments/ reactor-year[2]
Reference LWR	3800	3800	1100	0.80	3800	46
AP1000	2000	3900	2230[3]	0.93	1700	21

1 Annual waste generation rates normalized to equivalent electrical output of 880 MWe for reference LWR (1100-MWe plant with an 80 percent capacity factor) analyzed in WASH-1238.
2 The number of shipments was calculated assuming the average waste shipment capacity of 82.6 ft^3 per shipment (3800 ft^3/yr divided by 46 shipments/yr) used in WASH-1238.
3 The AP1000 site includes two reactor units at net 1115 MWe per unit.

Table 5.11-4 AP1000 Comparisons to Table S-4 Reference Conditions

Characteristic	Table S-4 Condition	AP1000 Single Unit 1115 MWe
Reactor Power Level (MWt)	not exceeding 3800 per reactor	3415
Fuel Form	sintered UO_2 pellets	sintered UO_2 pellets
U235 Enrichment (%)	Not exceeding 4	Initial Core Region 1: 2.35 Region 2: 3.40; Region 3: 4.45 Reload Average 4.51
Fuel Rod Cladding	Zircaloy rods; NRC has also accepted ZIRLO™ per 10 CFR 50.44	Zircaloy or ZIRLO™
Average burnup (MWd/MTU)	Not exceeding 33,000	48,700
Unirradiated Fuel		
Transport Mode	truck	truck
No. of shipments for initial core loading[1]		23
No. of reload shipments per year[1]		5.3
Irradiated Fuel		
Transport mode	truck, rail or barge	truck, rail
Decay time prior to shipment	Not less than 90 days is a condition for use of Table S-4; 5 years is per contract with DOE	10 years
No. of spent fuel shipments by truck[1]		46 per year
No. of spent fuel shipments by rail		not analyzed
Radioactive Waste		
Transport mode	truck or rail	truck
Waste form	solid	solid
Packaged	yes	yes
No. of waste shipments by truck[1]		24 per year
Traffic Density		
Trucks per day[2] (normalized total)	Less than 1	<1 (65 per year)
Rail cars per month	Less than 3	not analyzed

1 Table provides the total numbers of truck shipments of fuel and waste for the AP1000. These values are then normalized based on electric output and summed for comparison to the traffic density condition in Table S-4.
2 Total truck shipments per year calculated after normalization of estimated fuel and waste shipments for equivalent electrical output to the reference reactor analyzed in WASH-1238.

Table 5.11-5 RADTRAN 5 Input Parameters for NRC Analysis of Unirradiated Fuel Shipments

Parameter	RADTRAN 5 Input Value
Shipping distance, miles[1]	2000
Travel Fraction — Rural	0.90
Travel Fraction — Suburban	0.05
Travel Fraction — Urban	0.05
Population Density — Rural, persons/mi^2	25.9
Population Density — Suburban, persons/mi^2	904
Population Density — Urban, persons/mi^2	5850
Vehicle speed — Rural, miles/hr	55
Vehicle speed — Suburban, miles/hr	55
Vehicle speed — Urban, miles/hr	55
Traffic count — Rural, vehicles/hr	530
Traffic count — Suburban, vehicles/hr	760
Traffic count — Urban, vehicles/hr	2400
Dose rate at 1 meter from vehicle, mrem/hr	0.1
Packaging length, ft	22
Number of truck crew	2
Stop time, hr/trip	4.5
Population density at stops, persons/mi^2	166,500

Source: **NRC (2004, 2005, 2006)**.

1 WASH-1238 had a range of shipping distances between 25 and 3000 miles for unirradiated fuel shipments. A 2000-mile “average” shipping distance was used in the NRC analyses of other potential ESP sites.

Table 5.11-6 Radiological Impacts of Transporting Unirradiated Fuel to VEGP by Truck

Reactor Type	Normalized Average Annual Shipments	Cumulative Annual Dose, person-rem per reference reactor year		
		Transport Workers	General Public - onlookers	General Public - along route
Reference LWR	6.3	0.011	0.042	0.0010
AP1000	4.9	0.0084	0.033	7.9×10^{-4}
10 CFR 51.52 Table S-4 condition	365 (<1 per day)	4	3	3

Table 5.11-7 Transportation Route Information for Spent Fuel Shipments from VEGP to the Potential Yucca Mountain Disposal Facility

Reactor Site	One-way Shipping Distance, miles				Population Density, persons per square mile			Stop Time per trip, hr
	Total	Rural	Suburban	Urban	Rural	Suburban	Urban	
SRS[1]	2649	2026	547	76	28.5	859	5986	5
VEGP	2564	2009	488	67	25.0	856	5879	5
Hatch	2595	2043	489	63	25.1	838	5872	5
Farley	2559	2043	450	67	24.8	867	6076	5

1 SRS transportation route information presented in Table G-4 of **NRC (2004)**

Table 5.11-8 Population Doses from Spent Fuel Transportation, Normalized to Reference LWR

		Reactor Type	
		Reference LWR	AP1000
		Normalized Number of Spent Fuel Shipments per year	
	Cumulative dose limit specified in Table S-4,	60	39
Exposed Population	**person-rem per reactor year**	**Environmental Effects, person-rem per reactor year**	
Crew	4	5.9	3.8
Onlookers	3	21	14
Along route	3	0.60	0.39

Section 5.11 References

(DOE 2002a) U.S. Department of Energy, A Research Handbook on DOE Transportation Risk Assessment, DOE/EM/NTP/HB-01, Washington, D.C.

(DOE 2002b) U.S. Department of Energy, Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada, DOE/EIS-0250, Office of Civilian Radioactive Waste Management, U.S. Department of Energy, Washington, D.C., February, 2002.

(ICRP 1991) International Council on Radiation Protection 1991. *Recommendations of the International Commission on Radiological Protection*, ICRP Publication 60.

(Johnson and Michelbaugh 2000) Johnson, P. E. and R. D. Michelhaugh, *Transportation Routing Analysis Geographic Information System (WebTRAGIS) User's Manual*, ORNL/TM-2000/86, Oak Ridge National Laboratory, Oak Ridge, Tennessee, available on the Internet at http://www.ornl.gov/~webworks/cpr/v823/rpt/106749.pdf.

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(NRC 2005) U.S. Nuclear Regulatory Commission, Draft Environmental Impact Statement for an Early Site Permit (ESP) at the Exelon ESP Site, NUREG-1815, Office or Nuclear Reactor Regulation, Washington, D.C., February.

(NRC 2006) U.S. Nuclear Regulatory Commission, Environmental Impact Statement for an Early Site Permit (ESP) at the Grand Gulf ESP Site, NUREG-1817, Office or Nuclear Reactor Regulation, Washington, D.C., April.

(Sprung et al. 2000) Sprung, J. L., D. J. Ammerman, N. L. Breivik, R. J. Dukart, F. L. Kanipe, J. A. Koski, G. S. Mills, K. S. Neuhauser, H. D. Radloff, R. F. Weiner, and H. R. Yoshimura, Reexamination of Spent Fuel Shipment Risk Estimates, NUREG/CR-6672, Volume 1, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D.C., March.

(Westinghouse 2005) Westinghouse Electric Company LLC, AP1000 Design Control Document, Revision 15, Pittsburgh, PA, November 11.

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5.12 Nonradiological Health Impacts

5.12.1 Public Health

New units at VEGP could cause non-radiological health impacts to the public. Nonradiological air emissions can move offsite to nearby residences or businesses. Noise can be heard offsite. The electrical transmission system can produce induced currents in metal fences and vehicles beneath the transmission lines. In the Savannah River, pathogenic organisms could exist due to the heated effluent from the plant.

Section 5.3.4, Impacts to Members of the Public (from cooling system operation), addresses the impacts to the public from pathogenic organisms and noise concludes that the impacts to the public from both are small. Section 5.6.3, Impacts to Members of the Public (from transmission line operation), examines the risk from electric shock from induced currents under transmission lines. The magnitude of the shock will be within the limits established by the National Electrical Safety Code. Section 5.8.1, Physical Impacts of Station Operation, describes the risks from air pollution and concludes that the risks are small.

Impacts to members of the public will be SMALL and will not warrant mitigation.

5.12.2 Occupational Health

Workers at the new nuclear units could be susceptible to industrial accidents (e.g., falls, electric shock, burns), or occupational illnesses due to noise exposure, exposure to toxic or oxygen-replacing gases, exposure to thermophilic organisms in the condenser bays, and exposure to caustic agents. SNC has a health and safety program that addresses industrial safety risks and that will be invoked for the new units. In accordance with this plan, SNC maintains records of a statistic known as total recordable cases (TRC). TRCs include work-related injuries or illnesses that include death, days away from work, restricted work activity, medical treatment beyond first aid, and other criteria.

The incidence rate of recordable cases at Plant Vogtle between 2000 and 2004 averaged 1.8 cases per 100 workers or 1.8 percent. This compares favorably to the nationwide TRC rate for electrical power generation workers of 3.5 percent **(BLS 2003a)** and of 4.5 percent for Georgia **(BLS 2003b)**.

SNC estimates that two AP1000s will employ 662 workers. During outages, these numbers could increase significantly for short durations.

The number of total recordable cases per year for the new units can be estimated as the number of workers times the VEGP TRC rate. Therefore, the estimated TRC incidence will be:

No. Workers	TRC Incidence at U.S. Rate	TRC Incidence at Georgia Rate	TRC Incidence at VEGP Rate
662	23	30	12

Section 5.12 References

(BLS 2003a) Bureau of Labor Statistics, “Table 1, Incidence rates of nonfatal occupational injuries and illnesses by industry and case types, 2003,” available on the internet from http://www.bls.gov/iif/, accessed July 14, 2005.

(BLS 2003b) Bureau of Labor Statistics, “Table 6, Incidence rates of nonfatal occupational injuries and illnesses by industry and case types, 2003, Georgia,” available on the internet from http://www.bls.gov/iif/, accessed July 14, 2005.