5.0 Environmental Impacts of Postulated Accidents

Environmental issues associated with postulated accidents are discussed in the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS), NUREG-1437, Volumes 1 and 2 (NRC 1996; 1999).[(a)] The GEIS includes a determination of whether the analysis of the environmental issue could be applied to all plants and whether additional mitigation measures would be warranted. Issues are then assigned a Category 1 or a Category 2 designation. As set forth in the GEIS, Category 1 issues are those that meet all of the following criteria:

(1) The environmental impacts associated with the issue have been determined to apply either to all plants or, for some issues, to plants having a specific type of cooling system or other specified plant or site characteristic.

(2) Single significance level (i.e., SMALL, MODERATE, or LARGE) has been assigned to the impacts (except for collective offsite radiological impacts from the fuel cycle and from high level waste and spent fuel disposal).

(3) Mitigation of adverse impacts associated with the issue has been considered in the analysis, and it has been determined that additional plant-specific mitigation measures are likely not to be sufficiently beneficial to warrant implementation.

For issues that meet the three Category 1 criteria, no additional plant-specific analysis is required unless new and significant information is identified.

Category 2 issues are those that do not meet one or more of the criteria for Category 1, and therefore, additional plant-specific review of these issues is required.

This chapter describes the environmental impacts from postulated accidents that might occur during the license renewal term.

5.1 Postulated Plant Accidents

Two classes of accidents are evaluated in the GEIS. These are design-basis accidents (DBAs) and severe accidents, as discussed below.

(a) The GEIS was originally issued in 1996. Addendum 1 to the GEIS was issued in 1999. Hereafter, all references to the "GEIS" include the GEIS and Addendum 1.

5.1.1 Design-Basis Accidents

In order to receive NRC approval to operate a nuclear power facility, an applicant must submit a safety analysis report (SAR) as part of its application. The SAR presents the design criteria and design information for the proposed reactor and comprehensive data on the proposed site. The SAR also discusses various hypothetical accident situations and the safety features that are provided to prevent and mitigate accidents. The NRC staff reviews the application to determine whether the plant design meets the Commission's regulations and requirements and includes, in part, the nuclear plant design and its anticipated response to an accident.

DBAs are those accidents that both the licensee and the NRC staff evaluate to ensure that the plant can withstand normal and abnormal transients, and a broad spectrum of postulated accidents without undue hazard to the health and safety of the public. A number of these postulated accidents are not expected to occur during the life of the plant, but are evaluated to establish the design basis for the preventive and mitigative safety systems of the facility. The acceptance criteria for DBAs are described in 10 CFR Part 50 and 10 CFR Part 100. The environmental impacts of DBAs are evaluated during the initial license process, and the ability of the plant to withstand these accidents is demonstrated to be acceptable before issuance of the operating license (OL). The results of these evaluations are found in license documentation such as the staff's Safety Evaluation Report (SER), the Final Environmental Statement (FES), the licensee's Updated Final Safety Analysis Report (UFSAR), and Section 5.1 of this supplemental environmental impact statement (SEIS). The licensee is required to maintain the acceptable design and performance criteria throughout the life of the plant including any extended-life operation. The consequences for these events are evaluated for the hypothetical maximum exposed individual; as such, changes in the plant environment will not affect these evaluations. Because of the requirements that continuous acceptability of the consequences and aging management programs be in effect for license renewal, the environmental impacts as calculated for DBAs should not differ significantly from initial licensing assessments over the life of the plant, including the license renewal period. Accordingly, the design of the plant relative to DBAs during the extended period is considered to remain acceptable and the environmental impacts of those accidents were not examined further in the GEIS.

The Commission has determined that the environmental impacts of DBAs are of SMALL significance for all plants because the plants were designed to successfully withstand these accidents. Therefore, for the purposes of license renewal, design-basis events are designated as a Category 1 issue in 10 CFR Part 51, Subpart A, Appendix B, Table B-1. The early resolution of the DBAs make them a part of the current licensing basis of the plant; the current licensing basis of the plant is to be maintained by the licensee under its current license and, therefore, under the provisions of 10 CFR 54.30, is not subject to review under license renewal. This issue, applicable to Surry Power Station, Units 1 and 2, is listed in Table 5-1.

Table 5-1. Category 1 Issue Applicable to Postulated Accidents During the Renewal Term

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Section
POSTULATED ACCIDENTS	
Design-basis accidents (DBAs)	5.3.2; 5.5.1

Based on information in the GEIS, the Commission found that

> The NRC staff has concluded that the environmental impacts of design basis accidents are of small significance for all plants.

The Virginia Electric and Power Company (VEPCo) stated in its Environmental Report (ER; VEPCo 2001a) that it is not aware of any new and significant information associated with the renewal of the Surry Units 1 and 2 OLs. The staff has not identified any significant new information during its independent review of the VEPCo ER, the staff's site visit, the scoping process, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts related to this issue beyond those discussed in the GEIS.

5.1.2 Severe Accidents

Severe nuclear accidents are those that are more severe than DBAs because they could result in substantial damage to the reactor core, whether or not there are serious offsite consequences. In the GEIS, the staff assessed the impacts of severe accidents during the license renewal period, using the results of existing analyses and site-specific information to conservatively predict the environmental impacts of severe accidents for each plant during the renewal period.

Based on information in the GEIS, the Commission found that

> The probability weighted consequences of atmospheric releases, fallout onto open bodies of water, releases to ground water, and societal and economic impacts from severe accidents are small for all plants. However, alternatives to mitigate severe accidents must be considered for all plants that have not considered such alternatives.

Therefore, the Commission has designated mitigation of severe accidents as a Category 2 issue in 10 CFR Part 51, Subpart A, Appendix B, Table B-1. This issue, applicable to Surry Units 1 and 2, is listed in Table 5-2.

Table 5-2. Category 2 Issue Applicable to Postulated Accidents During the Renewal Term

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Sections	10 CFR 51.53(c)(3)(ii) Subparagraph	SEIS Section
POSTULATED ACCIDENTS			
Severe Accidents	5.3.3; 5.3.3.2; 5.3.3.3; 5.3.3.4; 5.3.3.5; 5.4; 5.5.2	L	5.2

The staff has not identified any significant new information with regard to the consequences from severe accidents during its independent review of the VEPCo ER (VEPCo 2001a), the staff's site visit, the scoping process, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts of severe accidents beyond those discussed in the GEIS. However, in accordance with 10 CFR 51.53(c)(3)(ii)(L), the staff has reviewed severe accident mitigation alternatives (SAMAs) for Surry Units 1 and 2. The results of its review are discussed in Section 5.2.

5.2 Severe Accident Mitigation Alternatives

10 CFR 51.53(c)(3)(ii)(L) requires that license renewal applicants consider alternatives to mitigate severe accidents if the staff has not previously evaluated SAMAs for the applicant's plant in an environmental impact statement (EIS) or related supplement or in an environmental assessment. The purpose of this consideration is to ensure that plant changes (i.e., hardware, procedures, and training) with the potential for improving severe accident safety performance are identified and evaluated. SAMAs have not been previously considered for Surry Power Station, Units 1 and 2; therefore, the following sections address those alternatives.

5.2.1 Introduction

VEPCo submitted an assessment of SAMAs for Surry Units 1 and 2 as part of the ER (VEPCo 2001a). The assessment was based on the Surry Probabilistic Risk Assessment (PRA), which is an updated version of the Surry Individual Plant Examination (IPE) for internal events (VEPCo 1991), the Surry Individual Plant Examination for External Events (IPEEE) (VEPCo 1994), and supplemental analyses of offsite consequences and economic impacts performed specifically for the SAMA analysis. VEPCo generated a list of 160 candidate SAMAs based on a review of previous SAMA analyses in support of original plant licensing and license renewal, NRC and industry reports discussing potential plant improvements, dominant risk contributors in the plant-specific risk study, and insights provided by VEPCo's PRA staff. VEPCo assessed

the costs and benefits associated with each of the potential SAMAs and concluded that none of the candidate SAMAs evaluated were cost-beneficial for Surry Power Station.

Based on a review of the applicant's SAMA assessment, the NRC issued a request for additional information (RAI) to VEPCo by letter dated October 17, 2001 (NRC 2001). Key questions concerned the modifications to the Surry PRA made subsequent to the IPE, treatment of external events in the SAMA analysis, the use of the plant-specific risk study in the SAMA identification process, and the evaluation of costs and benefits for certain SAMAs. VEPCo submitted additional information by letter dated December 10, 2001 (VEPCo 2001b) and by e-mails dated January 15 and January 22, 2002 (NRC 2002) in response to the staff's RAIs. These responses addressed the staff's concerns and reaffirmed the conclusion that none of the SAMAs would be cost-beneficial.

The staff's assessment of SAMAs for Surry Power Station follows.

5.2.2 Estimate of Risk for Surry Power Station

VEPCo's estimates of offsite risk at Surry Power Station are summarized below. The summary is followed by the staff's review of VEPCo's risk estimates.

5.2.2.1 VEPCo's Risk Estimates

Two distinct analyses are combined to form the basis for the risk estimates used in the SAMA analysis: (1) the Surry Level 1 and 2 PRA models, which is an updated version of the IPE, and (2) a supplemental analysis of offsite consequences and economic impacts (essentially a Level 3 PRA model) developed specifically for the SAMA analysis. The Surry PRA Level 1 and 2 models were originally developed in response to the request for an IPE contained in Generic Letter 88-20 (NRC 1988). The Level 1 model was updated in 1994 before performing the IPEEE fire analysis, and again in 1997 to support implementation of the maintenance rule. In addition, before performing the SAMA analysis, a number of changes were made to the Level 2 model to reflect new experimental results, and to provide more consistency with the Level 2 model for VEPCo's North Anna Power Station.

The baseline core damage frequency (CDF) for the purpose of SAMA evaluation is approximately 3.8×10^{-5} per reactor-year, based on the risk assessment for internally initiated events. Although VEPCo did not include the contribution of risk from external events within the Surry Power Station risk estimates, it did account for the potential risk-reduction benefits associated with external events by doubling the estimated benefits for internal events. This is discussed further in Section 5.2.2.2. A breakdown of the CDF is provided in Table 5-3. As shown in this table, loss-of-coolant accidents (LOCAs) contribute about 58 percent, while transients

Table 5-3. Surry Power Station Core Damage Frequency

Initiating Event	Frequency (per reactor-year)
Loss-of-coolant accident (LOCA)	2.2×10^{-5}
Transients	9.3×10^{-6}
Loss of offsite power/station blackout (LOOP/SBO)	2.5×10^{-6}
Steam generator tube rupture (SGTR)	2.3×10^{-6}
Interfacing system LOCA (ISLOCA)	1.6×10^{-6}
Anticipated transient without scram (ATWS)	4.5×10^{-9}
Total CDF from internal events	3.8×10^{-5}

contribute about 25 percent of the total internal events CDF. Anticipated transients without scram (ATWS) are negligible contributors to CDF for Surry Power Station. The frequency associated with the largest releases (i.e., interfacing system LOCA [ISLOCA] and steam generator tube rupture [SGTR]) for Surry Power Station is estimated to be about 3.9×10^{-6} per reactor-year. The station blackout (SBO) contribution to the transients was not explicitly provided in the submittal; however, in response to an RAI, VEPCo provided the frequency and contribution to the total frequency (see Table 5-3). The CDFs cited here and used in the SAMA analysis are best-estimate values. The uncertainty analysis for the updated PRA indicates a 95 percent confidence-level (upper) CDF value of 1.16×10^{-4} per reactor-year, or about three times the best-estimate value. The impact of this uncertainty on the SAMA analysis is discussed in Section 5.2.6.2.

The offsite consequences and economic impact analyses use the MELCOR Accident Consequence Code System 2 (MACCS2), Version 1.12, to determine the offsite risk impacts on the surrounding environment and public. Inputs for this analysis include plant/ site-specific input values for core radionuclide inventory, source term and release fractions, meteorological data, projected population distribution, emergency response evacuation modeling, and economic data. The magnitude of the onsite impacts (in terms of clean-up and decontamination costs and occupational dose) is based on information provided in NUREG/BR-0184 (NRC 1997b).

VEPCo estimated the dose to the population within 80 km (50 mi) of the Surry Power Station from internal initiators to be about 0.18 person-Sv (18 person-rem) per year. Table 5-4 shows the contributions to population dose by containment release mode. SGTRs and ISLOCAs together account for approximately 95 percent of the population dose although they collectively comprise only about 10 percent of the total internal events CDF. This is due to the relatively

Table 5-4. Risk Profile for Surry Power Station

Containment Release Mode	Contribution to Release Frequency[(a)] (%)	Contribution to Population Dose[(b)] (%)
Containment intact	59	<0.1
Early containment failure	1	1
Late containment failure	30	4
Containment bypass - SGTR	6	65
Containment bypass - ISLOCA	4	30

(a) Total release frequency for internal events = 3.8×10^{-5} per reactor-year.
(b) Total population dose = 0.18 person-Sv (18 person-rem) per reactor-year.

high fission-product releases in these sequences. Early and late containment failure contribute about 5 percent of the population dose. About 60 percent of the core melt accidents at Surry Power Station do not result in containment failure and have only a minimal contribution to population dose.

5.2.2.2 Review of VEPCo's Risk Estimates

VEPCo's determination of offsite risk at Surry Power Station is based on the following three major elements of analysis:

- the Level 1 and 2 risk models for Surry Power Station that form the basis for the 1991 IPE submittal and the 1994 IPEEE submittal
- the major modifications to the risk model subsequent to the IPE that distinguish the current PRA from the IPE
- the MACCS2 analyses performed to translate fission-product release frequencies from the Level 2 PRA model into offsite consequence measures.

Each of these analyses was reviewed to determine the acceptability of VEPCo's risk estimates for the SAMA analysis, as summarized below.

The staff's review of the Surry IPE is described in a staff report dated December 16, 1993 (NRC 1993). In that review, the staff evaluated the methodology, models, data, and assumptions used to estimate the CDF and characterize containment performance and fission product releases. The staff concluded that VEPCo's analysis met the intent of Generic Letter 88-20

(NRC 1988); that is, the IPE was of adequate quality to be used to look for design or operational vulnerabilities. Although the staff reviewed certain aspects of the IPE in more detail than others, it primarily focused on the licensee's ability to examine Surry Power Station for severe accident vulnerabilities and not specifically on the detailed findings or quantification estimates. Overall, the staff believed that the Surry IPE was of adequate quality to be used as a tool in searching for areas with high potential for risk reduction and to assess such risk reductions, especially when the risk models are used in conjunction with insights, sensitivity, and uncertainty analyses. It is important to note that some changes have been made to the Surry risk model since the original IPE was completed and reviewed by the NRC staff. These include both modifications to the models and changes due to plant modification, as discussed below.

A comparison of CDF profiles between the IPE and the updated PRA indicates that the estimate of the CDF for internal events has been reduced from 7.4×10^{-5} per reactor-year to 3.8×10^{-5} per reactor-year. The lower values in the updated PRA are attributed to plant and modeling improvements which have been implemented at Surry Power Station since the IPE was submitted.

The original Level 1 model documented in the 1991 Surry IPE submittal had a CDF of 7.4×10^{-5} per reactor-year (from internally initiated events, including internal flooding). A minor update to the Level 1 model was performed before the licensee completed the IPEEE fire analysis in December 1994.

A significant update to the Level 1 model occurred in 1997 to support implementation of the maintenance rule. A third update to the PRA model occurred in late 1997/early 1998. These updates were performed to incorporate significant plant modifications, correct model errors, and enhance the model with state-of-the-art improvements. Among the individual fault tree models changed or added were those involving auxiliary feedwater, the swing diesel, the station blackout diesel, the ATWS mitigating systems actuation circuitry, the component cooling water system, station service and switchyard buses, and various support systems for balance-of-plant components and backup mitigating functions. Modeling for the loss of emergency switchgear room (ESGR) and loss of 4160-V emergency bus initiating events were also modified, and the human error probability was modified to account for reduced time to hot leg recirculation during large LOCA events. The modified baseline CDF, as of the most recent model changes, is 3.8×10^{-5} per reactor-year.

A comprehensive peer review of the Level 1 and 2 PRA model used in the IPE was completed in August 1991. This review was conducted by a team composed of both VEPCo personnel and outside contractors. In addition, the updated Level 1 PRA model used as a basis for the SAMA analysis was reviewed as the pilot in the Westinghouse Owners Group peer certification effort.

The updated CDF value is lower than most of the original IPE values estimated for other pressurized water reactors (PWRs) with large dry containments. Figure 11.6 of NUREG-1560 (NRC 1997c) shows that the IPE-based total internal events CDF for Westinghouse three-loop plants range from 6×10^{-5} to 4×10^{-4} per reactor-year. However, many of these CDF estimates have similarly been reduced due to modeling and hardware changes subsequent to the respective IPE submittals. Thus, this observation may no longer be significant.

As noted in Table 5-4, SGTR and ISLOCA contribute 6 percent and 4 percent, respectively, to the total release frequency in internal events. Because of the large fission product releases for bypass sequences relative to other release modes, these sequences dominate the Surry Power Station risk profile. The conditional probability of early containment failure is approximately 1 percent, and about 30 percent of core damage sequences are expected to lead to late containment failure. Due to the sub-atmospheric design of the containment, containment isolation failures are relatively insignificant (about 0.3 percent of CDF). With the exception of the somewhat high CDF associated with bypass of the containment, and the lack of credit in the PRA for scrubbing releases from SGTRs, the results of the updated Surry PRA appear to be consistent with those of other IPEs for PWRs with large dry or subatmospheric containments insofar as the general CDF, containment response, and release and risk profiles are concerned.

VEPCo submitted an IPEEE by letter dated December 14, 1994 (VEPCo 1994). VEPCo did not identify any fundamental weaknesses or vulnerabilities to severe accident risk in regard to the external events related to seismic, fire, high winds, floods, transportation and nearby facility accidents, and other external hazards. In the associated safety evaluation report (NRC 2000), the staff concluded that the IPEEE met the intent of Supplement 4 to Generic Letter 88-20 (NRC 1991).

Although VEPCo used probabilistic risk methods for the seismic and fire portions of the IPEEE, in their SAMA analysis they chose to capture the potential risk benefits associated with external events by doubling the calculated internal events benefits for each SAMA. In assessing the reasonableness of this assumption, the staff considered the relative contribution to the total risk from the various external events based on best available information. The Surry Power Station high winds and external flooding analyses show that the plant is adequately designed to protect against the effects of these natural events. Transportation and nearby facility accidents were not considered to be potential sources of damage at the plant because of the plant's rural location. Other external events were evaluated and found to be insignificant contributors to CDF. Even though VEPCo's doubling of CDF to account for the benefits of a SAMA in external events provides a reasonable numerical estimate of the potential impact, this approach may potentially fail to capture the benefits that could result from specific SAMAs aimed at particular external events. In response to an RAI, VEPCo reasoned that since no external event

vulnerabilities in terms of containment bypass or isolation failure were identified in the IPEEE, the offsite consequences can be bounded by the use of an internal events profile. In addition, the CDF cited by VEPCo from external events – approximately 1.3×10^{-5} per reactor-year – is considerably lower than the CDF for internal events (3.8×10^{-5} per reactor-year). Therefore, the approach used by VEPCo is considered to be acceptable.

The Surry Power Station Level 2 IPE model (VEPCo 1991) that was reviewed by NRC in 1993 has been modified to make the model consistent with that for VEPCo's North Anna Power Station. Both plants' models were converted to large early release frequency (LERF) models shortly after the IPE/IPEEE process was completed. The models remained unchanged until the beginning of the SAMA analysis, at which time a unified source-term category (STC) grouping was implemented that essentially used the approach presented in the North Anna IPE. The general containment event tree (CET) was also modified to reflect recent experimental results in severe accident analysis research (e.g., the resolution of the direct containment heating issue). The revision in the Level 2 PRA model, as a result of the aforementioned changes, resulted in a reduction in the overall contribution to early containment failure. This has a relatively small impact on the overall risk of severe accidents at Surry Power Station since the contribution to risk from early containment failure was already small. The staff concludes that the use of the Surry Power Station Level 2 model provides a sufficiently detailed characterization of containment response to support a license renewal SAMA analysis.

The staff reviewed the process used by VEPCo to extend the containment performance (Level 2) portion of the PRA to an assessment of offsite consequences (essentially a Level 3 PRA). This included consideration of the source terms used to characterize fission product releases for each of 24 source-term categories and consideration of the major inputs and assumptions used in the offsite consequence analyses. VEPCo used the severe accident source terms presented in the Surry IPE as input to the NRC-developed MACCS2 code. For radionuclides not reported in the IPE, releases were set to zero. VEPCo's source terms were reviewed and found to be consistent with the source terms provided in other plants' submittals and are considered reasonable.

VEPCo used site-specific meteorological data processed from hourly measurements for one full year (1998) as input to the MACCS2 code. All data was collected at the Surry Power Station meteorology tower. Hourly meteorological data for two additional years (1996 and 1997) was also used for sensitivity comparison. The use of data from either 1996 or 1997 results in only a few percent change in the total benefit of the candidate SAMAs. Year-to-year weather variations are not significant in the SAMA analysis because (1) weather variations are diminished in the MACCS2 analyses due to its weather-sampling scheme, and (2) the same meteorological assumptions are used in estimating both the base-case consequences and the SAMA-case consequences.

The population distribution the applicant used as input to the MACCS2 analysis was initially prepared using the computer program SECPOP90 (NRC 1997a). The output from SECPOP90 is a file based on a reference database for the specified site. The SECPOP90-prepared population data was then modified and updated using the Surry Power Station UFSAR, Section 2.1.3, 50-mile population distribution for the year 2030 in place of the SECPOP90 1990 Census data. The methods and assumptions for estimating population are considered reasonable and acceptable for purposes of the SAMA evaluation.

VEPCo's emergency evacuation modeling was based on a single evacuation zone extending out 16 km (10 mi) from the plant. VEPCo assumed that the people within the evacuation zone would move at an average evacuation speed of 1.8 m/s (4 mph) with a 7200-second delay between the alarm and start of evacuation. The applicant's base-case analysis assumed 100 percent of the population within the emergency planning zone would participate in the evacuation. In contrast, in NUREG-1150 (NRC 1990a) the staff assumed evacuation of 99.5 percent of the population. VEPCo performed a sensitivity analysis in which only 95 percent of the population evacuates. The result was only about a 1-percent change in the total benefit of the candidate SAMAs. Additional sensitivity analyses were also performed in which MACCS2 parameters relating to the time and duration of release and evacuation delay times were increased and decreased by 50 percent. The result was about a 10-percent change in the total benefit of the candidate SAMAs. This change is small and would not alter the outcome of the SAMA analysis. Accordingly, the evacuation assumptions and analysis are deemed reasonable and acceptable for purposes of the SAMA evaluation.

Much of the site-specific economic data were provided by SECPOP90 (NRC 1997a) and used in the MACCS2 analyses. SECPOP90 contains a database extracted from U.S. Census Bureau CD-ROMs (1990 census data), the 1992 Census of Agriculture CD-ROM Series 1B, the 1994 U.S. Census County and City Data Book CD-ROM, the 1993 and 1994 Statistical Abstract of the United States, and other sources. These regional economic values were updated to 1999 using cost-of-living and other data from the U.S. Census Bureau and the Department of Agriculture. VEPCo performed a sensitivity analysis in which the farmland and non-farmland decontamination costs were increased by 25 percent. The result was about a 6 percent or less increase in the total benefit of the candidate SAMAs.

The staff concludes that the methodology used by VEPCo to estimate the CDF and offsite consequences for Surry Power Station provides an acceptable basis from which to proceed with an assessment of the risk reduction potential for candidate SAMAs. Accordingly, the staff based its assessment of offsite risk on the CDF and offsite doses reported by VEPCo.

5.2.3 Potential Design Improvements

The process for identifying potential plant improvements, an evaluation of that process, and the improvements evaluated in detail by VEPCo are discussed in this section.

5.2.3.1 Process for Identifying Potential Design Improvements

VEPCo's process for identifying potential plant improvements consisted of the following elements:

- a review of SAMA analyses submitted in support of original licensing and license renewal activities for other operating nuclear power plants and advanced light water reactor plants,

- a review of other NRC and industry reports discussing potential plant improvements, e.g., NUREG-1560 (NRC 1997c), and NUREG/CR-5575 (NRC 1990b)

- a review of plant-specific improvements identified in the Surry IPE and IPEEE

- a review of the top 100 cutsets of the updated Surry PRA, and survey of Surry PRA staff for additional insights.

VEPCo's initial list of 160 candidate improvements was extracted from the process and is reported in Table G.2-1 in Appendix G of the ER (VEPCo 2001a).

VEPCo performed a qualitative screening on the initial list of 160 SAMAs using the following criteria:

- The SAMA is not applicable to Surry Power Station either because (1) the enhancement is only for boiling water reactors, the Westinghouse AP600 design, or ice condenser containments, or (2) it is a plant-specific enhancement that does not apply at Surry Power Station, or

- The SAMA has already been implemented at Surry Power Station (or the Surry Power Station design meets the intent of the SAMA), or

- The SAMA is related to a reactor coolant pump (RCP) seal vulnerability at many PWRs, stemming from charging pump dependency on component cooling water (CCW). The Surry plants do not have this vulnerability because the charging pumps do not rely on

CCW. However, other RCP seal LOCA improvements are considered, such as installing improved RCP seals.

Based on the qualitative screening, 107 SAMAs were eliminated. Of these 107 SAMAs, 38 were eliminated because they had already been implemented at Surry Power Station (or the design met the intent of the SAMA). The 53 remaining SAMAs are listed in Table G.2-2 of Appendix G of the ER (VEPCo 2001a), and were subjected to a final screening and evaluation process. The final screening process involved identifying and eliminating those SAMAs whose cost exceeded their benefit by at least a factor of two. All of the 53 remaining SAMAs were eliminated in this final screening.

5.2.3.2 Staff Evaluation

The preliminary review of VEPCo's SAMA identification process raised several questions regarding the set of SAMAs identified. The staff requested clarification regarding the portion of risk represented by the top 100 cutsets, and whether an importance analysis was used to confirm the adequacy of the SAMA identification process, since a review of the importance ranking of basic events in the PRA has the potential to identify SAMAs that may not be apparent from a review of the top cutsets.

VEPCo chose to review the top 100 cutsets for identification of potential SAMAs because they contain the dominant contributors to risk. The applicant states that the top 100 cutsets examined account for the majority (about 60 percent) of the CDF for internal events and contain all of the ISLOCA and much of the SGTR contribution to offsite consequences. The cutsets appearing below the 100th cutset have an individual frequency of 4.8×10^{-8} per reactor-year or less, and a collective frequency of approximately 1.5×10^{-5} per reactor-year. VEPCo also noted that since none of the SAMAs identified from the top 100 cutsets were found to be cost-beneficial, it is not likely that SAMAs from the cutsets below the top 100 would be either.

VEPCo indicated that an importance analysis was not used in the initial SAMA identification process. However, an importance analysis was performed as part of the model update. The importance list contained 131 basic events with a risk reduction worth (RRW) above 1.005. VEPCo performed a limited review of the importance list and verified that the risk-significant basic events were contained in the top 100 cutsets.

The staff notes that SAMAs with the greatest risk reduction potential should be revealed through the cutset screening because the top cutsets include the majority of the CDF and the risk-significant sequences, and all elements of their contribution are examined. Further, since the individual frequency of cutsets below the cutoff is 4.8×10^{-8} per reactor-year or less, and the collective frequency of cutsets below the cutoff is about 1.5×10^{-5} per reactor-year, it is unlikely

that consideration of additional cutsets or further importance analyses would identify additional SAMAs that offer similar or greater risk reduction potential than those identified through cutset screening. The staff concludes that the process used to identify candidate SAMAs is sufficient to identify potential plant improvements that can significantly reduce risk.

VEPCo's efforts to identify potential SAMAs focused primarily on areas associated with internal initiating events. This is reasonable since external events only contribute a small amount to the total CDF and the containment response to external events was found to be similar to that from internal events in the IPE. The list of 53 SAMAs generally addressed the accident categories that are dominant CDF contributors or issues that tend to have a large impact on a number of accident sequences at Surry Power Station. The potential SAMA candidates included a balance of hardware, procedure, and training enhancements, as in the following examples:

- for loss of offsite power sequences, SAMAs included providing a hardwired connection to alternate offsite power (SAMA 77), and a lower-cost alternative of developing procedures to repair or change out failed 4-kV breakers (SAMA 69),

- for sequences with loss of heating, ventilation, and air conditioning, SAMAs included providing a non-safety-related, redundant train of switchgear ventilation (SAMA 25), and a lower-cost alternative of developing procedures for opening doors and using fans to limit temperature increases (SAMA 26), the latter of which is already implemented at Surry Power Station, and

- for sequences involving loss of support systems, SAMAs included adding a third component cooling water pump (SAMA 15), and a lower-cost alternative of enhancing training and procedures for loss of component cooling water or service water (SAMA 21).

The set of SAMAs submitted is not all-inclusive because additional, possibly even less-expensive, design alternatives can always be postulated. However, the staff concludes that the benefits of any additional modifications are unlikely to exceed the benefits of the modifications evaluated and that the alternative improvements would not likely cost less than the least expensive alternatives evaluated, when the subsidiary costs associated with maintenance, procedures, and training are considered.

The staff concludes that VEPCo used a systematic and comprehensive process for identifying potential plant improvements for Surry Power Station. While explicit treatment of external events in the SAMA identification process was limited, VEPCo doubled the estimated benefit for internal events to account for any unmodelled risk reduction that could be attributed to external events. Therefore, the staff concludes that this limited treatment of external events is acceptable.

5.2.4 Risk Reduction Potential of Design Improvements

VEPCo evaluated each of the 53 SAMAs remaining after the initial screening using a bounding technique. Thirty-three bounding analysis cases were developed to accomplish this effort. Table 5-5 lists the remaining SAMAs, the bounding analyses performed to estimate the risk reduction for each SAMA, the estimated risk reduction in terms of percent reduction in CDF and person-sievert (person-rem) dose, and the estimated total benefit (present value) of the averted risk. As discussed previously, VEPCo doubled the estimated benefit for internal events to account for any unmodelled risk reduction that could also occur in external events. The total benefit values reported in Table 5-5 incorporate this doubling. The determination of the benefits for the various SAMAs is discussed in Section 5.2.6.

The staff has reviewed VEPCo's bases for calculating the risk reduction for the various plant improvements and concludes that the rationale and assumptions for estimating risk reduction are reasonable and generally conservative (i.e., the estimated risk reduction is higher than what would actually be realized). Accordingly, the staff based its estimates of averted risk for the various SAMAs on VEPCo's risk-reduction estimates. The estimated risk reduction for several of the SAMAs was negligible or zero, and in one case was slightly negative. In these instances, the SAMA either affects sequences or phenomena that do not contribute to risk at Surry Power Station or represents an ineffective plant improvement. As such, a minimal impact on risk is not unreasonable in those cases.

5.2.5 Cost Impacts of Candidate Design Improvements

VEPCo estimated the costs of implementing each SAMA through the application of engineering judgment, estimates from other applicants' submittals, and site-specific cost estimates. The SAMA cost analyses were prepared by VEPCo staff experienced in estimating the cost of performing work at a nuclear plant. Cost estimates were made as order-of-magnitude approximations. The depth of analysis performed varied depending on the magnitude of the expected benefit. For most of the SAMAs considered, because the cost estimates were sufficiently greater than the benefits calculated, no detailed evaluation was required. In these cases, the applicant indicated that the implementation costs would exceed twice the benefit. Detailed cost estimating was only applied in those situations in which the benefit was significant and application of judgement would be questioned. Detailed cost estimates were developed for the eight SAMAs listed in Table 5-6.

VEPCo assumed the minimum cost of generating a new procedure, including its implementation, to be $30,000. If the SAMA involved a hardware modification, it was assumed that the cost would be at least $100,000.

Table 5-5. SAMA Cost/Benefit Screening Analysis

Analysis Case and Applicable SAMAs	Analysis Assumption	Percent Reduction		Total Benefit ($)
		CDF	Dose	
IMPROVEMENTS RELATED TO EX-VESSEL ACCIDENT MITIGATION/CONTAINMENT PHENOMENA				
Qualitative Assessment 39-Create a concrete crucible with heat-removal potential under the basemat to contain molten debris 40-Create a water-cooled rubble bed on the pedestal 47-Create a core melt source reduction system 55-Create another building, maintained at a vacuum to be connected to containment	Eliminate all offsite releases.	0.0	100.0	1.64 million
SCB[(a)] 42-Enhance fire-protection system and/or standby gas treatment system hardware and procedures 54-Provide a reactor vessel exterior cooling system	Set the frequencies for source-term categories 1 through 16, 19 and 20, to zero.	0.0	4.9	45,000
HYD 37-Create/enhance hydrogen igniters with independent power supply 38-Create a passive hydrogen ignition system 48-Provide containment inerting capability	Set the probability of late containment failure due to hydrogen burn to zero.	0.0	0.02	1,000
DEB 43-Create reactor cavity flooding system 44-Create other options for reactor cavity flooding 154-Enhance reactor coolant system depressurization ability	Modify the CET failure probabilities for debris cooling.	0.0	0.0	0
No analysis case 46-Provide core-debris control system	This failure mode was zero in the Surry Level 2 analysis, so no further calculation was required.	0.0	0.0	0

Table 5-5. (contd)

Analysis Case and Applicable SAMAs	Analysis Assumption	Percent Reduction		Total Benefit ($)
		CDF	Dose	
CSP				
30-Install containment spray throttle valves 32-Install a redundant containment spray system 33-Enhance the existing containment spray system 49-Use fire-water spray pump for containment spray 50-Install a passive containment spray system	Replace event tree functional equations related to containment and recirculation sprays with an event that has an unavailability of zero.	0.0	0.00	0
IMPROVEMENTS RELATED TO RCP SEAL LOCAS				
SWP				
9-Provide an additional service water (SW) pump	Add logic for a new pump to fault trees CW1 and CW2.	2.0	0.3	34,000
SLO				
10-Create independent RCP seal injection system with dedicated diesel 11-Create independent RCP seal injection system without dedicated diesel 14-Install improved RCP seals	Change event tree functional equations to eliminate the RCP seal LOCA contribution.	4.0	0.3	63,000
CCP[(a)]				
15-Add a third component cooling water (CCW) pump 21-Enhance training and procedures for loss of CCW or SW	Add logic for a new pump to fault tree CC1.	0.02	0.3	5,000
IMPROVEMENTS RELATED TO SECONDARY/SUPPORT SYSTEMS				
CWV				
23-Alter circulating water valve power-supply arrangement	Revise SWN0IC1 fault tree at four gates to provide a redundant 480-V power supply.	-0.5	-0.08	-4,000

Table 5-5. (contd)

Analysis Case and Applicable SAMAs	Analysis Assumption	Percent Reduction		Total Benefit ($)
		CDF	Dose	
BCC 81-Alter electric power dependency to BC and CC service water valves	Replace the motor-operated isolation-valve basic events with air-operated valve basic events, and remove power dependencies for each of the motor-operated valves.	0.7	0.5	17,000
IMPROVEMENTS IN AC/DC POWER RELIABILITY AND AVAILABILITY				
BCH 61-Use fuel cells instead of lead-acid batteries 64-Provide alternate battery-charging capability	Set battery failure basic events to zero.	5.4	0.8	88,000
OSP 77-Provide a connection to alternate offsite power source	Reduce loss of offsite power frequency by a factor of 5.	5.5	1.5	105,000
OPR 70-Emphasize steps in recovery of offsite power after SBO	Reduce offsite power recovery basic events by 25 percent.	1.8	0.5	33,000
4 kV 69-Develop procedures to repair or change out failed 4-kV breakers	Reduce basic events for all 4-kV breaker failures by a factor of 4.	1.9	2.0	62,000
IMPROVEMENTS RELATED TO HEATING, VENTILATION, AND AIR CONDITIONING (HVAC)				
HVC 25-Provide a non-safety-related, redundant train of switchgear ventilation	Change the initiating events frequency of the loss of HVAC to zero, and eliminate conditional ESGR failure by setting unavailability to zero.	13.9	5.0	278,000

Table 5-5. (contd)

Analysis Case and Applicable SAMAs	Analysis Assumption	Percent Reduction		Total Benefit ($)
		CDF	Dose	
HVA				
27-Add a switchgear room high temperature alarm	Reduce operator error for failure to recover HVAC by a factor of 10.	0.02	0.00	<1,000
IMPROVEMENTS RELATED TO DECAY HEAT REMOVAL CAPABILITY				
DHR				
34-Install a containment vent large enough to remove ATWS decay heat	Replace event-tree functional equations related to containment heat removal with an event that has an unavailability of zero.	4.9	1.6	90,000
35-Install a filtered containment vent to remove decay heat		4.9	5.5	135,000
36-Install an unfiltered containment vent to remove decay heat		4.9	1.6	90,000
FWS				
111-Install accumulators for turbine-driven auxiliary feedwater (TDAFW) pump flow control valves 115-Provide portable generators to be hooked in to the TDAFW after battery depletion	Modify event-tree functional equations related to auxiliary feedwater (AFW) in an SBO to use a basic event whose unavailability is zero.	0.1	0.04	4,000
FDW				
122-Create passive secondary side coolers	Modify event-tree functional equations related to main feedwater or AFW to use a basic event whose unavailability is zero.	12.8	17.2	490,000
SGP				
123-Automate air bottle swap for steam generator power-operated relief valves	Set basic event REC-INAIR-LOCAL to zero.	0.0	0.03	<1,000
SLB				
158-Install secondary side guard pipes up to the main steam isolation valves	Set the main steam line break initiating event frequencies to zero.	0.0	0.0	0

Table 5-5. (contd)

Analysis Case and Applicable SAMAs	Analysis Assumption	Percent Reduction		Total Benefit ($)
		CDF	Dose	
CND				
124-Utilize bypass around the main steam trip valves to use condenser dump after safety injection	Remove house event XHOS-NO-CND-DUMP from five fault trees and gates.	2.2	0.01	33,000
IMPROVEMENTS FOR COPING WITH/IDENTIFYING CONTAINMENT BYPASS				
SGI				
86-Install improved instrumentation and control circuits to detect and respond to SGTR	Set human error probabilities for isolating the faulted steam generator to zero.	2.8	27	256,000
SGR				
88-Increase secondary side-pressure such that a SGTR would not cause the relief valves to lift 89-Replace steam generators with new design	Set the frequency of Plant Damage State 25 to zero.	5.7	60	576,000
ISS				
101-Add remotely operated firewater line that could be used to scrub ISLOCA releases	Transfer the entire frequency of CET endstate 23 (unscrubbed ISLOCA) to CET endstate 22 (scrubbed ISLOCA).	0.0	5.3	40,000
ISL				
103-Add a check valve downstream of the low head safety injection pumps on cold leg injection line to reduce ISLOCA frequency	Reduce ISLOCA frequency to zero.	4.3	30	253,000

Table 5-5. (contd)

Analysis Case and Applicable SAMAs	Analysis Assumption	Percent Reduction		Total Benefit ($)
		CDF	Dose	
IMPROVEMENTS RELATED TO ECCS				
LHI 125-Provide capability for diesel-driven, low-pressure vessel makeup	Use unavailability of zero for all "late" low head safety injection and recirculation events in the event trees, and credit the fire protection connection to low head safety injection and recirculation in the fault trees.	5.0	0.01	76,000
HPI 126/127-Provide an additional high-pressure injection pump with independent diesel	Add new pump logic to all charging and high head safety injection fault trees.	3.5	2.1	89,000
IMPROVEMENTS RELATED TO REDUCING INITIATING EVENT FREQUENCY				
ATW 145/146-Install motor generator (MG) set trip breakers in control room	Set the frequency of ATWS initiating events to zero.	0.01	0.0	<1,000
LLO 159-Add digital large break LOCA protection	Reduce the large LOCA initiating event frequency by 25 percent.	3.3	0.01	25,000
RTB 82-Relocate transfer buses to different room	Add the entire fire CDF (1.9×10^{-6}) to STC 19 (SBO).	5.0	0.7	41,000
MGB 83-Install fast-acting MG breaker	Reduce the transient initiating event frequency by 25 percent.	0.1	0.04	3,000

(a) Requires both plant hardware and procedure modifications.

Table 5-6. Surry Power Station SAMAs with Detailed Cost Estimates

SAMA No.	Description	Cost ($)
24	Provide a non-safety-related, redundant train of switchgear ventilation	15-25 million
64	Provide a portable, diesel-driven battery charger and associated disconnects	1.5-3 million
77	Provide a hard-wired connection to alternate offsite power source (Gravel Neck Combustion Turbines Station) and associated switchgear and disconnects	2-5 million
81	Replace service-water isolation valves with air-operated, fail close design	0.9-1.5 million
86	Provide improved instrumentation and control circuits to detect and respond to SGTR	1.5-3 million
101	Add remotely operated firewater line that could be used to scrub ISLOCA releases	125,000
103	Add check valve in each cold leg injection path to reduce ISLOCA frequency	0.75-1.25 million
125	Add a line to permit low-pressure vessel makeup from firewater header	350,000-600,000

The staff requested additional justification for several of the detailed cost estimates provided by VEPCo, including SAMAs 64, 77, and 86. VEPCo provided this information by e-mail, dated January 22, 2002 (NRC 2002). The staff reviewed the bases for the applicant's cost estimates. For certain improvements, the staff also compared the quantitative or qualitative cost estimates provided in Table 4-6 of the ER to estimates developed elsewhere for similar improvements, including estimates developed as part of other applicants' analyses of SAMAs for operating reactors and advanced light-water reactors. Based on this audit, the detailed cost estimates were judged to reflect valid bases and assumptions, with the exception of some labor estimates, which appear high. However, even if such estimates were lowered by an order of magnitude, the cost of the alternative would not be altered to the extent that it would become cost-beneficial. The qualitative cost estimates in Table 4-6 of the ER were found to be consistent with previous estimates and reasonable for the SAMAs under consideration. The NRC staff concludes that the cost estimates are sufficient and appropriate for use in the SAMA evaluations.

5.2.6 Cost-Benefit Comparison

The cost-benefit comparison as evaluated by VEPCo and the NRC staff evaluation of the cost-benefit analysis are described in the following sections.

5.2.6.1 VEPCo Evaluation

The methodology used by VEPCo was based primarily on NRC's guidance for performing cost-benefit analysis, i.e., NUREG/BR-0184, *Regulatory Analysis Technical Evaluation Handbook* (NRC 1997b). The guidance involves determining the net value for each SAMA according to the following formula:

$$\text{Net Value} = (\$APE + \$AOC + \$AOE + \$AOSC) - COE$$

where
- $APE = present value of averted public exposure ($)
- $AOC = present value of averted offsite property damage costs ($)
- $AOE = present value of averted occupational exposure ($)
- $AOSC = present value of averted onsite costs ($)
- COE = cost of enhancement ($).

If the net value of a SAMA is negative, the cost of implementing the SAMA is larger than the benefit associated with the SAMA and it is not considered cost-beneficial. VEPCo's derivation of each of the associated costs is summarized below.

Averted Public Exposure (APE) Costs

The APE costs were calculated using the following formula:

APE = Annual reduction in public exposure (Δperson-rem/reactor-year)
x monetary equivalent of unit dose ($2000 per person-rem)
x present value conversion factor (10.76, based on a 20-year period with a 7-percent discount rate).

As stated in NUREG/BR-0184 (NRC 1997b), it is important to note that the monetary value of the public health risk after discounting does not represent the expected reduction in public health risk due to a single accident. Rather, it is the present value of a stream of potential losses extending over the remaining lifetime (in this case, the renewal period) of the facility. Thus, it reflects the expected annual loss due to a single accident, the possibility that such an accident could occur at any time over the renewal period, and the effect of discounting these

potential future losses to present value. For the purposes of determining the maximum attainable benefit, VEPCo calculated an APE of $392,000.

Averted Offsite Property Damage Costs (AOC)

The AOCs were calculated using the following formula:

AOC = Annual CDF reduction
x offsite economic costs associated with a severe accident (on a per-event basis)
x present value conversion factor.

VEPCo cited an annual offsite economic risk of $39,585 based on the Level 3 risk analysis. This value appears to be higher than values for other sites and those presented in NUREG/BR-0184 (NRC 1997b). This higher value is primarily due to the relatively high frequency of SGTRs in the Surry PRA (2.33×10^{-6} per reactor-year, including both SGTR initiators and induced ruptures), which contribute 75 percent of the total offsite economic risk. For the purposes of determining the maximum attainable benefit, VEPCo calculated an AOC of $426,000.

Averted Occupational Exposure (AOE) Costs

The AOE costs were calculated using the following formula:

AOE = Annual CDF reduction
x occupational exposure per core damage event
x monetary equivalent of unit dose
x present value conversion factor.

VEPCo derived the values for averted occupational exposure based on information provided in Section 5.7.3 of NUREG/BR-0184 (NRC 1997b). Best estimate values provided for immediate occupational dose [33 person-Sv (3300 person-rem)] and long-term occupational dose [200 person-Sv (20,000 person-rem over a 10-year cleanup period)] were used. The present value of these doses was calculated using the equations provided in NUREG/BR-0184 in conjunction with a monetary equivalent of unit dose of $2000 per person-rem, a real discount rate of 7 percent, and a time period of 20 years to represent the license renewal period. For the purposes of determining the maximum attainable benefit, VEPCo calculated an AOE of $14,400.

Averted Onsite Costs (AOSC)

The AOSCs include averted cleanup and decontamination costs and averted power replacement costs. Repair and refurbishment costs are considered for recoverable accidents only and not for severe accidents. VEPCo derived the values for AOSC based on information provided in Section 5.7.6 of NUREG/BR-0184 (NRC 1997b).

Averted cleanup and decontamination costs (ACC) are calculated using the following formula:

ACC = Annual CDF reduction
x present value of cleanup costs per core damage event
x present value conversion factor.

The total cost of cleanup and decontamination subsequent to a severe accident is estimated in NUREG/BR-0184 (NRC 1997b) as $\$1.5 \times 10^9$ (undiscounted). This value was converted to present costs over a 10-year cleanup period and integrated over the term of the proposed license extension.

Averted power replacement costs (RPC) are calculated using the following formula:

RPC = Annual CDF reduction
x present value of replacement power for a single event
x factor to account for remaining service years for which replacement power is required
x reactor power scaling factor.

Each of the units at Surry Power Station has a gross electrical output of 855.4 MWe, which is lower than the reference rating in NUREG/BR-0184 (NRC 1997b). Thus, a scaling factor (855.4/910) of 0.94 could be applied to the corresponding formulae. However, a scaling factor of 1.0 was conservatively used. For the purposes of determining the maximum attainable benefit, VEPCo calculated an AOSC (combination of ACC and RPC) of $738,000.

Using the above equations, VEPCo estimated the total present dollar value equivalent associated with completely eliminating internally initiated severe accidents at Surry Power Station is $1.57 million for each unit. This value was then doubled to account for additional risk reduction associated with also eliminating external events. This results in a maximum attainable benefit of $3.2 million for eliminating all severe accident risk.

VEPCo Results

The total benefit associated with each of the 53 SAMAs remaining after the initial screening is provided in column 5 of Table 5-5. These values were determined based on the above equations for the various averted costs together with the estimated annual reductions in CDF and person-Sv (person-rem) dose (columns 3 and 4 of Table 5-5). The estimated benefits were then doubled to account for additional risk reduction in external events. The values for total benefit reported in Table 5-5 include this doubling.

In determining the net value of each SAMA, VEPCo applied an additional factor of 2 multiplier to account for uncertainties in the cost-benefit methodology. Specifically, for each SAMA, they compared the total benefit[(a)] (doubled to account for external events) to the estimated cost of the enhancement and screened out the SAMA only if the cost of the enhancement was at least twice the benefit. All 53 SAMAs were eliminated because the estimated costs are expected to exceed the total benefit by at least a factor of 2. The end result was that no SAMA candidates were found to be cost-beneficial.

VEPCo performed sensitivity analyses to evaluate the impact of parameter choices on the analysis results. The sensitivity analyses included the calculation of candidate SAMA benefits using a 3-percent discount rate as recommended in NUREG/BR-0184 (NRC 1997b). The sensitivity cases resulted in less than a factor of 2 increase in the benefit calculation, and, therefore, all SAMAs were still screened out. Thus, the conclusion that none of the candidate SAMAs would be cost-beneficial remains unchanged.

5.2.6.2 Staff Evaluation

The cost-benefit analysis performed by VEPCo was based primarily on NUREG/BR-0184 (NRC 1997b) and was executed appropriately. The risk profile for Surry Power Station is observed to be dominated by containment bypass events (primarily SGTRs). With the exception of six costly modifications that are not properly applicable to an existing plant (e.g., redesign of the reactor cavity to accommodate a water-cooled rubble bed), the analysis found a maximum benefit of $278,000 with most changes resulting in a benefit of less than about $100,000.

The staff questioned the evaluation of several SAMAs in an RAI (NRC 2001). One SAMA in particular, SAMA 70, appeared to be cost-beneficial. This alternative involves a change to procedures for recovery of offsite power after a station blackout. According to Table 4-6 of the ER (VEPCo 2001a), a benefit of $33,000 was calculated. VEPCo estimated the minimum cost

(a) The benefit can be due to a reduction in CDF and/or a reduction in person-Sv (person-rem) dose resulting from the alternative being implemented.

of a procedure change to be $30,000. Because this amount is less than the estimated benefit, the SAMA appears to be cost-beneficial. However, in their RAI response (NRC 2002), VEPCo indicated that the benefit was calculated assuming a 25 percent reduction in the offsite power nonrecovery terms, and that this is very optimistic because training for offsite power recovery is already given, and failure to recover offsite power is more likely attributed to actual failures of the grid and not to personnel error. Operator training has no impact on these types of failure. VEPCo indicated that the benefit in this area is actually quite small and would realistically be 1 or 2 percent as opposed to the 25 percent presented in the SAMA analysis. Based on this assessment, the total benefit would be at least an order of magnitude less than that provided in Table 4-6 of the ER. VEPCo further stated that it would not be practical to eliminate or trade off any of the current training material given the heavily loaded training schedule. Based on the rationale, the staff agrees that this SAMA does not appear to be warranted.

The staff believes that the costs of the 53 candidate SAMAs assessed would be considerably higher than the associated benefits. This conclusion is upheld despite a number of uncertainties and nonquantifiable factors in the calculations, noted as follows:

- External events were accounted for in the analysis by doubling the risk-benefits found considering internal events only. This was justified on the basis of the fact that the externally initiated CDF (1.3×10^{-5} per reactor-year) at Surry Power Station is less than the internally initiated CDF (3.8×10^{-5} per reactor-year), and the observation that there are no particular containment vulnerabilities in the external event risk profile.

- Uncertainty in the internal events CDF was not explicitly included in the calculations, which employed best-estimate values. The 95-percent confidence level for the internal events CDF is approximately three times the best estimate, and the results of the analysis show that no SAMA is found to be cost-beneficial within a factor of 3 or 4. Therefore, consideration of CDF uncertainty is not expected to alter the conclusions of the analysis.

- Risk reduction and cost estimates were generally found to be conservative. As such, uncertainty in the costs of any of the contemplated changes would not likely have the effect of making them cost-beneficial.

- A number of sensitivity risk-benefit calculations were performed with respect to the discount rate (as low as 3 percent) and various MACCS2 parameters, including evacuation time and completeness, meteorological data, source-term energy, and sheltering. The results of these calculations showed that none of the risk benefits were increased by more than a factor of 2. Because this is less than the margin between cost

and benefit for most of the SAMAs considered, the staff concludes that uncertainties in these parameters would not alter the conclusions.

5.2.7 Conclusions

VEPCo compiled a list of 160 SAMA candidates based on the SAMA analyses submitted in support of licensing activities for other nuclear power plants, NRC and industry reports discussing potential plant improvements, and the plant-specific insights from the VEPCo IPE, IPEEE, and PRA model. Candidate SAMAs were identified by a thorough and systematic process that included examination of the Surry IPE and IPEEE, the top cutsets from the updated Surry PRA, and review of SAMA analyses for other operating nuclear power plants and other NRC and industry documentation. While few SAMAs were identified with a view towards external events, the IPEEE revealed no containment vulnerabilities particular to external events, and the staff judges that the process could be effectively carried out by considering primarily internal events. A qualitative screening removed SAMA candidates that did not apply to Surry Power Station for various reasons. A total of 107 SAMA candidates were either eliminated or combined with other potential improvements during the initial screening process, leaving only 53 SAMA candidates subject to the final screening process.

Using guidance in NUREG/BR-0184 (NRC 1997b), the updated Surry PRA model, and a Level 3 analysis developed specifically for SAMA evaluation, VEPCo estimated the total benefits for each of the 53 remaining SAMAs based on consideration of internal events, and then doubled the benefits for each SAMA to account for additional risk reduction in external events. In determining the net value of each SAMA, VEPCo applied an additional factor of 2 multiplier to account for uncertainties in the cost-benefit methodology. Specifically, for each SAMA, they compared the total benefit (which had been doubled to account for external events) to the estimated cost of the enhancement, and screened out the SAMA only if the cost of the enhancement was at least twice the benefit. All 53 SAMAs were eliminated because the estimated costs are expected to exceed the total benefit by at least a factor of 2. The end result was that no SAMA candidates were found to be cost-beneficial.

The staff reviewed the VEPCo analysis and concluded that the methods used and the implementation of those methods were sound. Based on its review, the staff concurs that none of the candidate SAMAs are cost beneficial. This conclusion is consistent with the low residual level of risk indicated in the Surry PRA and the fact that VEPCo has already implemented many plant improvements identified from the IPE and IPEEE process at the Surry Power Station.

5.3 References

10 CFR Part 50. Code of Federal Regulations, Title 10, *Energy,* Part 50, "Domestic Licensing of Production and Utilization Facilities."

10 CFR Part 51. Code of Federal Regulations, Title 10, *Energy,* Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions."

10 CFR Part 54. Code of Federal Regulations, Title 10, *Energy,* Part 54, "Requirements for Renewal of Operating Licenses for Nuclear Power Plants."

10 CFR Part 100. Code of Federal Regulations, Title 10, *Energy,* Part 100, "Reactor Site Criteria."

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U.S. Nuclear Regulatory Commission (NRC). 2000. Letter from G. E. Edison, Nuclear Regulatory Commission, to D. A. Christian, Virginia Electric and Power Company. Subject: Surry Power Station, Units 1 and 2–Review of Individual Plant Examination of External Events (IPEEE) (TAC Nos. M83681 and M83682). Dated June 29, 2000.

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Virginia Electric and Power Company (VEPCo). 1991. Letter from W.L. Stewart, Virginia Electric and Power Company, to U. S. Nuclear Regulatory Commission. Subject: Individual Plant Examination--Surry Power Station Units 1 and 2. Dated August 30, 1991.

Virginia Electric and Power Company (VEPCo). 1994. Letter from J. P. O'Hanlon, Virginia Electric and Power Company, to U. S. Nuclear Regulatory Commission. Subject: Individual Plant Examination of Non-Seismic External Events and Fires--Surry Power Station Units 1 and 2. Dated December 14, 1994.

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6.0 Environmental Impacts of the Uranium Fuel Cycle and Solid Waste Management

Environmental issues associated with the uranium fuel cycle and solid waste management are discussed in the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS), NUREG-1437; Volumes 1 and 2 (NRC 1996; 1999.)[(a)] The GEIS includes a determination of whether the analysis of the environmental issue could be applied to all plants and whether additional mitigation measures would be warranted. Issues are then assigned a Category 1 or a Category 2 designation. As set forth in the GEIS, Category 1 issues are those that meet all of the following criteria:

(1) The environmental, impacts associated with the issue have been determined to apply either to all plants or, for some issues, to plants having a specific type of cooling system or other specified plant or site characteristic.

(2) A single significance level (i.e., SMALL, MODERATE, or LARGE) has been assigned to the impacts (except for collective offsite radiological impacts from the fuel cycle and from high-level waste [HLW] and spent fuel disposal).

(3) Mitigation of adverse impacts associated with the issue has been considered in the analysis, and it has been determined that additional plant-specific mitigation measures are likely not to be sufficiently beneficial to warrant implementation.

For issues that meet the three Category 1 criteria, no additional plant-specific analysis is required unless new and significant information is identified.

Category 2 issues are those that do not meet one or more of the criteria for Category 1, and, therefore, additional plant-specific review of these issues is required.

This chapter addresses the issues that are related to the uranium fuel cycle and solid waste management during the license renewal term that are listed in Table B-1 of 10 CFR Part 51, Subpart A, Appendix B, and are applicable to Surry Power Station, Units 1 and 2. The generic potential impacts of the radiological and nonradiological environmental impacts of the uranium fuel cycle and transportation of nuclear fuel and wastes are described in detail in the GEIS, based, in part, on the generic impacts provided in 10 CFR 51.51(b), Table S-3, "Table of Uranium Fuel Cycle Environmental Data," and in 10 CFR 51.52(c), Table S-4, "Environmental Impact of Transportation of Fuel and Waste to and from One Light-Water-Cooled Nuclear

(a) The GEIS was originally issued in 1996. Addendum 1 to the GEIS was issued in 1999. Hereafter, all references to the "GEIS" include the GEIS and its Addendum 1.

Power Reactor." The GEIS also addresses the impacts from radon-222 and technetium-99. There are no Category 2 issues for the uranium fuel cycle and solid waste management.

6.1 The Uranium Fuel Cycle

Category 1 issues in 10 CFR Part 51, Subpart A, Appendix B, Table B-1, that are applicable to Surry Power Station, Units 1 and 2 from the uranium fuel cycle and solid waste management are listed in Table 6-1.

Table 6-1. Category 1 Issues Applicable to the Uranium Fuel Cycle and Solid Waste Management During the Renewal Term

ISSUE-10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Section
URANIUM FUEL CYCLE AND WASTE	
Offsite radiological impacts (individual effects from other than the disposal of spent fuel and HLW)	6.1; 6.2.1; 6.2.2.1,; 6.2.2.3; 6.2.3; 6.2.4; 6.6
Offsite radiological impacts (collective effects)	6.1; 6.2.2.1; 6.2.3; 6.2.4; 6.6
Offsite radiological impacts (spent fuel and HLW)	6.1; 6.2.2.1; 6.2.3; 6.2.4; 6.6
Nonradiological impacts of the uranium fuel cycle	6.1; 6.2.2.6; 6.2.2.7; 6.2.2.8; 6.2.2.9; 6.2.3; 6.2.4; 6.6
Low-level waste storage and disposal	6.1; 6.2.2.2; 6.4.2; 6.4.3; 6.4.3.1; 6.4.3.2; 6.4.3.3; 6.4.4; 6.4.4.1; 6.4.4.2; 6.4.4.5.1; 6.4.4.5.2; 6.4.4.5.3; 6.4.4.5.4; 6.4.4.6; 6.6
Mixed waste storage and disposal	6.4.5.1; 6.4.5.2; 6.4.5.3; 6.4.5.4; 6.4.5.5; 6.4.5.6; 6.4.5.6.1; 6.4.5.6.2; 6.4.5.6.3; 6.4.5.6.4; 6.6
Onsite spent fuel	6.1; 6.4.6; 6.4.6.1; 6.4.6.2; 6.4.6.3; 6.4.6.4; 6.4.6.5; 6.4.6.6; 6.4.6.7; 6.6
Nonradiological waste	6.1; 6.5; 6.5.1; 6.5.2; 6.5.3; 6.6
Transportation	6.1; 6.3.1; 6.3.2.3; 6.3.3; 6.3.4; 6.6, Addendum 1

The Virginia Electric and Power Company (VEPCo) stated in its Environmental Report (ER; VEPCo 2001) that it is not aware of any new and significant information associated with the renewal of the Surry Power Station, Units 1 and 2, operating licenses. No significant new information has been identified by the staff in the review process and in the staff's independent review. Therefore, the staff concludes that there are no impacts related to these issues beyond

those discussed in the GEIS. For all of those issues, the staff concluded in the GEIS that the impacts are SMALL except for the collective offsite radiological impacts from the fuel cycle and from HLW and spent fuel disposal, as discussed below, and that plant-specific mitigation measures are not likely to be sufficiently beneficial to be warranted.

A brief description of the staff review and the GEIS conclusions, as codified in Table B-1, 10 CFR 51, for each of these issues follows:

- Offsite radiological impacts (individual effects from other than the disposal of spent fuel and HLW . Based on information in the GEIS, the Commission found that

  > Off-site impacts of the uranium fuel cycle have been considered by the Commission in Table S-3 of this part [10 CFR 51.51(b)]. Based on information in the GEIS, impacts on individuals from radioactive gaseous and liquid releases including radon-222 and technetium-99 are small.

  The staff has not identified any new and significant information during its independent review of the VEPCo ER (VEPCo 2001), the staff's site visit, the scoping process, or its evaluation of other available information. Therefore, the staff concludes that there are no offsite radiological impacts (individual effects from other than the disposal of spent fuel and HLW) of the uranium fuel cycle during the renewal term beyond those discussed in the GEIS.

- Offsite radiological impacts (collective effects). Based on information in the GEIS, the Commission found that

  > The 100 year environmental dose commitment to the U.S. population from the fuel cycle, high level waste and spent fuel disposal excepted, is calculated to be about 14,800 person rem [148 person Sv], or 12 cancer fatalities, for each additional 20-year power reactor operating term. Much of this, especially the contribution of radon releases from mines and tailing piles, consists of tiny doses summed over large populations. This same dose calculation can theoretically be extended to include many tiny doses over additional thousands of years as well as doses outside the U.S. The result of such a calculation would be thousands of cancer fatalities from the fuel cycle, but this result assumes that even tiny doses have some statistical adverse health effect, which will not ever be mitigated (for example no cancer cure in the next thousand years), and that these doses projected over thousands of years are meaningful. However, these assumptions are questionable. In particular, science cannot rule out the possibility that there will be no cancer fatalities from these tiny doses. For perspective, the doses are

> very small fractions of regulatory limits and even smaller fractions of natural background exposure to the same populations.
>
> Nevertheless, despite all the uncertainty, some judgement as to the regulatory NEPA [National Environmental Policy Act] implications of these matters should be made and it makes no sense to repeat the same judgement in every case. Even taking the uncertainties into account, the Commission concludes that these impacts are acceptable in that these impacts would not be sufficiently large to require the NEPA conclusion, for any plant, that the option of extended operation under 10 CFR Part 54 should be eliminated. Accordingly, while the Commission has not assigned a single level of significance for the collective effects of the fuel cycle, this issue is considered Category 1.

The staff has not identified any new and significant information during its independent review of the VEPCo ER (VEPCo 2001), the staff's site visit, the scoping process, or its evaluation of other available information. Therefore, the staff concludes that there are no offsite radiological impacts (collective effects) from the uranium fuel cycle during the renewal term beyond those discussed in the GEIS

- Offsite radiological impacts (spent fuel and HLW disposal). Based on information in the GEIS, the Commission found that

  > For the high level waste and spent fuel disposal component of the fuel cycle, there are no current regulatory limits for offsite releases of radionuclides for the current candidate repository site. However, if we assume that limits are developed along the lines of the 1995 National Academy of Sciences (NAS) report, `Technical Bases for Yucca Mountain Standards," and that in accordance with the Commission's Waste Confidence Decision, 10 CFR 51.23, a repository can and likely will be developed at some site which will comply with such limits, peak doses to virtually all individuals will be 100 millirem [1 mSv] per year or less. However, while the Commission has reasonable confidence that these assumptions will prove correct, there is considerable uncertainty since the limits are yet to be developed, no repository application has been completed or reviewed, and uncertainty is inherent in the models used to evaluate possible pathways to the human environment. The NAS report indicated that 100 millirem [1 mSv] per year should be considered as a starting point for limits for individual doses, but notes that some measure of consensus exists among national and international bodies that the limits should be a fraction of the 100 millirem [1 mSv] per year. The lifetime individual risk from 100 millirem [1 mSv] annual dose limit is about 3×10^{-3}.

Estimating cumulative doses to populations over thousands of years is more problematic. The likelihood and consequences of events that could seriously compromise the integrity of a deep geologic repository were evaluated by the Department of Energy in the "Final Environmental Impact Statement: Management of Commercially Generated Radioactive Waste," October 1980 [DOE 1980]. The evaluation estimated the 70-year whole-body dose commitment to the maximum individual and to the regional population resulting from several modes of breaching a reference repository in the year of closure, after 1,000 years, after 100,000 years, and after 100,000,000 years. Subsequently, the NRC and other federal agencies have expended considerable effort to develop models for the design and for the licensing of a high level waste repository, especially for the candidate repository at Yucca Mountain. More meaningful estimates of doses to population may be possible in the future as more is understood about the performance of the proposed Yucca Mountain repository. Such estimates would involve very great uncertainty, especially with respect to cumulative population doses over thousands of years. The standard proposed by the NAS is a limit on maximum individual dose. The relationship of potential new regulatory requirements, based on the NAS report, and cumulative population impacts has not been determined, although the report articulates the view that protection of individuals will adequately protect the population for a repository at Yucca Mountain. However, EPA's [the Environmental Protection Agency's) generic repository standards in 40 CFR part 191 generally provide an indication of the order of magnitude of cumulative risk to population that could result from the licensing of a Yucca Mountain repository, assuming the ultimate standards will be within the range of standards now under consideration. The standards in 40 CFR part 191 protect the population by imposing "containment requirements" that limit the cumulative amount of radioactive material released over 10,000 years. Reporting performance standards that will be required by EPA are expected to result in releases and associated health consequences in the range between 10 and 100 premature cancer deaths with an upper limit of 1,000 premature cancer deaths world-wide for a 100,000 metric tonne (MTHM) repository.

Nevertheless, despite all the uncertainty, some judgement as to the regulatory NEPA implications of these matters should be made and it makes no sense to repeat the same judgement in every case. Even taking the uncertainties into account, the Commission concludes that these impacts are acceptable in that these impacts would not be sufficiently large to require the NEPA conclusion, for any plant, that the option of extended operation under 10 CFR part 54 should be eliminated. Accordingly, while the Commission has not assigned a single level of

> significance for the impacts of spent fuel and high level waste disposal, this issue is considered Category 1.

Since the GEIS was originally issued in 1996, EPA published radiation protection standards for Yucca Mountain, Nevada, at 40 CFR Part 197, "Public Health and Environmental Radiation Protection Standards for Yucca Mountain, Nevada," on June 13, 2001 (66 FR 32132). The Energy Policy Act of 1992 directs the NRC to adopt these standards into its regulations for reviewing and licensing the repository. NRC published its regulations at 10 CFR Part 63, "Disposal of High-Level Radioactive Wastes in Geologic Repository at Yucca Mountain, Nevada," on November 2, 2001 (66 FR 55792). These standards include the following: (1) a 0.15 mSv/yr (15 mrem/yr) dose limit for members of the public during the storage period prior to repository closure, (2) a 0.15 mSv/yr (15 mrem/yr) dose limit for the reasonably maximally exposed individual from the undisturbed repository for 10,000 years following disposal, (3) a 0.15 mSv/yr (15 mrem/yr) dose limit for the reasonably maximally exposed individual as a result of a human intrusion at or before 10,000 years after disposal, and (4) a ground-water protection standard that states that for 10,000 years of undisturbed performance after disposal, radioactivity in a representative volume of groundwater will not exceed (a) 0.2 Bq/L (5 pCi/L) for radium-226 and radium-228, (b) 0.56 Bq/L (15 pCi/L) for gross alpha activity, and (c) 0.04 mSv/yr (4 mrem/yr) to the whole body or any organ (from combined beta- and photon-emitting radionuclides, assuming consumption of 2 Lpd of the affected water).

On February 15, 2002, subsequent to receipt of a recommendation by Secretary Abraham, U.S. Department of Energy, the President recommended the Yucca Mountain site for the development of a repository for the geologic disposal of spent nuclear fuel and high-level nuclear waste. The U.S. Congress approved this recommendation on July 9, 2002. This development does not represent new and significant information with respect to the offsite radiological impacts related to spent fuel and HLW disposal during the renewal term.

The staff has not identified any new and significant information during its independent review of the VEPCo ER (VEPCo 2001), the staff's site visit, the scoping process, or its evaluation of other available information. Therefore, the staff concludes that there are no offsite radiological impacts related to spent fuel and HLW disposal during the renewal term beyond those discussed in the GEIS.

- Nonradiological impacts of the uranium fuel cycle. Based on information in the GEIS, the Commission found that

  > The nonradiological impacts of the uranium fuel cycle resulting from the renewal of an operating license for any plant are found to be small.

The staff has not identified any new and significant information during its independent review of the VEPCo ER (VEPCo 2001), the staff's site visit, the scoping process, or its evaluation of other available information. Therefore, the staff concludes that there are no nonradiological impacts of the uranium fuel cycle during the renewal term beyond those discussed in the GEIS.

- Low-level waste storage and disposal. Based on information in the GEIS, the Commission found that

  > The comprehensive regulatory controls that are in place and the low public doses being achieved at reactors ensure that the radiological impacts to the environment will remain small during the term of a renewed license. The maximum additional on-site land that may be required for low-level waste storage during the term of a renewed license and associated impacts will be small. Nonradiological impacts on air and water will be negligible. The radiological and nonradiological environmental impacts of long-term disposal of low-level waste from any individual plant at licensed sites are small. In addition, the Commission concludes that there is reasonable assurance that sufficient low-level waste disposal capacity will be made available when needed for facilities to be decommissioned consistent with NRC decommissioning requirements.

  The staff has not identified any new and significant information during its independent review of the VEPCo ER (VEPCo 2001), the staff's site visit, the scoping process, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts of low-level waste storage and disposal associated with the renewal term beyond those discussed in the GEIS.

- Mixed waste storage and disposal. Based on information in the GEIS, the Commission found that

  > The comprehensive regulatory controls and the facilities and procedures that are in place ensure proper handling and storage, as well as negligible doses and exposure to toxic materials for the public and the environment at all plants. License renewal will not increase the small, continuing risk to human health and the environment posed by mixed waste at all plants. The radiological and nonradiological environmental impacts of long-term disposal of mixed waste from any individual plant at licensed sites are small. In addition, the Commission concludes that there is reasonable assurance that sufficient mixed waste

> disposal capacity will be made available when needed for facilities to be decommissioned consistent with NRC decommissioning requirements.

The staff has not identified any new and significant information during its independent review of the VEPCo ER (VEPCo 2001), the staff's site visit, the scoping process, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts of mixed waste storage and disposal associated with the renewal term beyond those discussed in the GEIS.

- Onsite spent fuel. Based on information in the GEIS, the Commission found that

> The expected increase in the volume of spent fuel from an additional 20 years of operation can be safely accommodated on site with small environmental effects through dry or pool storage at all plants if a permanent repository or monitored retrievable storage is not available.

The staff has not identified any new and significant information during its independent review of the VEPCo ER (VEPCo 2001), the staff's site visit, the scoping process, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts of onsite spent fuel associated with license renewal beyond those discussed in the GEIS.

- Nonradiological waste. Based on information in the GEIS, the Commission found that

> No changes to generating systems are anticipated for license renewal. Facilities and procedures are in place to ensure continued proper handling and disposal at all plants.

The staff has not identified any new and significant information during its independent review of the VEPCo ER (VEPCo 2001), the staff's site visit, the scoping process, or its evaluation of other available information. Therefore, the staff concludes that there are no nonradiological waste impacts during the renewal term beyond those discussed in the GEIS.

- Transportation. Based on information contained in the GEIS, the Commission found that

> The impacts of transporting spent fuel enriched up to 5 percent uranium-235 with average burnup for the peak rod to current levels approved by NRC; up to 62,000 MWd/MTU and the cumulative impacts of transporting high-level waste to

> a single repository, such as Yucca Mountain, Nevada are found to be consistent with the impact values contained in 10 CFR 51.52(c), Summary Table S-4 Environmental Impact of Transportation of Fuel and Waste to and from One Light-Water-Cooled Nuclear Power Reactor. If fuel enrichment or burnup conditions are not met, the applicant must submit an assessment of the implications for the environmental impact values reported in § 51.52.

Surry Power Station, Units 1 and 2 meet the fuel-enrichment and burnup conditions set forth in Addendum 1 to the GEIS. The staff has not identified any new and significant information during its independent review of the VEPCo ER (VEPCo 2001), the staff's site visit, the scoping process, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts of transportation associated with license renewal beyond those discussed in the GEIS.

6.2 References

10 CFR Part 51. Code of Federal Regulations, Title *10, Energy,* Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions."

10 CFR Part 54. Code of Federal Regulations, Title *10, Energy,* Part 54, "Requirements for Renewal of Operating Licenses for Nuclear Power Plants."

10 CFR Part 63. Code of Federal Regulations, Title 10, Energy, Part 63, "Disposal of High-Level Radioactive Wastes in a Geologic Repository at Yucca Mountain, Nevada."

40 CFR Part 191. Code of Federal Regulations, Title 40, *Protection of Environment,* Part 191, "Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level, and Transuranic Radioactive Waste."

40 CFR Part 197. Code of Federal Regulations, Title 40, *Protection of Environment,* Part 197, "Public Health and Environmental Radiation Protection Standards for Yucca Mountain, Nevada."

Energy Policy Act of 1992. 42 USC 10101, et seq.

National Academy of Sciences (NAS). 1995. *Technical Bases for Yucca Mountain Standards.* Washington, D.C.

National Environmental Policy Act (NEPA) of 1969, as amended. 42 USC 4321, et seq.

U.S. Department of Energy (DOE). 1980. *Final Environmental Impact Statement: Management of Commercially Generated Radioactive Waste*. DOE/EIS-0046F, DOE, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1996. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. NUREG-1437, Volumes land 2, NRC, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1999. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Main Report, "Section 6.3 - Transportation, Table 9.1, "Summary of findings on NEPA issues for license renewal of nuclear power plants, Final Report.*" NUREG-1437, Volume 1, Addendum 1, NRC, Washington, D.C.

Virginia Electric and Power Company (VEPCo). 2001. Application for license Renewal for Surly Power Station, Units 1 and 2, "Appendix E, Environmental Report - Operating License Renewal Stage." Richmond, Virginia.

7.0 Environmental Impacts of Decommissioning

Environmental issues associated with decommissioning, which result from continued plant operation during the renewal terms are discussed in the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS), NUREG-1437, Volumes 1 and 2 (NRC 1996; 1999).[(a)] The GEIS includes a determination of whether the analysis of the environmental issue could be applied to all plants and whether additional mitigation measures would be warranted. Issues are then assigned a Category 1 or a Category 2 designation. As set forth in the GEIS, Category 1 issues are those that meet all of the following criteria:

(1) The environmental impacts associated with the issue have been determined to apply either to all plants or, for some issues, to plants having a specific type of cooling system or other specified plant or site characteristic.

(2) A single significance level (i.e., SMALL, MODERATE, or LARGE) has been assigned to the impacts (except for collective offsite radiological impacts from the fuel cycle and from high level waste and spent fuel disposal).

(3) Mitigation of adverse impacts associated with the issue has been considered in the analysis, and it has been determined that additional plant-specific mitigation measures are likely not to be sufficiently beneficial to warrant implementation.

For issues that meet the three Category 1 criteria, no additional plant-specific analysis is required unless new and significant information is identified.

Category 2 issues are those that do not meet one or more of the criteria for Category 1, and therefore, additional plant-specific review of these issues is required. There are no Category 2 issues related to decommissioning Surry Power Station, Units 1 and 2.

Category 1 issues in Table B-1 of 10 CFR Part 51, Subpart A, Appendix B that are applicable to Surry Power Station, Units 1 and 2, decommissioning following the renewal term are listed in Table 7-1. The Virginia Electric and Power Company (VEPCo) stated in its Environmental Report (ER; VEPCo 2001) that it is aware of no new and significant information regarding the environmental impacts of Surry Power Station, Units 1 and 2, license renewal. The staff has not identified any significant new information during its independent review of the VEPCo ER (VEPCo 2001), the staff's site visit, the scoping process, or its evaluation of other available information.

(a) The GEIS was originally issued in 1996. Addendum 1 to the GEIS was issued in 1999. Hereafter, all references to the "GEIS" include the GEIS and its Addendum 1.

Table 7-1. Category 1 Issues Applicable to the Decommissioning of Surry Power Station Following the Renewal Term

ISSUE—10 CFR Part 51, Subpart A, Appendix B, Table B-1	GEIS Section
DECOMMISSIONING	
Radiation Doses	7.3.1; 7.4
Waste Management	7.3.2; 7.4
Air Quality	7.3.3; 7.4
Water Quality	7.3.4; 7.4
Ecological Resources	7.3.5; 7.4
Socioeconomic Impacts	7.3.7; 7.4

Therefore, the staff concludes that there are no impacts related to these issues beyond those discussed in the GEIS. For all of these issues, the staff concluded in the GEIS that the impacts are SMALL, and plant-specific mitigation measures are not likely to be sufficiently beneficial to be warranted.

A brief description of the staff's review and the GEIS conclusions, as codified in Table B-1, for each of the issues follows:

- Radiation doses. Based on information in the GEIS, the Commission found that

  > Doses to the public will be well below applicable regulatory standards regardless of which decommissioning method is used. Occupational doses would increase no more than 1 man-rem [0.01 person-Sv] caused by buildup of long-lived radionuclides during the license renewal term.

  The staff has not identified any new and significant information during its independent review of the VEPCo ER (VEPCo 2001), the staff's site visit, the scoping process, or its evaluation of other available information. Therefore, the staff concludes that there are no radiation doses associated with decommissioning following license renewal beyond those discussed in the GEIS.

- Waste management. Based on information in the GEIS, the Commission found that

  > Decommissioning at the end of a 20-year license renewal period would generate no more solid wastes than at the end of the current license term. No increase in the quantities of Class C or greater than Class C wastes would be expected.

The staff has not identified any new and significant information during its independent review of the VEPCo ER (VEPCo 2001), the staff's site visit, the scoping process, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts of solid waste associated with decommissioning following the license renewal term beyond those discussed in the GEIS.

- Air quality. Based on information in the GEIS, the Commission found that

  > Air quality impacts of decommissioning are expected to be negligible either at the end of the current operating term or at the end of the license renewal term.

  The staff has not identified any new and significant information during its independent review of the VEPCo ER (VEPCo 2001), the staff's site visit, the scoping process, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts of license renewal on air quality during decommissioning beyond those discussed in the GEIS.

- Water quality. Based on information in the GEIS, the Commission found that

  > The potential for significant water quality impacts from erosion or spills is no greater whether decommissioning occurs after a 20-year license renewal period or after the original 40-year operation period, and measures are readily available to avoid such impacts.

  The staff has not identified any new and significant information during its independent review of the VEPCo ER (VEPCo 2001), the staff's site visit, the scoping process, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts of the license renewal term on water quality during decommissioning beyond those discussed in the GEIS.

- Ecological resources. Based on information in the GEIS, the Commission found that

  > Decommissioning after either the initial operating period or after a 20-year license renewal period is not expected to have any direct ecological impacts.

  The staff has not identified any new and significant information during its independent review of the VEPCo ER (VEPCo 2001), the staff's site visit, the scoping process, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts of the license renewal term on ecological resources during decommissioning beyond those discussed in the GEIS.

- Socioeconomic Impacts. Based on information in the GEIS, the Commission found that

  > Decommissioning would have some short-term socioeconomic impacts. The impacts would not be increased by delaying decommissioning until the end of a 20-year relicense period, but they might be decreased by population and economic growth.

  The staff has not identified any new and significant information during its independent review of the VEPCo ER (VEPCo 2001), the staff's site visit, the scoping process, or its evaluation of other available information. Therefore, the staff concludes that there are no impacts of license renewal on the socioeconomic impacts of decommissioning beyond those discussed in the GEIS.

7.1 References

10 CFR Part 51. Code of Federal Regulations, Title 10, *Energy,* Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions."

U.S. Nuclear Regulatory Commission (NRC). 1996. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants*. NUREG-1437, Volumes 1 and 2, Washington, D.C.

U.S. Nuclear Regulatory Commission (NRC). 1999. *Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Main Report*, "Section 6.3 – Transportation, Table 9.1, Summary of findings on NEPA issues for license renewal of nuclear power plants, Final Report." NUREG-1437, Volume 1, Addendum 1, Washington, D.C.

Virginia Electric and Power Company (VEPCo). 2001. *Application for License Renewal for Surry Power Station, Units 1 and 2,* "Appendix E, Environmental Report - Operating License Renewal Stage." Richmond, Virginia.

8.0 Environmental Impacts of Alternatives to Operating License Renewal

This chapter examines the potential environmental impacts associated with denying the renewal of the operating licenses (OLs) (i.e., the no-action alternative); the potential environmental impacts from electric generating sources other than Surry Power Station, Units 1 and 2; the possibility of purchasing electric power from other sources to replace power generated by Units 1 and 2 and the associated environmental impacts; the potential environmental impacts from a combination of generation and conservation measures; and other generation alternatives that were deemed unsuitable for replacement of power generated by Units 1 and 2. The environmental impacts are evaluated using the U.S. Nuclear Regulatory Commission's (NRC's) three-level standard of significance—SMALL, MODERATE, or LARGE, as developed using the Council on Environmental Quality guidelines and set forth in a footnote to Table-B-1 of 10 CFR Part 51, Subpart A, Appendix B:

SMALL – Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource.

MODERATE – Environmental effects are sufficient to alter noticeably, but not to destabilize important attributes of the resource.

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

The impact categories evaluated in this chapter are the same as those used in the Generic Environmental Impact Statement for License Renewal of Nuclear Plants (GEIS), NUREG-1437, Volumes 1 and 2 (NRC 1996; 1999)[(a)], with the additional impact categories of environmental justice and transportation.

8.1 No-Action Alternative

NRC's regulations implementing the National Environmental Policy Act (NEPA) specify that the no-action alternative be discussed in an NRC environmental impact statement (EIS, see 10 CFR Part 51, Subpart A, Appendix A[4]). For license renewal, the no-action alternative refers to a scenario in which the NRC would not renew the OLs for Surry Power Station, Units 1 and 2, and the Virginia Electric and Power Company (VEPCo) would then decommission

(a) The GEIS was originally issued in 1996. Addendum 1 to the GEIS was issued in 1999. Hereafter, all references to the "GEIS" include the GEIS and its Addendum 1.

Units 1 and 2, when plant operations cease. Replacement of Units 1 and 2 electricity generation capacity would be met by (1) demand-side management and energy conservation, (2) power purchased from other electricity providers, (3) generating alternatives other than Units 1 and 2, or (4) some combination of these options. The environmental impacts associated with alternative generation technologies are discussed in Section 8.2.

VEPCo will be required to comply with NRC decommissioning requirements whether or not the OLs are renewed. If the Units 1 and 2 OLs are renewed, decommissioning activities may be postponed for up to an additional 20 years. If the OLs are not renewed, VEPCo would conduct decommissioning activities according to the requirements in 10 CFR 50.82. The GEIS (NRC 1996) and the *Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities* (NRC 1988) provide descriptions of decommissioning activities.[(a)]

The environmental impacts associated with decommissioning under the no-action alternative would be bounded by the discussion of impacts in Chapter 7 of the GEIS, Chapter 7 of this Supplemental Environmental Impact Statement (SEIS), and the *Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities* (NRC 1988). The impacts of decommissioning after 60 years of operation are not expected to be significantly different from those occurring after 40 years of operation.

The environmental impacts for the socioeconomic, historic and archaeological resources, and environmental justice impact categories are summarized in Table 8-1 and discussed in the following paragraphs. The no-action alternative would also have certain positive impacts in that adverse environmental impacts associated with current operation of Surry Power Station, for example, solid waste impacts and impacts on aquatic life, would be eliminated.

Table 8-1. Summary of Environmental Impacts of the No-Action Alternative

Impact Category	Impact	Comment
Socioeconomic	LARGE	Decrease in employment, higher-paying jobs, and tax revenues
Historic and Archaeological Resources	SMALL to MODERATE	Land occupied by Units 1 and 2 would likely be retained by VEPCo
Environmental Justice	MODERATE to LARGE	Loss of employment opportunities and social programs

(a) The NRC staff is currently updating the GEIS on decommissioning nuclear facilities. A draft for comment was issued on November 9, 2001 (66 FR 56721) (NRC 2001b). The staff is currently finalizing the draft Supplement for publication as a final document.

- Socioeconomic: When Surry Units 1 and 2 cease operation, there will be a decrease in employment and tax revenues associated with the closure. Employment (primary and secondary) impacts would be concentrated in Surry, James City, and Isle of Wight Counties and the City of Newport News. Approximately 60 percent of the employees who work at Surry Units 1 and 2 live in Surry, James City, and Isle of Wight Counties or the City of Newport News. The remainder live in other nearby locations (VEPCo 2001).

  Most of the tax revenue losses resulting from closure of Surry Units 1 and 2 would occur in Surry County. In 2001, VEPCo paid $10.9 million in property taxes to Surry County for the nuclear and fossil generation units at the Surry Power Station, or about 70 percent of all property taxes collected by the county (VEPCo 2001). The majority of the $10.9 million was attributable to Surry Power Station, Units 1 and 2. The no-action alternative would result in the loss of the taxes attributable to Surry Units 1 and 2 as well as the loss of plant payrolls 20 years earlier than if the OLs were renewed. Loss of the property tax revenue would have a significant negative impact on the ability of Surry County to provide public services such as schools and road maintenance. There would also be an adverse impact on housing values and the local economy in Surry County and surrounding areas if Surry Units 1 and 2 were to cease operations.

  VEPCo employees working at Surry Units 1 and 2 currently contribute time and money toward community involvement, including schools, churches, charities, and other civic activities. It is likely that with a reduced presence in the community following decommissioning, community involvement efforts by VEPCo and its employees in the region would be less. The socioeconomic impacts of this alternative are considered LARGE.

- Historic and Archaeological Resources: The potential for future adverse impacts to known or unrecorded cultural resources at the Surry Power Station following decommissioning of Units 1 and 2 will depend on the future use of the land occupied by the two units. Following decommissioning, land occupied by Units 1 and 2 would likely be retained by VEPCo for other corporate purposes. Eventual sale or transfer of the land occupied by Units 1 and 2, however, could result in adverse impacts to cultural resources if the land-use pattern changes dramatically. Notwithstanding this possibility, the impacts of this alternative on historic and archaeological resources are considered SMALL to MODERATE.

- Environmental Justice for No-Action: Current operations at Surry Units 1 and 2 have no disproportionate impacts on the minority and low-income populations of Surry and surrounding counties, and no environmental pathways have been identified that would cause disproportionate impacts. Closure of Units 1 and 2 would result in decreased

employment opportunities and tax revenues in Surry County and surrounding counties with possible negative and disproportionate impacts on minority or low-income populations. Because the Surry Power Station is located in a relatively rural area, the environmental justice impacts under the no-action alternative are considered MODERATE to LARGE.

Impacts for all other impact categories would be SMALL, as shown in Table 9-1.

8.2 Alternative Energy Sources

This section discusses the environmental impacts associated with alternative sources of electric power to replace the power generated by Surry Units 1 and 2, assuming that the OLs for Units 1 and 2 are not renewed. The order of presentation of alternative energy sources in Section 8.2 does not imply which alternative would be most likely to occur or to have the least environmental impacts. The following generation alternatives are considered in detail:

- coal-fired generation at the Surry Power Station site and at an alternate greenfield[(a)] site (Section 8.2.1)
- natural gas-fired generation at the Surry Power Station site and at an alternate greenfield site (Section 8.2.2)
- nuclear generation at the Surry Power Station site and at an alternate greenfield site (Section 8.2.3).

The alternative of purchasing power from other sources to replace power generated at Surry Units 1 and 2 is discussed in Section 8.2.4. Other power generation alternatives and conservation alternatives considered by the staff and found not to be reasonable replacements for Units 1 and 2 are discussed in Section 8.2.5. Section 8.2.6 discusses the environmental impacts of a combination of generation and conservation alternatives.

Each year, the Energy Information Administration (EIA), a component of the U.S. Department of Energy (DOE), issues an Annual Energy Outlook. In the *Annual Energy Outlook 2002* issued in December 2001 (DOE/EIA 2001a), EIA projects that combined-cycle or combustion turbine technology fueled by natural gas is likely to account for approximately 88 percent of new electric generating capacity between the years 2000 and 2020. Both technologies are designed primarily to supply peak and intermediate capacity, but combined-cycle technology can also be

(a) A greenfield site is assumed to be an undeveloped site with no previous construction.

used to meet baseload[a] requirements. Coal-fired plants are projected by EIA to account for approximately 9 percent of new capacity during this period. Coal-fired plants are generally used to meet baseload requirements. Renewable energy sources, primarily wind, geothermal, and municipal solid waste units, are projected by EIA to account for the remaining 3 percent of capacity additions. EIA's projections are based on the assumption that providers of new generating capacity will seek to minimize cost while meeting applicable environmental requirements. Combined-cycle plants are projected by EIA to have the lowest generation cost in 2005 and 2020, followed by coal-fired plants and then wind generation (DOE/EIA 2001a).

EIA projects that oil-fired plants will account for very little of new generation capacity in the U.S. during the 2000 to 2020 time period because of higher fuel costs and lower efficiencies (DOE/EIA 2001a).

EIA also projects that new nuclear power plants will not account for any new generation capacity in the U.S. during the 2000 to 2020 time period because natural gas and coal-fired plants are projected to be more economical (DOE/EIA 2001a). In spite of this projection, a new nuclear plant alternative for replacing power generated by Surry Units 1 and 2 is considered in Section 8.2.3. Since 1997, the NRC has certified three new standard designs for nuclear power plants under the procedures in 10 CFR Part 52, Subpart B: the U.S. Advanced Boiling Water Reactor (10 CFR Part 52, Appendix A), the System 80+ Design (10 CFR Part 52, Appendix B), and the AP600 Design (10 CFR Part 52, Appendix C). The submission to the NRC of these three applications for certification indicates continuing interest in the possibility of licensing new nuclear power plants. NRC has recently established a New Reactor Licensing Program Organization to prepare for and manage future reactor and site licensing applications (NRC 2001a).

Surry Units 1 and 2 have a combined average net capacity of 1602 megawatts electric (MW[e]). For the coal and natural gas alternatives, VEPCo's Environmental Report (ER) assumes three standard 508-MW(e) units[b] as potential replacements for Units 1 and 2 (VEPCo 2001). The staff used this assumption in their evaluation, although it results in some environmental impacts that are roughly 5 percent lower than if full replacement capacity were constructed. VEPCo's reasoning is that although customized unit sizes can be built, use of standardized sizes is more

(a) A baseload plant normally operates to supply all or part of the minimum continuous load of a system and consequently produces electricity at an essentially constant rate. Nuclear power plants are commonly used for baseload generation, i.e., these units generally run near full load.

(b) Each of the coal-fired units would have a rating of 538 gross MW and 508 net MW. Each of the gas-fired units would have a rating of 528 gross MW and 508 net MW. The difference between "gross" and "net" is the electricity consumed onsite.

economical. Moreover, using four 508-MW(e) units for the analysis would overestimate environmental impacts and tend to make the fossil alternatives less attractive.

8.2.1 Coal-Fired Generation

The coal-fired alternative is analyzed for both the Surry Power Station site and an alternate greenfield site. As discussed in Section 8.2, the staff assumed construction of three 508-MW(e) units.

The VEPCo ER assumes that coal and lime or limestone for a coal-fired plant sited at the Surry Power Station would be delivered by barge to the existing receiving dock (VEPCo 2001). Lime[(a)] (or limestone) is used in the scrubbing process for control of sulfur dioxide (SO_2) emissions. Rail delivery would be the most likely option for delivering coal and lime/limestone to an alternate inland site for the coal-fired plant. Barge delivery of coal and lime/limestone is potentially feasible for a coastal site. A coal slurry pipeline is also a technically feasible delivery option; however, the associated cost and environmental impacts make a slurry pipeline an unlikely transportation alternative. Construction at an alternate site could necessitate the construction of a new transmission line to connect to existing lines and a rail spur to the plant site.

The coal-fired plant would consume approximately 4.4 million MT (4.9 million tons) per year of pulverized bituminous coal with an ash content by weight of approximately 10.7 percent (VEPCo 2001). The ER assumes a heat rate[(b)] of 3 J fuel/J electricity (10,200 Btu/kWh) and a capacity factor[(c)] of 0.85 (VEPCo 2001). After combustion, 99.9 percent of the ash (approximately 474,000 MT/yr [522,000 tons/yr]) would be collected and disposed of at the plant site. In addition, approximately 221,000 MT/yr (244,000 tons/yr) of scrubber sludge would be disposed of at the plant site based on annual lime usage of approximately 76,000 MT (84,000 tons) (VEPCo 2001).

Unless otherwise indicated, the assumptions and numerical values used in Section 8.2.1 are from the VEPCo ER (VEPCo 2001). The staff reviewed this information and compared it to

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(a) In a typical wet scrubber, lime (calcium hydroxide) or limestone (calcium carbonate) is injected as a slurry into the hot effluent combustion gases to remove entrained sulfur dioxide. The lime-based scrubbing solution reacts with sulfur dioxide to form calcium sulfite, which precipitates out and is removed in sludge form.

(b) Heat rate is a measure of generating-station thermal efficiency. In English units, it is generally expressed in British thermal units (Btu) per net kilowatt-hour (kWh). It is computed by dividing the total Btu content of fuel burned for electric generation by the resulting net kWh generation.

(c) The capacity factor is the ratio of electricity generated, for the period of time considered, to the energy that could have been generated at continuous full-power operation during the same period.

environmental impact information in the GEIS. Although the OL renewal period is only 20 years, the impact of operating the coal-fired alternative for 40 years is considered (as a reasonable projection of the operating life of a coal-fired plant).

8.2.1.1 Once-Through Cooling System

For purposes of this SEIS, the staff assumed that a coal-fired plant located at the Surry Power Station would use the existing once-through system as a source of cooling. An alternate greenfield site could use either a closed-cycle or a once-through cooling system.

The overall impacts of the coal-fired generating system are discussed in the following sections and summarized in Table 8-2. The extent of impacts at an alternate site would depend on the location of the particular site selected.

- **Land Use**

  The existing facilities and infrastructure at the Surry Power Station site would be used to the extent practicable, limiting the amount of new construction that would be required. Specifically, the staff assumed that the coal-fired replacement plant alternative would use the existing once-through cooling system, switchyard, offices, and transmission line rights-of-way. Some additional land beyond the current Surry Power Station site boundary may be needed to construct a new coal-fired plant while the existing nuclear Units 1 and 2 continue to operate.

  The coal-fired generation alternative would necessitate converting most of the unused land at the Surry Power Station to industrial use for the plant, coal storage, and landfill disposal of ash, spent selective catalytic reduction catalyst (used for control of nitrogen oxide emissions), and scrubber sludge. VEPCo estimates that ash and scrubber waste disposal over a 40-year plant life would require approximately 172 ha (425 ac) (VEPCo 2001). Additional land-use changes would occur offsite in an undetermined coal-mining area to supply coal for the plant. The GEIS estimated that approximately 8900 ha (22,000 ac) would be affected for mining the coal and disposing of the waste to support a 1000-MW(e) coal plant during its operational life (NRC 1996). A replacement coal-fired plant for Surry Units 1 and 2 would be 1524 MW(e) and would affect proportionately more land. Partially offsetting this offsite land use would be the elimination of the need for uranium mining to supply fuel for Surry Units 1 and 2. The GEIS states that approximately 400 ha (1000 ac) would be affected for mining the uranium and processing it during the operating life of a 1000-MW(e) nuclear power plant (NRC 1996).

Table 8-2. Summary of Environmental Impacts of Coal-Fired Generation at Surry Power Station and an Alternate Greenfield Site Using Once-Through Cooling

	Surry Power Station Site		Alternate Greenfield Site	
Impact Category	**Impact**	**Comments**	**Impact**	**Comments**
Land Use	MODERATE	Uses most of unused portion of Surry Power Station site for plant, infrastructure, and waste disposal. Additional offsite land may also be needed. Additional offsite land impacts for coal and limestone mining.	MODERATE to LARGE	Uses up to 700 ha (1700 ac) for plant and infrastructure; additional land impacts for coal and limestone mining; possible impacts for transmission line and rail spur.
Ecology	MODERATE to LARGE	Uses undeveloped areas at Surry Power Station plus some offsite land. Potential habitat loss and fragmentation and reduced productivity and biological diversity.	MODERATE to LARGE	Impact depends on location and ecology of the site, surface-water body used for intake and discharge, and transmission line route; potential habitat loss and fragmentation; reduced productivity and biological diversity.
Water Use and Quality	SMALL	Uses existing once-through cooling system	SMALL to MODERATE	Impact will depend on the volume of water withdrawn and discharged and the characteristics of the surface-water body.
Air Quality	MODERATE	Sulfur oxides • 4126 MT/yr (4548 tons/yr) Nitrogen oxides • 1075 MT/yr (1185 tons/yr) Particulates • 237 MT/yr (261 tons/yr) of total suspended particulates which would include 54 MT/yr (60 tons/yr) of PM_{10} Carbon monoxide • 1108 MT/yr (1221 tons/yr) Small amounts of mercury and other hazardous air pollutants and naturally occurring radioactive materials – mainly uranium and thorium	MODERATE	Potentially same impacts as the Surry Power Station site, although pollution control standards may vary.

Table 8-2. (contd)

	Surry Power Station Site		Alternate Greenfield Site	
Impact Category	**Impact**	**Comments**	**Impact**	**Comments**
Waste	MODERATE	Total waste volume would be approximately 700,000 MT/yr (770,000 tons/yr) of ash, spent catalyst, and scrubber sludge requiring approximately 172 ha (425 ac) for disposal during the 40-year life of the plant.	MODERATE	Same impacts as Surry Power Station site; waste disposal constraints may vary.
Human Health	SMALL	Impacts are uncertain, but considered SMALL in the absence of more quantitative data.	SMALL	Same impact as Surry Power Station site.
Socioeconomics	SMALL to LARGE	During construction, impacts would be MODERATE to LARGE. Up to 2500 workers during the peak of the 5-year construction period, followed by reduction from current Surry Units 1 and 2 workforce of 990 to 200. Tax base preserved. Impacts during operation would be SMALL. Transportation impacts associated with construction workers could be MODERATE to LARGE. For barge transportation of coal and lime/limestone, the impact is considered SMALL.	SMALL to LARGE	Construction impacts depend on location, but could be LARGE if plant is located in a rural area. Surry County would experience loss of Units 1 and 2 tax base and employment with potentially LARGE impacts. Impacts during operation would be SMALL. Transportation impacts associated with construction workers could be MODERATE to LARGE. For rail transportation of coal and lime/limestone, the impact is considered MODERATE to LARGE. For barge transportation, the impact is considered SMALL.

Table 8-2. (contd)

	Surry Power Station Site		Alternate Greenfield Site	
Impact Category	**Impact**	**Comments**	**Impact**	**Comments**
Aesthetics	MODERATE to LARGE	MODERATE to LARGE aesthetic impact. Exhaust stacks will be visible from the Hog Island Wildlife Management Area, the James River, Chippokes Plantation State Park, and Colonial National Historical Park. Barge transportation of coal and lime/limestone would have a SMALL aesthetic impact. Noise impact would be SMALL to MODERATE.	MODERATE to LARGE	Impact would depend on the site selected and the surrounding land features. If needed, a new transmission line or rail spur would add to the aesthetic impact. Rail transportation of coal and lime/limestone would have a MODERATE aesthetic impact. Barge transportation of coal and lime/limestone would have a SMALL aesthetic impact. Noise impact would be SMALL to MODERATE.
Historic and Archeological Resources	SMALL	Some construction would affect previously developed parts of Surry Power Station site; cultural resource inventory should minimize any impacts on undeveloped lands.	SMALL	Alternate location would necessitate cultural resource studies.
Environmental Justice	MODERATE	Impacts on minority and low-income communities should be similar to those experienced by the population as a whole. Some impacts on housing may occur during construction; loss of 790 operating jobs at Surry Power Station could reduce employment prospects for minority and low-income populations.	MODERATE to LARGE	Impacts at alternate site vary depending on population distribution and makeup at site. Surry County would lose significant revenue, which could have MODERATE to LARGE impacts on minority and low-income populations.

The impact of a coal-fired generating unit on land use at the Surry Power Station site is best characterized as MODERATE. The impact would definitely be greater than the OL renewal alternative.

In the GEIS, NRC staff estimated that a 1000-MW(e) coal-fired plant would require approximately 700 ha (1700 ac) (NRC 1996). It is likely that this acreage would be sufficient for a 1524-MW(e) coal-fired generation alternative at an alternate greenfield site. Additional land could be needed for a transmission line and for a rail spur to the plant site. Depending

particularly on transmission line and rail line routing requirements, this alternative would result in MODERATE to LARGE land-use impacts.

- **Ecology**

  Locating a coal-fired plant at the Surry Power Station site would alter ecological resources because of the need to convert most of the currently unused land at the Station to industrial use for the plant, coal storage, and ash and scrubber sludge disposal. However, some of this land would have been previously disturbed.

  Siting a coal-fired plant at the Surry Power Station would have a MODERATE to LARGE ecological impact that would be greater than renewal of the Units 1 and 2 OLs.

  At an alternate site, the coal-fired generation alternative would introduce construction impacts and new incremental operational impacts. Even assuming siting at a previously disturbed area, the impacts would alter the ecology. Impacts could include wildlife habitat loss, reduced productivity, habitat fragmentation, and a local reduction in biological diversity. Use of cooling makeup water from a nearby surface-water body could have adverse aquatic resource impacts. If needed, construction and maintenance of a transmission line and a rail spur would have ecological impacts. Overall, the ecological impacts at an alternate site would be MODERATE to LARGE.

- **Water Use and Quality**

  The coal-fired generation alternative at the Surry Power Station site is assumed to use the existing once-through cooling system, which would minimize incremental water use and quality impacts. Surface-water impacts are expected to remain SMALL; the impacts would be sufficiently minor that they would not noticeably alter any important attribute of the resource.

  The staff assumed that a coal-fired plant located at the Surry Power Station would obtain potable, process, and fire-protection water from the series of groundwater wells that currently supply Units 1 and 2 (see Section 2.2.2). Use of groundwater for a coal-fired plant at an alternate site is a possibility. Groundwater withdrawal at an alternate site would likely require a permit.

  Some erosion and sedimentation would likely occur during construction (NRC 1996).

For a coal-fired plant located at an alternate site, the impact on the surface water would depend on the discharge volume and the characteristics of the receiving body of water. Intake from and discharge to any surface body of water would be regulated by the Commonwealth of Virginia or another state. The impacts would be SMALL to MODERATE.

- **Air Quality**

The air-quality impacts of coal-fired generation vary considerably from those of nuclear generation due to emissions of sulfur oxides (SO_x), nitrogen oxides (NO_x), particulates, carbon monoxide, hazardous air pollutants such as mercury, and naturally occurring radioactive materials.

Surry County is in the State Capital Intrastate Air Quality Control Region (40 CFR 81.145). Surry County is in compliance with the national ambient air quality standards for particulate matter, carbon monoxide, nitrogen dioxide, lead, sulfur dioxide (SO_2), and ozone (40 CFR 81.347).

A new coal-fired generating plant located at the Surry Power Station would likely need a prevention of significant deterioration (PSD) permit and an operating permit under the Clean Air Act. The plant would need to comply with the performance standards for new plants set forth in 40 CFR Part 60, Subpart Da. The standards establish limits for particulate matter and opacity (40 CFR 60.42a), SO_2 (40 CFR 60.43a), and NO_x (40 CFR 60.44a).

The U.S. Environmental Protection Agency (EPA) has various regulatory requirements for visibility protection in 40 CFR Part 51, Subpart P, including a specific requirement for review of any new major stationary source in an area designated as attainment or unclassified under the Clean Air Act. Surry County is classified as attainment or unclassified for criteria pollutants.[(a)]

Section 169A of the Clean Air Act (42 USC 7401) establishes a national goal of preventing future and remedying existing impairment of visibility in mandatory Class I Federal areas when impairment results from man-made air pollution. EPA issued a new regional haze rule in 1999 (64 FR 35714; July 1,1999 [EPA 1999]). The rule specifies that for each mandatory Class I Federal area located within a state, the state must establish goals that provide for reasonable progress towards achieving natural visibility conditions. The reasonable progress goals must provide for an improvement in visibility for the most-impaired days over

(a) Existing criteria pollutants under the Clean Air Act are ozone, carbon monoxide, particulates, sulfur dioxide, lead, and nitrogen oxide. Ambient air standards for criteria pollutants are set out in 40 CFR Part 50.

the period of the implementation plan and ensure no degradation in visibility for the least impaired days over the same period (40 CFR 51.308[d][1]). If a coal-fired plant were located close to a mandatory Class I area, additional air pollution control requirements could be imposed. However, the closest mandatory Class I Federal areas to Surry Power Station are the Swanquarter Wilderness in eastern North Carolina located approximately 200 km (125 mi) southeast of Surry Power Station, Shenandoah National Park located approximately 225 km (140 mi) northwest of Surry Power Station, and the James River Face Wilderness located approximately 240 km (150 mi) west of Surry Power Station.

In 1998, EPA issued a rule requiring 22 eastern states, including Virginia, to revise their state implementation plans to reduce NO_x emissions (63 FR 49442, EPA 1998). Nitrogen-oxide emissions contribute to violations of the national ambient air quality standard for ozone. The total amount of nitrogen oxides that can be emitted by each of the 22 states in the year 2007 ozone season (May 1 - September 30) is set out at 40 CFR 51.121(e). For Virginia, the amount is 163,470 MT (180,195 tons). Any new coal-fired plant sited in Virginia would be subject to this limitation.

Impacts for particular pollutants are as follows:

Sulfur oxides emissions. VEPCo states in its ER that an alternative coal-fired plant located at the Surry Power Station site would use wet scrubber technology utilizing lime/limestone for flue gas desulfurization (VEPCo 2001).

A new coal-fired power plant would be subject to the requirements in Title IV of the Clean Air Act. Title IV was enacted to reduce emissions of SO_2 and NO_x, the two principal precursors of acid rain, by restricting emissions of these pollutants from power plants. Title IV caps aggregate annual power plant SO_2 emissions and imposes controls on SO_2 emissions through a system of marketable allowances. EPA issues one allowance for each ton of SO_2 that a unit is allowed to emit. New units do not receive allowances, but are required to have allowances to cover their SO_2 emissions. Owners of new units must, therefore, acquire allowances from owners of other power plants by purchase or reduce SO_2 emissions at other power plants they own. Allowances can be banked for use in future years. Thus, a new coal-fired power plant would not add to net regional SO_2 emissions, although it might do so locally. Regardless, SO_2 emissions would be greater for the coal alternative than the OL renewal alternative.
VEPCo estimates that by using the best technology to minimize SO_x emissions, the total annual stack emissions would be approximately 4130 MT (4548 tons) of SO_x (VEPCo 2001).

Nitrogen oxides emissions. Section 407 of the Clean Air Act establishes technology-based emission limitations for NO_x emissions. The market-based allowance system used for SO_2 emissions is not used for NO_x emissions. A new coal-fired power plant would be subject to

the new source performance standards for such plants in 40 CFR 60.44a(d)(1). This regulation, issued on September 16, 1998 (EPA 1998), limits the discharge of any gases that contain nitrogen oxides (expressed as NO_2) in excess of 200 ng/J of gross energy output (1.6 lb/MWh), based on a 30-day rolling average.

VEPCo estimates that by using NO_x burners with overfire air and selective catalytic reduction, the total annual NO_x emissions for a new coal-fired power plant would be approximately 1075 MT (1185 tons) (VEPCo 2001). This level of NO_x emissions would be greater than the OL renewal alternative.

Particulates emissions. VEPCo estimates that the total annual stack emissions would include 237 MT (261 tons) of filterable total suspended particulates (particulates that range in size from less than 0.1 micrometer up to approximately 45 micrometers). The 237 MT would include 54 MT (60 tons) of PM_{10} (particulate matter having an aerodynamic diameter less than or equal to 10 micrometers). Fabric filters or electrostatic precipitators would be used for control. In addition, coal-handling equipment would introduce fugitive particulate emissions. Particulate emissions would be greater under the coal alternative than the OL renewal alternative.

During the construction of a coal-fired plant, fugitive dust would be generated. In addition, exhaust emissions would come from vehicles and motorized equipment used during the construction process.

Carbon monoxide emissions. VEPCo estimates that the total carbon monoxide emissions would be approximately 1110 MT (1221 tons) per year (VEPCo 2001). This level of emissions is greater than the OL renewal alternative.

Hazardous air pollutants emissions, including mercury. In December 2000, EPA issued regulatory findings on emissions of hazardous air pollutants from electric utility steam generating units (65 FR 79825, EPA 2000b). EPA determined that coal- and oil-fired electric utility steam-generating units are significant emitters of hazardous air pollutants. Coal-fired power plants were found by EPA to emit arsenic, beryllium, cadmium, chromium, dioxins, hydrogen chloride, hydrogen fluoride, lead, manganese, and mercury (EPA 2000b). EPA concluded that mercury is the hazardous air pollutant of greatest concern. EPA found that (1) there is a link between coal consumption and mercury emissions, (2) electric utility steam-generating units are the largest domestic source of mercury emissions, and (3) certain segments of the U.S. population (e.g., developing fetuses and subsistence fish-eating populations) are believed to be at potential risk of adverse health effects due to mercury exposures resulting from consumption of contaminated fish (EPA 2000b). Accordingly, EPA added coal- and oil-fired electric utility steam-generating units to the list of

source categories under Section 112(c) of the Clean Air Act for which emission standards for hazardous air pollutants will be issued (EPA 2000b).

Uranium and thorium emissions. Coal contains uranium and thorium. Uranium concentrations are generally in the range of 1 to 10 parts per million. Thorium concentrations are generally about 2.5 times greater than uranium concentrations (Gabbard 1993). One estimate is that a typical coal-fired plant released roughly 4.7 MT (5.2 tons) of uranium and 11.6 MT (12.8 tons) of thorium in 1982 (Gabbard 1993). The population dose equivalent from the uranium and thorium releases and daughter products produced by the decay of these isotopes has been calculated to be significantly higher than that from nuclear power plants (Gabbard 1993).

A coal-fired plant would also have unregulated carbon-dioxide emissions that could contribute to global warming.

Summary. The GEIS analysis did not quantify emissions from coal-fired power plants, but implied that air impacts would be substantial. The GEIS also mentioned global warming from unregulated carbon-dioxide emissions and acid rain from SO_x and NO_x emissions as potential impacts (NRC 1996). Adverse human health effects such as cancer and emphysema have been associated with the products of coal combustion. The appropriate characterization of air impacts from coal-fired generation would be MODERATE. The impacts would be clearly noticeable, but would not destabilize air quality.

Siting a coal-fired generation plant at a site other than Surry Power Station would not significantly change air-quality impacts, although it could result in installing more or less stringent pollution-control equipment to meet applicable local requirements. Therefore, the impacts would be MODERATE.

- **Waste**

Coal combustion generates waste in the form of ash, and equipment for controlling air pollution generates spent selective catalytic reduction (SCR) catalyst, additional ash, and scrubber sludge. Three 508-MW(e) coal-fired units would generate approximately 695,000 MT (766,060 tons) of this waste annually. The waste would be disposed of onsite, accounting for approximately 172 ha (425 ac) of land area over the 40-year plant life. Waste impacts to groundwater and surface water could extend beyond the operating life of the plant if leachate and runoff from the waste storage area occurs. Disposal of the waste could noticeably affect land use and groundwater quality, but with appropriate management and monitoring, it would not destabilize any resources. After closure of the waste site and

revegetation, the land could be available for other uses. Construction-related debris would be generated during construction activities.

In May 2000, EPA issued a Notice of Regulatory Determination on Wastes from the Combustion of Fossil Fuels (65 FR 32214, EPA 2000a). EPA concluded that some form of national regulation is warranted to address coal combustion waste products because (1) the composition of these wastes could present danger to human health and the environment under certain conditions, (2) EPA has identified 11 documented cases of proven damage to human health and the environment by improper management of these wastes in landfills and surface impoundments, (3) present disposal practices are such that, in 1995, these wastes were being managed in 40 to 70 percent of landfills and surface impoundments without reasonable controls in place, particularly in the area of groundwater monitoring, and (4) EPA identified gaps in state oversight of coal combustion wastes. Accordingly, EPA announced its intention to issue regulations for disposal of coal combustion waste under Subtitle D of the Resource Conservation and Recovery Act (RCRA).

For all of the preceding reasons, the appropriate characterization of impacts from waste generated from burning coal is MODERATE; the impacts would be clearly noticeable, but would not destabilize any important resource.

Siting the facility at a site other than the Surry Power Station would not alter waste generation, although other sites might have more constraints on disposal locations. Therefore, the impacts would be MODERATE.

- **Human Health**

Coal-fired power generation introduces worker risks from coal and limestone mining, worker and public risks from coal and lime/limestone transportation, worker and public risks from disposal of coal combustion wastes, and public risks from inhalation of stack emissions. Emission impacts can be widespread and health risks difficult to quantify. The coal alternative also introduces the risk of coal pile fires and attendant inhalation risks.

In the GEIS, the staff stated that there could be human health impacts (cancer and emphysema) from inhalation of toxins and particulates from a coal-fired plant, but did not identify the significance of these impacts (NRC 1996). In addition, the discharges of uranium and thorium from coal-fired plants can potentially produce radiological doses in excess of those arising from nuclear power plant operations (Gabbard 1993).

Regulatory agencies, including EPA and State agencies, set air-emission standards and requirements based on human health impacts. These agencies also impose site-specific

emission limits as needed to protect human health. As discussed previously, EPA has recently concluded that certain segments of the U.S. population (e.g., developing fetuses and subsistence fish-eating populations) are believed to be at potential risk of adverse health effects due to mercury exposures from sources such as coal-fired power plants. However, in the absence of more quantitative data, human health impacts from radiological doses and inhaling toxins and particulates generated by burning coal are characterized as SMALL.

- **Socioeconomics**

  Construction of the coal-fired alternative would take approximately 5 years. The staff assumed that construction would take place while Surry Units 1 and 2 continue operation and would be completed by the time Units 1 and 2 permanently cease operations. The workforce would be expected to vary between 1200 and 2500 workers during the 5-year construction period (NRC 1996). These workers would be in addition to the approximately 990 workers employed at Units 1 and 2. During construction of the new coal-fired plant, communities near the Surry Power Station would experience demands on housing and public services that could have MODERATE to LARGE impacts. These impacts would be tempered by construction workers commuting to the site from more distant cities such as Hampton, Norfolk, Chesapeake, Portsmouth, and Virginia Beach. After construction, the nearby communities would be impacted by the loss of the construction jobs. VEPCo estimates that the completed coal plant would employ approximately 200 workers (VEPCo 2001).

  If the coal-fired replacement plant were constructed at the Surry Power Station site and Units 1 and 2 were decommissioned, there would be a loss of approximately 790 permanent high-paying jobs (from 990 for the two nuclear units down to 200 for the coal-fired plant), with a commensurate reduction in demand on socioeconomic resources and contribution to the regional economy. The coal-fired plants would provide a new tax base to offset the loss of tax base associated with decommissioning of the nuclear units. For all of these reasons, the appropriate characterization of nontransportation socioeconomic impacts for an operating coal-fired plant constructed at the Surry Power Station site would be MODERATE. The socioeconomic impacts would be noticeable, but would be unlikely to destabilize the area.

  During the 5-year construction period of replacement coal-fired units, up to 2500 construction workers would be working at the site in addition to the 990 workers at Units 1 and 2. The addition of these workers could place significant traffic loads on existing highways near the Surry Power Station. Such impacts would be MODERATE to LARGE.

For transportation related to commuting of plant-operating personnel, the impacts are considered SMALL. The maximum number of plant-operating personnel would be approximately 200. The current Surry Units 1 and 2 workforce is approximately 990. Therefore, traffic impacts associated with plant personnel commuting to a coal-fired plant would be expected to be SMALL compared to the current impacts from Unit 1 and 2 operations.

Barge delivery of coal and lime/limestone to the Surry Power Station would likely have SMALL socioeconomic impacts.

Construction of a replacement coal-fired power plant at an alternate greenfield site would relocate some socioeconomic impacts, but would not eliminate them. The communities around Surry Power Station would experience the impact of Surry Units 1 and 2 operational job loss and Surry County would lose a significant tax base. These losses would have potentially LARGE socioeconomic impacts. Communities around the new site would have to absorb the impacts of a large, temporary workforce (up to 2500 workers at the peak of construction) and a permanent workforce of approximately 200 workers. In the GEIS, the staff stated that socioeconomic impacts at a rural site would be larger than at an urban site because more of the peak construction workforce would need to move to the area to work (NRC 1996). Alternate sites would need to be analyzed on a case-by-case basis. Socioeconomic impacts at a rural site could be LARGE. Transportation-related impacts associated with commuting construction workers at an alternate site are site-dependent, but could be MODERATE to LARGE. Transportation impacts related to commuting of plant-operating personnel would also be site-dependent, but can be characterized as SMALL to MODERATE.

At an alternate greenfield site, coal and lime/limestone would likely be delivered by rail, although barge delivery is feasible for a coastal location. Transportation impacts would depend upon the site location. For the rail delivery option, coal would likely be delivered by rail trains of approximately 115 cars each. Each open-top rail car holds about 90 MT (100 tons) of coal. Additional rail cars would be needed for lime/limestone delivery. In all, approximately 440 trains per year would deliver the coal and lime/limestone for the three units. An average of roughly 17 train trips per week on the rail spur would be needed because for each full train delivery, there would be an empty return train. On several days per week, there could be three trains per day using the rail spur to the alternate site. Socioeconomic impacts associated with rail transportation, such as delays at rail crossings, would likely be MODERATE to LARGE. Barge delivery of coal and lime/limestone would likely have SMALL socioeconomic impacts.

- **Aesthetics**

The three coal-fired power plant units could be as much as 60 m (200 ft) tall and be visible in daylight hours over many miles. The three exhaust stacks would be as much as 185 m (600 ft) high (VEPCo 2001). Given the low elevation at the site and of the surrounding land, the stacks would likely be highly visible in daylight hours for distances up to 16 km (10 mi). The stacks would be visible from the Hog Island Wildlife Management Area, the James River, Chippokes Plantation State Park, and Colonial National Historical Park, particularly the historic Jamestown portion of the park. The plant units and associated stacks would also be visible at night because of outside lighting. Visual impacts of a new coal-fired plant could be mitigated by landscaping and color selection for buildings that is consistent with the environment. Visual impact at night could be mitigated by reduced use of lighting and appropriate use of shielding.

The aesthetic impact of the replacement coal-fired units on visitors to the historic Jamestown portion of Colonial National Historical Park would be particularly significant. Given the environmental sensitivity of the park and the associated expectations of visitors to national parks, the addition of the coal-fired units and the associated exhaust stacks would likely have a MODERATE to LARGE aesthetic impact.

Coal-fired generation would introduce mechanical sources of noise that would be audible offsite. Sources contributing to total noise produced by plant operation are classified as continuous or intermittent. Continuous sources include the mechanical equipment associated with normal plant operations. Intermittent sources include the equipment related to coal handling, solid-waste disposal, transportation related to coal and lime/limestone delivery, use of outside loudspeakers, and the commuting of plant employees. The incremental noise impacts of a coal-fired plant compared to existing Surry Units 1 and 2 operations are considered to be SMALL to MODERATE given the rural location of the plant.

Noise associated with barge transportation of coal and lime/limestone would be SMALL.

At an alternate greenfield site, there would be an aesthetic impact from the buildings and exhaust stacks. There would be an aesthetic impact that could be LARGE if construction of a new transmission line and/or rail spur is needed. Noise impacts associated with rail delivery of coal and lime/limestone would be most significant for residents living in the vicinity of the facility and along the rail route. Although noise from passing trains significantly raises noise levels near the rail corridor, the short duration of the noise reduces the impact. Nevertheless, given the frequency of train transport and the fact that many people are likely to be within hearing distance of the rail route, the impact of noise on residents in the vicinity of the facility and the rail line is considered MODERATE. Noise and

light from the plant would be detectable offsite. Aesthetic impacts at the plant site would be mitigated if the plant were located in an industrial area adjacent to other power plants. Overall, the aesthetic impacts associated with locating at an alternate site can be categorized as MODERATE to LARGE.

- **Historic and Archaeological Resources**

  At the Surry Power Station site or an alternate site, a cultural resource inventory would likely be needed for any onsite property that has not been previously surveyed. Other lands, if any, that are acquired to support the plant would also likely need an inventory of field cultural resources, identification and recording of existing historic and archaeological resources, and possible mitigation of adverse effects from subsequent ground-disturbing actions related to physical expansion of the plant site.

  Before construction at Surry Power Station or an alternate greenfield site, studies would likely be needed to identify, evaluate, and address mitigation of the potential impacts of new plant construction on cultural resources. The studies would likely be needed for all areas of potential disturbance at the proposed plant site and along associated corridors where new construction would occur (e.g., roads, transmission corridors, rail lines, or other rights-of-way). Historic and archaeological resource impacts can generally be effectively managed and as such are considered SMALL.

- **Environmental Justice**

  No environmental pathways or locations have been identified that would result in disproportionately high and adverse environmental impacts on minority and low-income populations if a replacement coal-fired plant were built at the Surry Power Station site. Some impacts on housing availability and prices during construction might occur, and this could disproportionately affect minority and low-income populations. Closure of Surry Units 1 and 2 would result in a decrease in employment of approximately 790 operating employees. Resulting economic conditions could reduce employment prospects for minority or low-income populations. Overall, impacts are expected to be MODERATE.

  Impacts at other sites would depend upon the site chosen and the nearby population distribution. If a replacement coal-fired plant were constructed at an alternate site, Surry County would experience a significant loss of property tax revenue, which would affect the County's ability to provide services and programs. Impacts to minority and low-income populations in Surry County could be MODERATE to LARGE.

8.2.1.2 Closed-Cycle Cooling System

The environmental impacts of constructing a coal-fired generation system at an alternate greenfield site using closed-cycle cooling with cooling towers are essentially the same as the impacts for a coal-fired plant using the once-through system. However, there are some environmental differences between the closed-cycle and once-through cooling systems. Table 8-3 summarizes the incremental differences.

8.2.2 Natural Gas-Fired Generation

The environmental impacts of the natural gas-fired alternative are examined in this section for both the Surry Power Station site and an alternate greenfield site. For the Surry Power Station site, the staff assumed that the plant would use the existing once-through cooling system.

The Surry Power Station site is currently served by natural gas pipelines from Newport News that pass under the James River (VEPCo 2001). The pipelines enter the VEPCo property near the cooling water intake structure. VEPCo assumes that construction of replacement natural gas-fired units at the Surry Power Station site would require a new dedicated high-pressure 61-cm (24-in.) diameter pipeline from Danville, Virginia (VEPCo 2001). Danville is approximately 238 km (148 mi) from the Surry Power Station. VEPCo also states in its ER that in the winter, when demand for natural gas is high, it may become necessary for a replacement natural gas- fired plant to operate on fuel oil due to a lack of gas supply (VEPCo 2001). Operation with oil would result in more stack emissions.

If a new natural gas-fired plant were built elsewhere to replace Surry Units 1 and 2, a new transmission line could need to be constructed to connect to existing lines. In addition, construction or upgrade of a natural gas pipeline from the plant to a supply point where a firm supply of gas would be available could be needed. One potential source of natural gas is liquefied natural gas (LNG) imported to either the Cove Point facility in Maryland or the Elba Island facility in Georgia. Both facilities are expected to be reactivated in 2002 (DOE/EIA 2001a). LNG imported to either facility would need to be vaporized and transported to the plant location via pipeline.

The staff assumed that a replacement natural gas-fired plant would use combined-cycle combustion turbines (VEPCo 2001). In a combined-cycle unit, hot combustion gases in a combustion turbine rotate the turbine to generate electricity. Waste combustion heat from the combustion turbine is routed through a heat-recovery boiler to make steam to generate additional electricity.

Table 8-3. Summary of Environmental Impacts of Coal-Fired Generation at an Alternate Greenfield Site with Closed-Cycle Cooling System Utilizing Cooling Towers

Impact Category	Change in Impacts from Once-Through Cooling System
Land Use	Requires 10-12 additional ha (25-30 ac) for cooling towers and associated infrastructure.
Ecology	Impact would depend on ecology at the site. Additional impact to terrestrial ecology from cooling tower drift. Reduced impact to aquatic ecology.
Surface Water Use and Quality	Discharge of cooling tower blowdown containing dissolved solids. Discharge would be regulated by the State. Decreased water withdrawal and less thermal load on receiving body of water. Consumptive use of water due to evaporation.
Groundwater Use and Quality	No change
Air Quality	No change
Waste	No change
Human Health	No change
Socioeconomics	No change
Aesthetics	Introduction of cooling towers and associated plumes. Natural draft towers could be up to 158 m (520 ft) high. Mechanical draft towers could be up to 30 m (100 ft) high and also have an associated noise impact.
Historic and Archaeological Resources	No change
Environmental Justice	No change

The following additional assumptions are made for the natural gas-fired plants (VEPCo 2001):

- three 508-MW(e) units, each consisting of two 168-MW combustion turbines and a 172-MW heat recovery boiler
- natural gas with an average heating value of 39 MJ/m^3 (1059 Btu/ft^3) as the primary fuel
- use of low-sulfur number 2 fuel oil as backup fuel
- heat rate of 2 J fuel/J electricity (6700 Btu/kWh)
- capacity factor of 0.85
- gas consumption of 2.11 billion m^3/yr (74.7 billion ft^3/yr).

Unless otherwise indicated, the assumptions and numerical values used in Section 8.2.2 are from the VEPCo ER. The staff reviewed this information and compared it to environmental impact information in the GEIS. Although the OL renewal period is only 20 years, the impact of operating the natural gas-fired alternative for 40 years is considered (as a reasonable projection of the operating life of a natural gas-fired plant).

8.2.2.1 Once-Through Cooling System

The overall impacts of the natural gas-generating system are discussed in the following sections and summarized in Table 8-4. The extent of impacts at an alternate greenfield site will depend on the location of the particular site selected.

- **Land Use**

  For siting at the Surry Power Station, existing facilities and infrastructure would be used to the extent practicable, limiting the amount of new construction that would be required. Specifically, the staff assumed that the natural gas-fired replacement plant alternative would use the existing once-through cooling system, switchyard, offices, and transmission line rights-of-way. For Surry Power Station, the staff assumed that approximately 14 ha (35 ac) would be needed for the plant and associated infrastructure. There would be an additional land use impact of up to approximately 1200 ha (3000 ac) for construction of a natural gas pipeline adjacent to existing previously disturbed pipeline easements (VEPCo 2001).

Table 8-4. Summary of Environmental Impacts of Natural Gas-Fired Generation at Surry Power Station and an Alternate Greenfield Site Using Once-Through Cooling

	Surry Power Station Site		Alternate Greenfield Site	
Impact Category	**Impact**	**Comments**	**Impact**	**Comments**
Land Use	MODERATE to LARGE	14 ha (35 ac) for powerblock, roads, and parking areas. Additional impact of up to approximately 1200 ha (3000 ac) for construction of an underground gas pipeline.	MODERATE to LARGE	45 ha (110 ac) for power-block, offices, roads, switchyard, and parking areas. Additional land possibly impacted for transmission line and/or natural gas pipeline.
Ecology	MODERATE to LARGE	Uses undeveloped areas at Surry Power Station plus land for a new gas pipeline.	MODERATE to LARGE	Impact depends on location and ecology of the site, surface water body used for intake and discharge, and possible transmission and pipeline routes; potential habitat loss and fragmentation; reduced productivity and biological diversity.
Water Use and Quality	SMALL	Uses existing once-through cooling system.	SMALL to MODERATE	Impact depends on volume of water withdrawal and discharge and characteristics of surface water body.
Air Quality	MODERATE	Sulfur oxides • 122 MT/yr (134 tons/yr) Nitrogen oxides • 459 MT/yr (506 tons/yr) Carbon monoxide • 602 MT/yr (664 tons/yr) PM_{10} particulates • 180 MT/yr (198 tons/yr) Some hazardous air pollutants	MODERATE	Same emissions as Surry Power Station site.
Waste	SMALL	The only significant waste would be spent SCR catalyst used for control of NO_x emissions.	SMALL	The only significant waste would be spent SCR catalyst used for control of NO_x emissions.
Human Health	SMALL	Impacts considered to be minor.	SMALL	Impacts considered to be minor.

Table 8-4. (contd)

	Surry Power Station Site		Alternate Greenfield Site	
Impact Category	**Impact**	**Comments**	**Impact**	**Comments**
Socioeconomics	MODERATE	During construction, impacts would be MODERATE. Up to 1200 additional workers during the peak of the 3-year construction period, followed by reduction from current Surry Units 1 and 2 workforce of 990 to 150; tax base preserved. Impacts during operation would be SMALL. Transportation impacts associated with construction workers would be MODERATE.	MODERATE to LARGE	During construction, impacts would be MODERATE. Up to 1200 additional workers during the peak of the 3-year construction period. Surry County would experience loss of Units 1 and 2 tax base and employment associated with Units 1 and 2 with potentially LARGE associated impacts. Transportation impacts associated with construction workers would be MODERATE.
Aesthetics	MODERATE	MODERATE aesthetic impact due to impact of plant units and stacks on environmentally sensitive Colonial National Historical Park.	SMALL to LARGE	SMALL to MODERATE impact from plant and stacks. Additional impact that could be LARGE if a new transmission line is needed.
Historic and Archeological Resources	SMALL	Any potential impacts can likely be effectively managed.	SMALL	Same as Surry Power Station site; any potential impacts can likely be effectively managed.
Environmental Justice	MODERATE	Impacts on minority and low-income communities should be similar to those experienced by the population as a whole. Some impacts on housing may occur during construction; loss of 840 operating jobs at Surry Power Station could reduce employment prospects for minority and low-income populations.	MODERATE to LARGE	Impacts at alternate site vary depending on population distribution and makeup at site. Surry County would lose significant revenue, which could have MODERATE to LARGE impacts on minority and low-income populations.

For construction at an alternate greenfield site, the staff assumed that 45 ha (110 ac) would be needed for the plant and associated infrastructure (NRC 1996). Additional land could be impacted for construction of a transmission line and/or natural gas pipeline to serve the plant.

For any new natural gas-fired plant, additional land would be required for natural gas wells and collection stations. In the GEIS the staff estimated that approximately 1500 ha (3600 ac) would be needed for a 1000-MW(e) plant (NRC 1996). A replacement gas-fired plant for Surry Units 1 and 2 would be 1524 MW(e) and would affect proportionately more land. Partially offsetting these offsite land requirements would be the elimination of the need for uranium mining to supply fuel for Units 1 and 2. The NRC staff states in the GEIS (NRC 1996) that approximately 400 ha (1000 ac) would be affected for mining the uranium and processing it during the operating life of a 1000-MW(e) nuclear power plant. Overall, land-use impacts at both the Surry Power Station and an alternate greenfield location would be MODERATE to LARGE.

- **Ecology**

At the Surry Power Station site, there would be ecological land-related impacts for siting of the gas-fired plant. There would also be significant ecological impacts associated with bringing a new underground gas pipeline to the Surry Power Station site. Ecological impacts at an alternate site would depend on the nature of the land converted for the plant and the possible need for a new transmission line and/or gas pipeline. Construction of a transmission line and a gas pipeline to serve the plant would be expected to have temporary ecological impacts. Ecological impacts to the plant site and utility easements could include impacts on threatened or endangered species, wildlife habitat loss and reduced productivity, habitat fragmentation, and a local reduction in biological diversity. At an alternate site, the cooling makeup water intake and discharge could have aquatic resource impacts. Overall, the ecological impacts are considered MODERATE to LARGE at either location.

- **Water Use and Quality**

Each of the natural gas-fired units would include a heat-recovery boiler from which steam would turn an electric generator. Steam would be condensed and circulated back to the boiler for reuse. A natural gas-fired plant sited at Surry Power Station is assumed to use the existing once-through cooling system.

The staff assumed that a natural gas-fired plant located at the Surry Power Station would obtain potable, process, and fire-protection water from the series of groundwater wells that currently supply Units 1 and 2 (see Section 2.2.2). It is possible that a natural gas-fired plant sited at an alternate site could use groundwater. Groundwater withdrawal at an alternate site would likely require a permit. Groundwater withdrawal impacts are considered SMALL.

For alternate sites, the impact on the surface water would depend on the discharge volume and the characteristics of the receiving body of water. Intake from and discharge to any surface body of water would be regulated by the State. A natural gas-fired plant sited at an alternate site may use groundwater.

Water-quality impacts from sedimentation during construction of a natural gas-fired plant were characterized in the GEIS as SMALL (NRC 1996). The staff also noted in the GEIS that operational water quality impacts would be similar to, or less than, those from other generating technologies.

Overall, water-use and quality impacts at an alternate site are considered SMALL to MODERATE.

- **Air Quality**

Natural gas is a relatively clean-burning fuel. The gas-fired alternative would release similar types of emissions, but in lesser quantities than the coal-fired alternative. A new combined-cycle natural gas power plant would be subject to the new source performance standards for such units in 40 CFR 60 Subpart Da. Subpart Da establishes emission limits for particulates, opacity, SO_2, and NO_x. A new gas-fired plant would also be subject to the visibility and NO_x emission reduction provisions discussed in Section 8.2.1.

VEPCo projects the following emissions for the natural gas-fired alternative (VEPCo 2001):

Sulfur oxides - 122 MT/yr (134 tons/yr)
Nitrogen oxides - 459 MT/yr (506 tons/yr)
Carbon monoxide - 602 MT/yr (664 tons/yr)
PM_{10} particulates - 180 MT/yr (198 tons/yr)

A natural gas-fired plant would also have unregulated carbon dioxide emissions that could contribute to global warming.

In December 2000, EPA issued regulatory findings on emissions of hazardous air pollutants from electric utility steam-generating units. Natural gas-fired power plants were found by EPA to emit arsenic, formaldehyde, and nickel (EPA 2000b). Unlike coal- and oil-fired plants, however, EPA did not determine that regulation of emissions of hazardous air pollutants from natural gas-fired power plants should be regulated under Section 112 of the Clean Air Act.

Construction activities would result in temporary fugitive dust. Exhaust emissions would also come from vehicles and motorized equipment used during the construction process.

The preceding emissions would likely be the same at the Surry Power Station or at an alternate site. Impacts from the above emissions would be clearly noticeable, but would not be sufficient to destabilize air resources as a whole. The overall air-quality impact for a new natural gas-generating plant sited at the Surry Power Station or at an alternate site is considered MODERATE.

- **Waste**

The only significant waste generated at a natural gas-fired plant would be small amounts of spent SCR catalyst, which is used for control of NO_x emissions. In the GEIS, the staff concluded that waste generation from gas-fired technology would be minimal (NRC 1996). Gas firing results in very few combustion by-products because of the clean nature of the fuel. Other than spent SCR catalyst, waste generation at an operating gas-fired plant would be largely limited to typical office wastes. Construction-related debris would be generated during construction activities. Overall, the waste impacts would be SMALL for a natural gas-fired plant sited at the Surry Power Station or at an alternate site.

In the winter, it may become necessary for a replacement baseload natural gas-fired plant to operate on fuel oil due to lack of gas supply. Number 2 fuel oil would be used. Combustion of number 2 fuel oil does not produce any appreciable solid waste. Overall, the waste impacts associated with fuel oil combustion at a combined cycle plant are expected to be SMALL.

- **Human Health**

In the GEIS, the staff identifies cancer and emphysema as potential health risks from gas-fired plants (NRC 1996). The risk may be attributable to NO_x emissions that contribute to ozone formation, which in turn contribute to health risks. For any gas-fired plant, NO_x emissions would be regulated. Human health effects are not expected to be detectable or sufficiently minor that they would neither destabilize nor noticeably alter any important attribute of the resource. Overall, the impacts on human health of the natural gas-fired alternative sited at the Surry Power Station or at an alternate site are considered SMALL.

- **Socioeconomics**

Construction of a natural gas-fired plant would take approximately 3 years. Peak employment could be up to 1200 workers (NRC 1996). The staff assumed that construction

would take place while Units 1 and 2 continue operation and would be completed by the time they permanently cease operations. During construction, the communities surrounding the Surry Power Station site would experience demands on housing and public services that could have MODERATE impacts. These impacts would be tempered by construction workers commuting to the site from more distant cities such as Hampton, Norfolk, Chesapeake, Portsmouth, and Virginia Beach. After construction, the communities would be impacted by the loss of jobs. The current Units 1 and 2 workforce (990 workers) would decline through a decommissioning period to a minimal maintenance size. The new natural gas-fired plant would replace the nuclear tax base at Surry Power Station or provide a new tax base at an alternate site and approximately 150 permanent jobs. Siting at an alternate site would result in the loss of the nuclear tax base and associated employment in Surry County with potentially LARGE socioeconomic impacts.

In the GEIS (NRC 1996), the staff concluded that socioeconomic impacts from constructing a natural gas-fired plant would not be very noticeable and that the small operational workforce would have the lowest socioeconomic impacts of any nonrenewable technology. Compared to the coal-fired and nuclear alternatives, the smaller size of the construction workforce, the shorter construction time frame, and the smaller size of the operations workforce would mitigate socioeconomic impacts.

Transportation impacts associated with construction and operating personnel commuting to the plant site would depend on the population density and transportation infrastructure in the vicinity of the site. The impacts can be classified as MODERATE for siting at Surry Power Station or at an alternate site.

Overall, socioeconomic impacts resulting from construction of a natural gas-fired plant at Surry Power Station would be MODERATE. For construction at an alternate site, socioeconomic impacts would be MODERATE to LARGE.

- **Aesthetics**

The turbine buildings and stacks (approximately 60 m [200 ft] tall) would be visible during daylight hours from offsite. The gas-pipeline compressors would also be visible. Noise and light from the plant would be detectable offsite. At the Surry Power Station site, these impacts would result in a MODERATE aesthetic impact given the environmental sensitivity of Colonial National Historical Park and the expectations of visitors to national parks.

At an alternate site, the buildings and stacks would be visible offsite. If a new transmission line is needed, the aesthetic impact could be LARGE. Aesthetic impacts would be mitigated if the plant were located in an industrial area adjacent to other power plants. Overall, the

aesthetic impacts associated with a replacement natural gas-fired plant at an alternate site are categorized as SMALL to LARGE with site-specific factors determining the final categorization.

- **Historic and Archaeological**

  At both Surry Power Station and an alternate site, a cultural resource inventory would likely be needed for any onsite property that has not been previously surveyed. Other lands, if any, that are acquired to support the plant would also likely need an inventory of field cultural resources, identification and recording of existing historic and archaeological resources, and possible mitigation of adverse effects from subsequent ground-disturbing actions related to physical expansion of the plant site.

  Before construction at Surry Power Station or an alternate site, studies would likely be needed to identify, evaluate, and address mitigation of the potential impacts of new plant construction on cultural resources. The studies would likely be needed for all areas of potential disturbance at the proposed plant site and along associated corridors where new construction would occur (e.g., roads, transmission and pipeline corridors, or other rights-of-way). Impacts to cultural resources can be effectively managed under current laws and regulations and kept SMALL.

- **Environmental Justice**

  No environmental pathways or locations have been identified that would result in disproportionately high and adverse environmental impacts on minority and low-income populations if a replacement natural gas-fired plant were built at the Surry Power Station. Some impacts on housing availability and prices during construction might occur, and this could disproportionately affect minority and low-income populations. Closure of Surry Units 1 and 2 would result in a decrease in employment of approximately 840 operating employees, possibly offset by general growth in the immediate area. Resulting economic conditions could reduce employment prospects for minority or low-income populations. Overall, impacts are expected to be MODERATE.

  Impacts at an alternate site would depend upon the site chosen and the nearby population distribution. If a replacement natural gas-fired plant were constructed at an alternate site, Surry County would experience a significant loss of property tax revenue which would affect the County's ability to provide services and programs. Impacts to minority and low-income populations in Surry County could be MODERATE to LARGE.

8.2.2.2 Closed-Cycle Cooling System

The environmental impacts of constructing a natural gas-fired generation system at an alternate location using a closed-cycle cooling system with cooling towers are essentially the same as the impacts for a natural gas-fired plant using once-through cooling. However, there are some environmental differences between the closed-cycle and once-through cooling systems. Table 8-5 summarizes the incremental differences.

8.2.3 Nuclear Power Generation

Since 1997, the NRC has certified three new standard designs for nuclear power plants under 10 CFR Part 52, Subpart B. These designs are the U.S. Advanced Boiling Water Reactor (10 CFR Part 52, Appendix A), the System 80+ Design (10 CFR Part 52, Appendix B), and the AP600 Design (10 CFR Part 52, Appendix C). All of these plants are light-water reactors. Although no applications for a construction permit or a combined license based on these certified designs have been submitted to NRC, the submission of the design certification applications indicates continuing interest in the possibility of licensing new nuclear power plants. In addition, recent volatility in prices of natural gas and electricity have made new nuclear power plant construction more attractive from a cost standpoint. Consequently, construction of a new nuclear power plant at the Surry Power Station site using the existing once-through cooling system and at an alternate greenfield site using both closed- and open-cycle cooling are considered in this section. The staff assumed that the new nuclear plant would have a 40-year lifetime.

NRC has summarized environmental data associated with the uranium fuel cycle in Table S-3 of 10 CFR 51.51. The impacts shown in Table S-3 are representative of the impacts that would be associated with a replacement nuclear power plant built to one of the certified designs sited at the Surry Power Station or an alternate site. The impacts shown in Table S-3 are for a 1000-MW(e) reactor and would need to be adjusted to reflect replacement of Units 1 and 2, which have a capacity of 1602 MW(e). The environmental impacts associated with transporting fuel and waste to and from a light-water-cooled nuclear power reactor are summarized in Table S-4 of 10 CFR 51.52. The summary of NRC's findings on NEPA issues for license renewal of nuclear power plants in Table B-1 of 10 CFR Part 51, Subpart A, Appendix B, is also relevant, although not directly applicable, for consideration of environmental impacts associated with the operation of a replacement nuclear power plant. Additional environmental impact information for a replacement nuclear power plant using once-through cooling is presented in Section 8.2.3.1 and using closed-cycle cooling in Section 8.2.3.2.

Table 8-5. Summary of Environmental Impacts of Natural Gas-Fired Generation at an Alternate Greenfield Site with Closed-Cycle Cooling Utilizing Cooling Towers

Impact Category	Change in Impacts from Once-Through Cooling System
Land Use	Required 10-12 additional ha (25-30 ac) for cooling towers and associated infrastructure.
Ecology	Impact would depend on ecology at the site. Additional impact to terrestrial ecology from cooling tower drift. Reduced impact to aquatic ecology.
Surface Water Use and Quality	Discharge of cooling tower blowdown containing dissolved solids. Discharge would be regulated by the State. Decreased water withdrawal and less thermal load on receiving body of water. Consumptive use of water due to evaporation from cooling towers.
Groundwater Use and Quality	No change
Air Quality	No change
Waste	No change
Human Health	No change
Socioeconomics	No change
Aesthetics	Introduction of cooling towers and associated plume. Possible noise impact from operation of cooling towers.
Historic and Archaeological Resources	No change
Environmental Justice	No change

8.2.3.1 Once-Through Cooling System

The overall impacts of the nuclear generating system are discussed in the following sections. The impacts are summarized in Table 8-6. The extent of impacts at an alternate greenfield site will depend on the location of the particular site selected.

- **Land Use**

  The existing facilities and infrastructure at the Surry Power Station site would be used to the extent practicable, limiting the amount of new construction that would be required. Specifically, the staff assumed that a replacement nuclear power plant would use the existing cooling system, switchyard, offices, and transmission line rights-of-way.

  A replacement nuclear power plant at Surry Power Station would require approximately 200 ha (500 ac), some of which may be previously undeveloped land. There would be no net change in land needed for uranium mining because land for the new nuclear plant would offset land needed to supply uranium for fuel for Units 1 and 2.

  The impact of a replacement nuclear generating plant on land use at the Surry Power Station site is best characterized as MODERATE. The impact would be greater than the OL renewal alternative.

  Land-use requirements at an alternate site would be approximately 200-400 ha (500-1000 ac) plus the possible need for a new transmission line (NRC 1996). In addition, it may be necessary to construct a rail spur to an alternate site to bring in equipment during construction. Depending particularly on transmission line routing, siting a new nuclear plant at an alternate site could result in MODERATE to LARGE land-use impacts.

- **Ecology**

  Locating a replacement nuclear power plant at the Surry Power Station site would alter ecological resources because of the need to convert land to an industrial use. Some of this land, however, would have been previously disturbed.

  Siting at the Surry Power Station would have a MODERATE ecological impact that would be greater than renewal of the Units 1 and 2 OLs.

  At an alternate site, there would be construction impacts and new incremental operational impacts. Even assuming siting at a previously disturbed area, the impacts would alter the

Table 8-6. Summary of Environmental Impacts of New Nuclear Generation at Surry Power Station and an Alternate Greenfield Site Using Once-Through Cooling

	Surry Power Station Site		Alternate Greenfield Site	
Impact Category	**Impact**	**Comments**	**Impact**	**Comments**
Land Use	MODERATE	Requires approximately 200 ha (500 ac) for the plant	MODERATE to LARGE	Requires approximately 200-400 ha (500-1000 ac) for the plant. Possible additional land if a new transmission line is needed.
Ecology	MODERATE	Uses undeveloped areas at current Surry Power Station site plus additional offsite land. Potential habitat loss and fragmentation and reduced productivity and biological diversity on offsite land.	MODERATE to LARGE	Impact depends on location and ecology of the site, surface-water body used for intake and discharge, and transmission line route; potential habitat loss and fragmentation; reduced productivity and biological diversity.
Water Use and Quality	SMALL	Uses existing once-through cooling system	SMALL to MODERATE	Impact will depend on the volume of water withdrawn and discharged and the characteristics of the surface water body.
Air Quality	SMALL	Fugitive emissions and emissions from vehicles and equipment during construction. Small amount of emissions from diesel generators and possibly other sources during operation.	SMALL	Same impacts as Surry Power Station site
Waste	SMALL	Waste impacts for an operating nuclear power plant are set out in 10 CFR Part 51, Appendix B, Table B-1. Debris would be generated and removed during construction.	SMALL	Same impacts as Surry Power Station site
Human Health	SMALL	Human health impacts for an operating nuclear power plant are set out in 10 CFR Part 51, Appendix B, Table B-1.	SMALL	Same impacts as Surry Power Station site

Table 8-6. (contd)

	Surry Power Station Site		Alternate Greenfield Site	
Impact Category	**Impact**	**Comments**	**Impact**	**Comments**
Socioeconomics	MODERATE to LARGE	During construction, impacts would be MODERATE to LARGE. Up to 2500 workers during the peak of the 6-year construction period. Operating workforce assumed to be similar to Units 1 & 2. Surry County tax base preserved.	MODERATE to LARGE	Construction impacts depend on location. Impacts at a rural location could be LARGE. Surry County would experience loss of a significant tax base and employment with potentially LARGE impacts.
		Transportation impacts associated with commuting construction workers could be MODERATE to LARGE. Transportation impacts during operation would be SMALL.		Transportation impacts associated with commuting construction workers could be MODERATE to LARGE. Transportation impacts during operation would be SMALL to MODERATE.
Aesthetics	SMALL	No exhaust stacks or cooling towers would be needed. Daytime visual impact could be mitigated by landscaping and appropriate color selection for buildings. Visual impact at night could be mitigated by reduced use of lighting and appropriate shielding. Noise impacts would be relatively small and could be mitigated.	SMALL to LARGE	Similar to impacts at Surry Power Station. Potential LARGE impact if a new transmission line is needed.
Historic and Archeological Resources	SMALL	Any potential impacts can likely be effectively managed.	SMALL	Any potential impacts can likely be effectively managed.
Environmental Justice	SMALL	Impacts on minority and low-income communities should be similar to those experienced by the population as a whole. Some impacts on housing may occur during construction.	MODERATE to LARGE	Impacts will vary depending on population distribution and makeup at the site. Impacts to minority and low-income residents of Surry County associated with closure of Surry Units 1 and 2 could be significant.

ecology. Impacts could include wildlife habitat loss, reduced productivity, habitat fragmentation, and a local reduction in biological diversity. Use of cooling water from a nearby surface water body could have adverse aquatic resource impacts. If needed, construction and maintenance of the transmission line would have ecological impacts. Overall, the ecological impacts at an alternate site would be MODERATE to LARGE.

- **Water Use and Quality**

  The staff assumed that a replacement nuclear plant alternative at the Surry Power Station would use the existing cooling system, which would minimize incremental water-use and quality impacts. Surface-water impacts are expected to remain SMALL; the impacts would be sufficiently minor so they would not noticeably alter any important attribute of the resource.

  The staff assumed that a new nuclear power plant located at the Surry Power Station would obtain potable, process, and fire-protection water from onsite groundwater wells similarly to the current practice for Units 1 and 2 (see Section 2.2.2). Some erosion and sedimentation would likely occur during construction as a result of land clearing.

  For alternate sites, the impact on the surface water would depend on the discharge volume and the characteristics of the receiving body of water. Intake from and discharge to any surface body of water would be regulated by the State. The impacts would be SMALL to MODERATE.

  A nuclear power plant sited at an alternate site may use groundwater. Groundwater withdrawal at an alternate site would likely require a permit. Groundwater withdrawal impacts would depend on availability and how the water is withdrawn, but overall are considered SMALL.

- **Air Quality**

  Construction of a new nuclear plant sited at the Surry Power Station or an alternate site would result in fugitive emissions during the construction process. Exhaust emissions would also come from vehicles and motorized equipment used during the construction process. An operating nuclear plant would have minor air emissions associated with diesel generators. These emissions would be regulated by the Virginia Department of Environmental Quality or another state. Overall, emissions and associated impacts are considered SMALL.

- **Waste**

  The waste impacts associated with operation of a nuclear power plant are set out in Table B-1 of 10 CFR Part 51, Subpart A, Appendix B. In addition to the impacts shown in Table B-1, construction-related debris would be generated during construction activities and removed to an appropriate disposal site. Overall, waste impacts are considered SMALL.

Siting the replacement nuclear power plant at a site other than the Surry Power Station would not alter waste generation. Therefore, the impacts would be SMALL.

- **Human Health**

  Human health impacts for an operating nuclear power plant are set out in 10 CFR Part 51, Subpart A, Appendix B, Table B-1. Overall, human health impacts are considered SMALL.

  Siting the replacement nuclear power plant at a site other than the Surry Power Station would not alter human health impacts. Therefore, the impacts would be SMALL.

- **Socioeconomics**

  The construction period and the peak workforce associated with construction of a new nuclear power plant are currently unquantified (NRC 1996). In the absence of quantified data, the staff assumed a construction period of 6 years and a peak workforce of 2500. The staff assumed that construction would take place while existing Units 1 and 2 continue operation and would be completed by the time Units 1 and 2 permanently cease operations. During construction, the communities surrounding the Surry Power Station site would experience demands on housing and public services that could have MODERATE to LARGE impacts. These impacts would be tempered by construction workers commuting to the site from more distant communities. After construction, the communities would be impacted by the loss of the construction jobs.

  The replacement nuclear units are assumed to have an operating workforce comparable to the 990 workers currently working at Units 1 and 2. The replacement nuclear units would provide a new tax base to offset the loss of tax base associated with decommissioning of Units 1 and 2. The appropriate characterization of nontransportation socioeconomic impacts for operating replacement nuclear units constructed at the Surry Power Station site would be SMALL.

  During the 6-year construction period, up to 2500 construction workers would be working at the Surry Power Station site in addition to the 990 workers at Units 1 and 2. The addition of the construction workers could place significant traffic loads on existing highways, particularly those leading to the Surry Power Station site. Such impacts would be MODERATE to LARGE. Transportation impacts related to commuting of plant operating personnel would be similar to current impacts associated with operation of Units 1 and 2 and are considered SMALL.

Construction of a replacement nuclear power plant at an alternate site would relocate some socioeconomic impacts, but would not eliminate them. Surry County and surrounding communities would experience the impact of Surry Units 1 and 2 operational job loss and the loss of tax base with potentially LARGE impacts given Surry County's heavy dependence on tax revenue from the Surry Power Station. The communities around the new site would have to absorb the impacts of a large, temporary workforce (up to 2500 workers at the peak of construction) and a permanent workforce of approximately 880 workers. In the GEIS (NRC 1996), the staff noted that socioeconomic impacts at a rural site would be larger than at an urban site because more of the peak construction workforce would need to move to the area to work. The Surry Power Station site is within commuting distance of a number of relatively large cities and, therefore, is not considered a rural site. Alternate sites would need to be analyzed on a case-by-case basis. Socioeconomic impacts at a rural site could be LARGE. Transportation-related impacts associated with commuting construction workers at an alternate site are site-dependent, but could be MODERATE to LARGE. Transportation impacts related to commuting of plant operating personnel would also be site-dependent, but can be characterized as SMALL to MODERATE.

- **Aesthetics**

  The containment buildings for a replacement nuclear power plant sited at the Surry Power Station and other associated buildings would likely be visible in daylight hours over many miles. Visual impacts could be mitigated by landscaping and selecting a color for buildings that is consistent with the environment. The visual impact could also be mitigated by below-grade construction similar to Surry Units 1 and 2. Visual impact at night could be mitigated by reduced use of lighting and appropriate use of shielding. No exhaust stacks would be needed. No cooling towers would be needed, assuming use of the existing once-through cooling system.

  Noise from operation of a replacement nuclear power plant would potentially be audible offsite in calm wind conditions or when the wind is blowing in the direction of the hearer. Mitigation measures, such as reduced or no use of outside loudspeakers, can be employed to reduce noise level and keep the impact SMALL.

  At an alternate site, there would be an aesthetic impact from the buildings. There would also be a significant aesthetic impact if a new transmission line were needed. Noise and light from the plant would be detectable offsite. The impact of noise and light would be mitigated if the plant is located in an industrial area adjacent to other power plants. Overall, the aesthetic impacts associated with locating at an alternative site can be categorized as

SMALL; however, the impact could be LARGE if a new transmission line is needed to connect the plant to the power grid.

- **Historic and Archaeological Resources**

  At both the Surry Power Station site and an alternate site, a cultural resource inventory would likely be needed for any onsite property that has not been previously surveyed. Other lands, if any, that are acquired to support the plant would also likely need an inventory of field cultural resources, identification and recording of existing historic and archaeological resources, and possible mitigation of adverse effects from subsequent ground-disturbing actions related to physical expansion of the plant site.

  Before construction at the Surry Power Station site or another site, studies would likely be needed to identify, evaluate, and address mitigation of the potential impacts of new plant construction on cultural resources. The studies would likely be needed for all areas of potential disturbance at the proposed plant site and along associated corridors where new construction would occur (e.g., roads, transmission corridors, rail lines, or other rights-of-way). Historic and archaeological resource impacts can generally be effectively managed and are considered SMALL.

- **Environmental Justice**

  No environmental pathways or locations have been identified that would result in disproportionately high and adverse environmental impacts on minority and low-income populations if a replacement nuclear plant were built at the Surry Power Station site. Some impacts on housing availability and prices during construction might occur, and this could disproportionately affect minority and low-income populations. After completion of construction, it is possible that the ability of local governments to maintain social services could be reduced at the same time as diminished economic conditions reduce employment prospects for minority and low-income populations. Overall, however, impacts are expected to be SMALL.

  Impacts at an alternate site would depend upon the site chosen and the nearby population distribution. If a replacement nuclear plant were constructed at an alternate site, Surry County would experience a significant loss of property tax revenue, which would affect the County's ability to provide services and programs. Impacts to minority and low-income populations in Surry County could be MODERATE to LARGE.

8.2.3.2 Closed-Cycle Cooling System

The environmental impacts of constructing a nuclear power plant at an alternate greenfield site using closed-cycle cooling with cooling towers are essentially the same as the impacts for a nuclear power plant using a once-through system. However, there are minor environmental differences between the closed-cycle and once-through cooling systems. Table 8-7 summarizes the incremental differences.

8.2.4 Purchased Electrical Power

If available, purchased power from other sources could potentially obviate the need to renew the Surry Units 1 and 2 OLs. VEPCo currently has purchase agreements for 145 MW from the Southeastern Power Administration and approximately 3500 MW of non-utility generation (VEPCo 2001). Overall, Virginia is a net importer of electricity.

To replace Surry Units 1 and 2 capacity with imported power, VEPCo would need to construct a new 500-kV transmission line, which VEPCo estimates would be approximately 160 km (100 mi) long (VEPCo 2001). Assuming a 0.09 km (300 ft) easement width, the transmission line would impact approximately 15 km^2 (6 mi^2).

Imported power from Canada or Mexico is unlikely to be available for replacement of Surry Power Station Units 1 and 2 capacity. In Canada, 62 percent of the country's electricity capacity is derived from renewable energy sources, principally hydropower (DOE/EIA 2001b). Canada has plans to continue developing hydroelectric power, but the plans generally do not include large-scale projects (DOE/EIA 2001b). Canada's nuclear generation is projected to increase by 1.7 percent by 2020, but its share of power generation in Canada is projected to decrease from 14 percent currently to 13 percent by 2020 (DOE/EIA 2001b). EIA projects that total gross U.S. imports of electricity from Canada and Mexico will gradually increase from 47.9 billion kWh in year 2000 to 66.1 billion kWh in year 2005, and then gradually decrease to 47.4 billion kWh in year 2020 (DOE/EIA 2001a). On balance, it is unlikely that electricity imported from Canada or Mexico would be able to replace the Surry Units 1 and 2 capacity.

If power to replace Surry Power Station Units 1 and 2 capacity were to be purchased from sources within the U.S. or a foreign country, the generating technology would likely be one of those described in this SEIS and in the GEIS (probably coal, natural gas, or nuclear). The description of the environmental impacts of other technologies in Chapter 8 of the GEIS is representative of the environmental impacts associated with the purchased electrical power alternative to renewal of the Surry Units 1 and 2 OLs. Under the purchased power alternative, the environmental impacts of imported power would still occur, but would be located elsewhere within the region, nation, or another country.

Table 8-7. Summary of Environmental Impacts of a New Nuclear Power Plant Sited at an Alternate Greenfield Site with Closed-Cycle Cooling

Impact Category	Change in Impacts from Once-Through Cooling System
Land Use	Required 10-12 additional ha (25-30 ac) for cooling towers and associated infrastructure.
Ecology	Impact would depend on ecology at the site. Additional impact to terrestrial ecology from cooling-tower drift. Reduced impact to aquatic ecology.
Surface Water Use and Quality	Discharge of cooling-tower blowdown containing dissolved solids. Discharge would be regulated by the State. Decreased water withdrawal and less thermal load on receiving body of water. Consumptive use of water due to evaporation from cooling towers.
Groundwater Use and Quality	No change
Air Quality	No change
Waste	No change
Human Health	No change
Socioeconomics	No change
Aesthetics	Introduction of cooling towers and associated plume. Natural draft towers could be up to 158 m (520 ft). Mechanical draft towers could be up to 30 m (100 ft) high and also have an associated noise impact.
Historic and Archaeological Resources	No change
Environmental Justice	No change

8.2.5 Other Alternatives

Other generation technologies are discussed in the following subsections.

8.2.5.1 Oil-Fired Generation

EIA projects that oil-fired plants will account for very little of the new generation capacity in the United States during the 2000 to 2020 time period because of higher fuel costs and lower efficiencies (DOE/EIA 2001a). Oil-fired operation is more expensive than nuclear or coal-fired operation. In addition, future increases in oil prices are expected to make oil-fired generation increasingly more expensive than coal-fired generation. The high cost of oil has prompted a steady decline in its use for electricity generation. Also, construction and operation of an oil-fired plant would have environmental impacts. For example, in Section 8.3.11 of the GEIS, the staff estimated that construction of a 1000-MWe oil-fired plant would require about 50 ha (120 ac) (NRC 1996). Additionally, operation of oil-fired plants would have environmental impacts (including impacts on the aquatic environment and air) that would be similar to those from a coal-fired plant.

8.2.5.2 Wind Power

Virginia is in a wind power Class 1 region (average wind speeds at 10-m (30-ft) elevation of 0 to 4.4 m/s [9.8 mph]). Class 1 has the lowest potential for wind energy generation (DOE 2001a). Wind turbines are economical in wind power Classes 4 through 7 (average wind speeds of 5.6 to 9.4 m/s [12.5 to 21.1 mph] [DOE 2001a]). The staff concludes that locating a wind-energy facility on or near the Surry Power Station site as a replacement for Surry Power Station generating capacity would not be economically feasible given the current state of wind energy generation technology. As of December 31, 2000, there were no grid-connected wind power plants in Virginia or North Carolina (NREL 2001).

8.2.5.3 Solar Power

Solar technologies use the sun's energy and light to provide heat and cooling, light, hot water, and electricity for homes, businesses, and industry. Solar power technologies (photovoltaic and thermal) cannot currently compete with conventional fossil-fueled technologies in grid-connected applications due to higher capital costs per kilowatt of capacity. The average capacity factor of photovoltaic cells is about 25 percent (NRC 1996), and the capacity factor for solar thermal systems is about 25 to 40 percent (NRC 1996). Energy storage requirements limit the use of solar-energy systems as baseload electricity supply.

There are substantial impacts to natural resources (wildlife habitat, land-use, and aesthetic impacts) from construction of solar-generating facilities. As stated in the GEIS, land requirements are high—14,000 ha (35,000 ac) per 1000 MW(e) for photovoltaic (NRC 1996) and approximately 6000 ha (14,000 ac) per 1000 MW(e) for solar thermal systems (NRC 1996). Neither type of solar electric system would fit at the Surry Power Station site, and both would have large environmental impacts at a greenfield site.

The Surry Power Station site receives approximately 4 kWh of direct normal solar radiation per square meter per day compared to 7 to 8 kWh of solar radiation per square meter per day in areas of the western U.S., such as California, which are most promising for solar technologies (DOE/EIA 2000a). Because of the natural resource impacts (land and ecological), the area's relatively low rate of solar radiation, and the high cost, solar power is not deemed a feasible baseload alternative to renewal of the Surry Power Station Units 1 and 2 OLs. Some onsite generated solar power, e.g., from rooftop photovoltaic applications, may substitute for electric power from the grid. Implementation of solar generation on a scale large enough to replace Surry Units 1 and 2 would likely result in LARGE environmental impacts.

8.2.5.4 Hydropower

Virginia has an estimated 617 MW of undeveloped hydroelectric resources (INEEL 1997). This amount is less than needed to replace the 1602 MW(e) capacity of Surry Units 1 and 2. As stated in Section 8.3.4 of the GEIS, hydropower's percentage of U.S. generating capacity is expected to decline because hydroelectric facilities have become difficult to site as a result of public concern about flooding, destruction of natural habitat, and alteration of natural river courses. In the GEIS, the staff estimated that land requirements for hydroelectric power are approximately 400,000 ha (1 million ac) per 1000 MW(e) (NRC 1996). Replacement of Surry Power Station Units 1 and 2 generating capacity would require flooding more than this amount of land. Due to the relatively low amount of undeveloped hydropower resource in Virginia and the large land-use and related environmental and ecological resource impacts associated with siting hydroelectric facilities large enough to replace Surry Units 1 and 2, the staff concludes that local hydropower is not a feasible alternative to renewal of the Surry Units 1 and 2 OLs. Any attempts to site hydroelectric facilities large enough to replace Surry Units 1 and 2 would result in LARGE environmental impacts.

8.2.5.5 Geothermal Energy

Geothermal energy has an average capacity factor of 90 percent and can be used for baseload power where available. However, geothermal technology is not widely used as baseload generation due to the limited geographical availability of the resource and immature status of the technology (NRC 1996). As illustrated by Figure 8-4 in the GEIS, geothermal plants are

most likely to be sited in the western continental U.S., Alaska, and Hawaii, where hydrothermal reservoirs are prevalent. There is no feasible eastern location for geothermal capacity to serve as an alternative to Surry Units 1 and 2. The staff concludes that geothermal energy is not a feasible alternative to renewal of the Surry Units 1 and 2 OLs.

8.2.5.6 Wood Waste

A wood-burning facility can provide baseload power and operate with an average annual capacity factor of around 70 to 80 percent and with 20 to 25 percent efficiency (NRC 1996). The fuels required are variable and site-specific. A significant barrier to the use of wood waste to generate electricity is the high delivered-fuel cost and high construction cost per MW of generating capacity. The larger wood-waste power plants are only 40 to 50 MW(e) in size. Estimates in the GEIS suggest that the overall level of construction impact per MW of installed capacity should be approximately the same as that for a coal-fired plant, although facilities using wood waste for fuel would be built at smaller scales (NRC 1996). Like coal-fired plants, wood-waste plants require large areas for fuel storage and processing and involve the same type of combustion equipment.

Due to uncertainties associated with obtaining sufficient wood and wood waste to fuel a base-load generating facility, ecological impacts of large-scale timber cutting (e.g., soil erosion and loss of wildlife habitat), and high inefficiency, the staff has determined that wood waste is not a feasible alternative to renewing the Surry Units 1 and 2 OLs.

8.2.5.7 Municipal Solid Waste

Municipal waste combustors incinerate the waste and use the resultant heat to generate steam, hot water, or electricity. The combustion process can reduce the volume of waste by up to 90 percent and the weight of the waste by up to 75 percent (EPA 2001). Municipal waste combustors use three basic types of technologies: mass burn, modular, and refuse-derived fuel (DOE/EIA 2001c). Mass-burning technologies are most commonly used in the U.S. This group of technologies process raw municipal solid waste “as is,” with little or no sizing, shredding, or separation before combustion. The initial capital costs for municipal solid-waste plants are greater than for comparable steam-turbine technology at wood-waste facilities. This is due to the need for specialized waste-separation and -handling equipment for municipal solid waste (NRC 1996).

Growth in the municipal waste combustion industry slowed dramatically during the 1990s after rapid growth during the 1980s. The slower growth was due to three primary factors: (1) the Tax Reform Act of 1986, which made capital-intensive projects such as municipal waste combustion facilities more expensive relative to less capital-intensive waste disposal

alternatives such as landfills; (2) the 1994 Supreme Court decision (*C&A Carbone v. Town of Clarkstown*), which struck down local flow control ordinances that required waste to be delivered to specific municipal waste combustion facilities rather than landfills that may have had lower fees; and (3) increasingly stringent environmental regulations that increased the capital cost necessary to construct and maintain municipal waste combustion facilities (DOE/EIA 2001c).

Municipal solid waste combustors generate an ash residue that is buried in landfills. The ash residue is composed of bottom ash and fly ash. Bottom ash refers to that portion of the unburned waste that falls to the bottom of the grate or furnace. Fly ash represents the small particles that rise from the furnace during the combustion process. Fly ash is generally removed from flue-gases using fabric filters and/or scrubbers (DOE/EIA 2001c).

Currently, there are approximately 102 waste-to-energy plants operating in the U.S. These plants generate approximately 2800 MW(e), or an average of approximately 28 MW(e) per plant (Integrated Waste Services Association 2001). The staff concludes that generating electricity from municipal solid waste would not be a feasible alternative to replace the 1602 MW(e) baseload capacity of Surry Units 1 and 2 and, consequently, would not be a feasible alternative to renewal of the Surry Units 1 and 2 OLs.

8.2.5.8 Other Biomass-Derived Fuels

In addition to wood and municipal solid waste fuels, there are several other concepts for fueling electric generators, including burning crops, converting crops to a liquid fuel such as ethanol, and gasifying crops (including wood waste). In the GEIS, the staff stated that none of these technologies has progressed to the point of being competitive on a large scale or of being reliable enough to replace a baseload plant such as Surry Units 1 and 2 (NRC 1996). For these reasons, such fuels do not offer a feasible alternative to renewal of the Surry Units 1 and 2 OLs.

8.2.5.9 Fuel Cells

Fuel cells work without combustion and its environmental side-effects. Power is produced electrochemically by passing a hydrogen-rich fuel over an anode and air over a cathode and separating the two by an electrolyte. The only by-products are heat, water, and carbon dioxide. Hydrogen fuel can come from a variety of hydrocarbon resources by subjecting them to steam under pressure. Phosphoric acid fuel cells are generally considered first-generation technology. Higher-temperature second-generation fuel cells achieve higher fuel-to-electricity and thermal efficiencies. The higher temperatures contribute to improved efficiencies and give the second-generation fuel cells the capability to generate steam for cogeneration and combined-cycle operations. DOE projects that by 2003, two second-generation fuel-cell

technologies using molten carbonate and solid oxide technology, respectively, will be commercially available in sizes up to 2 MW at a cost of $1000 to $1500 per kW of installed capacity (DOE 2001b). For comparison, the installed capacity cost for a natural gas-fired combined-cycle plant is approximately $456 per kW (DOE/EIA 2001a). As market acceptance and manufacturing capacity increase, natural gas-fueled fuel-cell plants in the 50- to 100-MW range are projected to become available (DOE 2001b). At the present time, however, fuel cells are not economically or technologically competitive with other alternatives for baseload electricity generation. Fuel cells are, consequently, not a feasible alternative to renewal of the Surry Units 1 and 2 OLs.

8.2.5.10 Delayed Retirement

The only VEPCo generating plants currently scheduled for retirement are Possum Point Units 1 and 2. These oil-fired units each have a nameplate generating capacity[(a)] of 69 MW (DOE/EIA 2000b). The Possum Point facility is located about 25 miles south of Washington, D.C. Delayed retirement of Possum Point Units 1 and 2 would not come close to replacing the 1602-MW(e) capacity of Surry Units 1 and 2. For this reason, delayed retirement of VEPCo generating units would not be a feasible alternative to renewal of the Surry Units 1 and 2 OLs.

8.2.5.11 Utility-Sponsored Conservation

VEPCo has developed residential, commercial, and industrial programs to reduce both peak demands and daily energy consumption. These programs are commonly referred to as demand-side management (DSM). VEPCo currently operates the following DSM programs: Rate Schedule SG (standby generation), Rate Schedule CS (curtailable service), Rider J (interruptible electric water heater service), and the Real Time Pricing Rate. VEPCo projects that by the year 2007, its DSM programs will reduce peak power requirements in the summer and winter by 74 and 130 MW, respectively (VEPCo 2001). VEPCo also projects that energy requirements in 2007 will be reduced by 14 gigawatt hours, 94 percent of which would be from load-management programs (VEPCo 2001).

Historic and projected reduction in generation needs as a result of DSM programs have been credited in VEPCo's planning to meet projected customer demand. Because these DSM savings are part of the long-range plan for meeting projected demand, they are not available offsets for Surry Units 1 and 2. Therefore, the conservation option is not considered a reasonable replacement for the OL renewal alternative.

(a) The nameplate generating capacity is the full-load continuous rating of a generating unit.

8.2.6 Combination of Alternatives

Even though individual alternatives to Surry Units 1 and 2 might not be sufficient to replace Surry Units 1 and 2 capacity due to the small size of the resource or lack of cost-effective opportunities, it is conceivable that a combination of alternatives might be cost-effective.

As discussed in Section 8.2, Surry Units 1 and 2 have a combined average net capacity of 1602 MW(e). For the coal and natural gas alternatives, VEPCo assumed three standard 508-MW(e) units as potential replacements for Surry Units 1 and 2 (VEPCo 2001). This approach is followed in this SEIS, although it results in some environmental impacts that are roughly 5 percent lower than if full replacement capacity were constructed.

There are many possible combinations of alternatives. Table 8-8 contains a summary of the environmental impacts of an assumed combination of alternatives consisting of 1016 MW(e) of combined cycle natural-gas-fired generation at Surry Power Station using the existing once-through cooling system and at an alternate greenfield location using closed-cycle cooling, 293 MW(e) purchased from other generators, and 293 MW(e) gained from additional DSM measures. The impacts associated with the combined cycle natural-gas-fired units are based on the gas-fired generation impact assumptions discussed in Section 8.2.2, adjusted for the reduced generating capacity. While the DSM measures would have few environmental impacts, operation of the new gas-fired plant would result in increased emissions and environmental impacts. The environmental impacts associated with power purchased from other generators would still occur, but would be located elsewhere within the region, nation, or another country, as discussed in Section 8.2.4. The environmental impacts associated with purchased power are not shown in Table 8-8. The staff concludes that it is very unlikely that the environmental impacts of any reasonable combination of generating and conservation options could be reduced to the level of impacts associated with renewal of the Surry Units 1 and 2 OLs.

8.3 Summary of Alternatives Considered

The environmental impacts of the proposed action, renewal of the OLs for Surry Units 1 and 2, are SMALL for all impact categories (except collective offsite radiological impacts from the fuel cycle and from high level waste and spent fuel disposal, for which a single significance level was not assigned). The following alternative actions were considered: no-action alternative (discussed in Section 8.1), new generation alternatives (from coal, natural gas, and nuclear discussed in Sections 8.2.1 through 8.2.3, respectively), purchased electrical power (discussed in Section 8.2.4), alternative technologies (discussed in Section 8.2.5), and the combination of alternatives (discussed in Section 8.2.6).

Table 8-8. Summary of Environmental Impacts for an Assumed Combination of Generating and Acquisition Alternatives

	Surry Power Station Site		Alternate Greenfield Site	
Impact Category	**Impact**	**Comments**	**Impact**	**Comments**
Land Use	MODERATE to LARGE	9 ha (23 ac) for powerblock, offices, roads, and parking areas. Additional impact of up to approximately 1200 ha (3000 ac) for construction of an underground gas pipeline.	MODERATE to LARGE	30 ha (74 ac) for power- block, offices, roads, and parking areas. Additional impact for construction of an underground natural gas pipeline and a transmission line.
Ecology	MODERATE to LARGE	Uses undeveloped areas at Surry Power Station site plus land for a new gas pipeline.	MODERATE to LARGE	Impact depends on location and ecology of the site, surface-water body used for intake and discharge, and transmission and pipeline routes; potential habitat loss and fragmentation; reduced productivity and biological diversity impact to terrestrial ecology from cooling tower drift.
Water Use and Quality	SMALL	Uses existing once-through cooling system	SMALL to MODERATE	Impact depends on volume of water withdrawal and discharge and characteristics of surface-water body. Discharge of cooling tower blowdown will have impacts. Consumptive use of water due to evaporation from cooling towers.
Air Quality	MODERATE	Sulfur oxides • 81 MT/yr (89 tons/yr) Nitrogen oxides • 306 MT/yr (337 tons/yr) Carbon monoxide • 402 MT/yr (443 tons/yr) PM_{10} particulates • 120 MT/yr (132 tons/yr) Some hazardous air pollutants	MODERATE	Same as siting at Surry Power Station
Waste	SMALL	The only significant waste would be spent SCR catalyst used for control of NO_x emissions.	SMALL	The only significant waste would be spent SCR catalyst used for control of NO_x emissions.
Human Health	SMALL	Impacts considered to be minor.	SMALL	Impacts considered to be minor.

Table 8-8. (contd)

	Surry Power Station Site		Alternate Greenfield Site	
Impact Category	**Impact**	**Comments**	**Impact**	**Comments**
Socioeconomics	MODERATE	During construction, impacts would be MODERATE. Up to 1200 additional workers during the peak of the 3-year construction period, followed by reduction from current Surry Units 1 and 2 workforce of 990 to approximately 100; tax base preserved. Impacts during operation would be SMALL. Transportation impacts associated with construction workers would be MODERATE.	MODERATE to LARGE	Construction impacts depend on location, but could be significant if location is in a rural area. Surry County would experience loss of tax base and employment with potentially LARGE impacts. Impacts during operation would be SMALL. Transportation impacts associated with construction workers would be MODERATE.
Aesthetics	MODERATE	MODERATE aesthetic impact due to impact of plant units and stacks on environmentally sensitive Colonial National Historical Park.	SMALL to LARGE	MODERATE impact from plant and stacks. Additional impact could be LARGE if a new transmission line is needed.
Historic and Archeological Resources	SMALL	Any potential impacts can likely be effectively managed.	SMALL	Any potential impacts can likely be effectively managed.
Environmental Justice	MODERATE	Impacts on minority and low-income communities should be similar to those experienced by the population as a whole. Some impacts on housing may occur during construction; loss of approximately 890 operating jobs at Surry Power Station could reduce employment prospects for minority and low-income populations.	MODERATE to LARGE	Impacts vary depending on population distribution and makeup at site. Surry County would lose significant property tax revenue, which could have MODERATE to LARGE impacts on minority and low-income populations.

The no-action alternative would result in decommissioning Surry Units 1 and 2 and would require replacing electrical generating capacity by (1) demand-side management and energy conservation, (2) power purchased from other electricity providers, (3) generating alternatives other than Surry Units 1 and 2, or (4) some combination of these options. For each of the new generation alternatives (coal, natural gas, and nuclear), the environmental impacts would not be less than the impacts of license renewal. For example, the land-disturbance impacts resulting from construction of any new facility would be greater than the impacts of continued operation of Surry Units 1 and 2. The impacts of purchased electrical power would still occur, but would occur elsewhere. Alternative technologies are not considered feasible at this time, and it is very unlikely that the environmental impacts of any reasonable combination of generation and conservation options could be reduced to the level of impacts associated with renewal of the OLs for Surry Units 1 and 2.

The staff concludes that the alternative actions, including the no-action alternative, may have environmental effects in at least some impact categories that reach MODERATE or LARGE significance.

8.4 References

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9.0 Summary and Conclusions

By letter dated May 29, 2001, the Virginia Electric and Power Company (VEPCo) submitted an application to the U.S. Nuclear Regulatory Commission (NRC) to renew the operating licenses (OLs) for Surry Power Station, Units 1 and 2, for an additional 20-year period (VEPCo 2001). If the OLs are renewed, State regulatory agencies and VEPCo will ultimately decide whether the plants will continue to operate based on factors such as the need for power or other matters within the State's jurisdiction or the purview of the owners. If the OLs are not renewed, then the plants must be shut down at or before the expiration of the current OLs, which expire on May 25, 2012, for Unit 1 and January 29, 2013, for Unit 2.

Section 102 of the National Environmental Policy Act (NEPA) (42 USC 4321) directs that an environmental impact statement (EIS) is required for major Federal actions that significantly affect the quality of the human environment. The NRC has implemented Section 102 of NEPA in 10 CFR Part 51, which identifies licensing and regulatory actions that require an EIS. In 10 CFR 51.20(b)(2), the Commission requires preparation of an EIS or a supplement to an EIS for renewal of a reactor OL; 10 CFR 51.95(c) states that the EIS prepared at the OL renewal stage will be a supplement to the *Generic Environmental Impact Statement for License Renewal of Nuclear Plant*s (GEIS), NUREG-1437, Volumes 1 and 2 (NRC 1996; 1999).[(a)]

Upon acceptance of the VEPCo application, the NRC began the environmental review process described in 10 CFR Part 51 for Surry Units 1 and 2 by publishing a notice of intent to prepare an EIS and conduct scoping (66 FR 42897 [NRC 2001]) on August 15, 2001. The staff visited the Surry Power Station in September 2001 and held public scoping meetings on September 19, 2001, in Surry County, Virginia. The staff reviewed the VEPCo Environmental Report for Surry Units 1 and 2 (ER; VEPCo 2001) and compared it to the GEIS, consulted with other agencies, and conducted an independent review of the issues following the guidance set forth in NUREG-1555, Supplement 1, the *Standard Review Plans for Environmental Reviews for Nuclear Power Plants, Supplement 1: Operating License Renewal* (NRC 2000). The staff also considered the public comments received during the scoping process for preparation of this Supplemental Environmental Impact Statement (SEIS) for Surry Units 1 and 2. The public comments received during the scoping process that were considered to be within the scope of the environmental review are provided in Appendix A, Part I, of this SEIS.

The staff prepared the draft SEIS, and on April 26, 2002, the U.S. Environmental Protection Agency (EPA) published an associated Notice of Availability in the *Federal Register* (67 FR 20763; EPA 2002). A 75-day comment period began on that date during which members of the public could comment on the preliminary results of the NRC staff's review.

(a) The GEIS was originally issued in 1996. Addendum 1 to the GEIS was issued in 1999. Hereafter, all references to the "GEIS" include the GEIS and its Addendum 1.

The staff held two public meetings in Surry, Virginia, on May 29, 2002, to describe the preliminary results of the NRC environmental review, answer questions, and provide members of the public with information to assist them in formulating comments on the draft SEIS. All comments received on the draft SEIS were considered by the staff in developing the final document and are presented in Appendix A, Part II, of this SEIS.

This SEIS includes the NRC staff's analysis in which the staff considers and weighs the environmental effects of the proposed action, the environmental impacts of alternatives to the proposed action, and mitigation measures available for reducing or avoiding adverse effects. It also includes the staff's recommendation regarding the proposed action.

The NRC has adopted the following statement of purpose and need for license renewal from the GEIS:

> The purpose and need for the proposed action (renewal of an operating license) is to provide an option that allows for power generation capability beyond the term of a current nuclear power plant operating license to meet future system generating needs, as such needs may be determined by State, utility, and, where authorized, Federal (other than NRC) decisionmakers.

The goal of the staff's environmental review, as defined in 10 CFR 51.95(c)(4) and the GEIS, is to determine

> ...whether or not the adverse environmental impacts of license renewal are so great that preserving the option of license renewal for energy planning decisionmakers would be unreasonable.

Both the statement of purpose and need and the evaluation criterion implicitly acknowledge that there are factors, in addition to license renewal, that will ultimately determine whether an existing nuclear power plant continues to operate beyond the period of the current OL.

NRC regulations [10 CFR 51.95(c)(2)] contain the following statement regarding the content of SEISs prepared at the license renewal stage:

> The supplemental environmental impact statement for license renewal is not required to include discussion of need for power or the economic costs and economic benefits of the proposed action or of alternatives to the proposed action except insofar as such benefits and costs are either essential for a determination regarding the inclusion of an alternative in the range of alternatives considered or relevant to mitigation. In addition, the supplemental environmental impact statement prepared at the license renewal stage

> need not discuss other issues not related to the environmental effects of the proposed action and the alternatives, or any aspect of the storage of spent fuel for the facility within the scope of the generic determination in § 51.23(a) and in accordance with § 51.23(b).[(a)]

The GEIS contains the results of a systematic evaluation of the consequences of renewing an OL and operating a nuclear power plant for an additional 20 years. It evaluates 92 environmental issues using the NRC's three-level standard of significance—SMALL, MODERATE, or LARGE—developed using the Council on Environmental Quality guidelines. The following definitions of the three significance levels are set forth in a footnote to Table B-1 of 10 CFR Part 51, Subpart A, Appendix B:

> SMALL – Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource.
>
> MODERATE – Environmental effects are sufficient to alter noticeably, but not to destabilize, important attributes of the resource.
>
> LARGE – Environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.

For 69 of the 92 issues considered in the GEIS, the analysis in the GEIS shows the following:

(1) The environmental impacts associated with the issue have been determined to apply either to all plants or, for some issues, to plants having a specific type of cooling system or other specified plant or site characteristic.

(2) A single significance level (i.e., SMALL, MODERATE, or LARGE) has been assigned to the impacts (except for collective offsite radiological impacts from the fuel cycle and from high level waste [HLW] and spent fuel disposal).

(3) Mitigation of adverse impacts associated with the issue has been considered in the analysis, and it has been determined that additional plant-specific mitigation measures are likely not to be sufficiently beneficial to warrant implementation.

These 69 issues were identified in the GEIS as Category 1 issues. In the absence of new and significant information, the staff relied on conclusions as amplified by supporting information in

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(a) The title of 10 CFR 51.23 is "Temporary storage of spent fuel after cessation of reactor operations-generic determination of no significant environmental impact."

the GEIS for issues designated Category 1 in Table B-1 of 10 CFR Part 51, Subpart A, Appendix B.

Of the 23 issues that do not meet the criteria set forth above, 21 are classified as Category 2 issues requiring analysis in a plant-specific supplement to the GEIS. The remaining two issues, environmental justice and chronic effects of electromagnetic fields, were not categorized. Environmental justice was not evaluated on a generic basis and must also be addressed in a plant-specific supplement to the GEIS. Information on the chronic effects of electromagnetic fields was not conclusive at the time the GEIS was prepared.

This SEIS documents the staff's evaluation of all 92 environmental issues considered in the GEIS. The staff considered the environmental impacts associated with alternatives to license renewal and compared the environmental impacts of license renewal and the alternatives. The alternatives to license renewal that were considered include the no-action alternative (not renewing the OLs for Surry Power Station, Units 1 and 2) and alternative methods of power generation. These alternatives were evaluated assuming that the replacement power generation plant is located at either the Surry Power Station site or some other unspecified location.

9.1 Environmental Impacts of the Proposed Action—License Renewal

VEPCo and the staff have established independent processes for identifying and evaluating the significance of any new information on the environmental impacts of license renewal. Neither VEPCo nor the staff has identified information that is both new and significant related to Category 1 issues that would call into question the conclusions in the GEIS. Similarly, neither VEPCo nor the staff has identified any new issue applicable to Surry Power Station, Units 1 and 2, that has a significant environmental impact. These determinations include the consideration of public comments. Therefore, the staff relies upon the conclusions of the GEIS for all Category 1 issues which are applicable to Surry Units 1 and 2.

VEPCo's license renewal application presents an analysis of the Category 2 issues that are applicable to Surry Units 1 and 2. The staff has reviewed the VEPCo analysis for each issue and has conducted an independent review of each issue. In addition, the staff has evaluated the two uncategorized issues, environmental justice and chronic effects from electromagnetic fields. Five Category 2 issues are not applicable because they are related to plant design features or site characteristics not found at Surry Power Station. Four Category 2 issues are not discussed in this SEIS because they are specifically related to refurbishment. VEPCo (VEPCo 2001) has stated that its evaluation of structures and components, as required by

10 CFR 54.21, did not identify any major plant refurbishment activities or modifications as necessary to support the continued operation of Surry Units 1 and 2, for the license renewal period. In addition, any replacement of components or additional inspection activities are within the bounds of normal plant component replacement and, therefore, are not expected to affect the environment outside of the bounds of the plant operations evaluated in the *Final Environmental Statement Related to Operation of Surry Power Station Unit 1* (AEC 1972a) and *Final Environmental Statement Related to Operation of Surry Power Station Unit 2* (AEC 1972b).

Twelve Category 2 issues related to operational impacts and postulated accidents during the renewal term, as well as environmental justice and chronic effects of electromagnetic fields, are discussed in detail in this SEIS. Five of the Category 2 issues and environmental justice apply to both refurbishment and to operation during the renewal term and are only discussed in this SEIS in relation to operation during the renewal term. For all 12 Category 2 issues and environmental justice, the staff concludes that the potential environmental effects are of SMALL significance in the context of the standards set forth in the GEIS. In addition, the staff determined that appropriate Federal health agencies have not reached a consensus on the existence of chronic adverse effects from electromagnetic fields. Therefore, no further evaluation of this issue is required. For severe accident mitigation alternatives (SAMAs), the staff concludes that a reasonable, comprehensive effort was made to identify and evaluate SAMAs. Based on its review of the SAMAs for Surry Units 1 and 2 and the plant improvements already made, the staff concludes that none of the candidate SAMAs are cost-beneficial.

Mitigation measures were considered for each Category 2 issue. Current measures to mitigate the environmental impacts of plant operation were found to be adequate, and no additional mitigation measures were deemed sufficiently beneficial to be warranted.

The following sections discuss unavoidable adverse impacts, irreversible or irretrievable commitments of resources, and the relationship between local short-term use of the environment and long-term productivity.

9.1.1 Unavoidable Adverse Impacts

An environmental review conducted at the license renewal stage differs from the review conducted in support of a construction permit because the plant is in existence at the license renewal stage and has operated for a number of years. As a result, adverse impacts associated with the initial construction have been avoided, have been mitigated, or have already occurred. The environmental impacts to be evaluated for license renewal are those associated with refurbishment and continued operation during the renewal term.

The adverse impacts of continued operation identified are considered to be of SMALL significance, and none warrants implementation of additional mitigation measures. The adverse impacts of likely alternatives if Surry Units 1 and 2 cease operation at or before the expiration of the current OLs will not be smaller than those associated with continued operation of these units, and they may be greater for some impact categories in some locations.

9.1.2 Irreversible or Irretrievable Resource Commitments

The commitment of resources related to construction and operation of Surry Units 1 and 2 during its current license period was made when the plant was built. The resource commitments to be considered in this SEIS are associated with continued operation of the plant for an additional 20 years. These resources include materials and equipment required for plant maintenance and operation, the nuclear fuel used by the reactors, and ultimately, permanent offsite storage space for the spent fuel assemblies.

The most significant resource commitments related to operation during the renewal term are the fuel and the permanent storage space. Surry Units 1 and 2 replace approximately one-third of the fuel assemblies in each of the two units during every refueling outage, which occurs on an 18-month cycle.

If Surry Units 1 and 2 cease operation on or before the expiration of the current OLs, the likely power generation alternatives will require a commitment of resources for construction of the replacement plants as well as for fuel to run the plants.

9.1.3 Short-Term Use Versus Long-Term Productivity

An initial balance between short-term use and long-term productivity of the environment at the Surry Power Station site was set when the plants were approved and construction began. That balance is now well established. Renewal of the OLs for Surry Units 1 and 2 and continued operation of the plants will not alter the existing balance, but may postpone the availability of the site for other uses. Denial of the application to renew the OLs will lead to shutdown of the plants and will alter the balance in a manner that depends on subsequent uses of the site. For example, the environmental consequences of turning the Surry Power Station site into a park or an industrial facility are quite different.

9.2 Relative Significance of the Environmental Impacts of License Renewal and Alternatives

The proposed action is renewal of the OLs for Surry Units 1 and 2. Chapter 2 describes the site, power plants, and interactions of the plant with the environment. As noted in Chapter 3, no refurbishment and no refurbishment impacts are expected at Surry Units 1 and 2. Chapters 4 through 7 discuss environmental issues associated with renewal of the OLs. Environmental issues associated with the no-action alternative and alternatives involving power generation and use reduction are discussed in Chapter 8.

The significance of the environmental impacts from the proposed action (approval of the application for renewal of the OLs), the no-action alternative (denial of the application), alternatives involving nuclear, coal, or gas generation of power at the Surry Units 1 and 2 an unspecified greenfield site, and a combination of alternatives are compared in Table 9-1.

Table 9-1 shows that the significance of the environmental effects of the proposed action are SMALL for all impact categories (except for collective offsite radiological impacts from the fuel cycle and from HLW and spent fuel disposal, for which a single significance level was not assigned [see Chapter 6]). The alternative actions, including the no-action alternative, may have environmental effects in at least some impact categories that reach MODERATE or LARGE significance.

9.3 Staff Conclusions and Recommendations

Based on (1) the analysis and findings in the GEIS (NRC 1996; 1999), (2) the ER submitted by VEPCo (VEPCo 2001), (3) consultation with Federal, State, and local agencies, (4) the staff's own independent review, and (5) the staff's consideration of public comments, the recommendation of the staff is that the Commission determine that the adverse environmental impacts of license renewal for Surry Units 1 and 2 are not so great that preserving the option of license renewal for energy planning decisionmakers would be unreasonable.

Table 9-1. Summary of Environmental Significance of License Renewal, the No-Action Alternative, and Alternative Methods of Generation

Impact Category	Proposed Action–License Renewal	No Action Alternative–Denial of Renewal	Coal-Fired Generation		Natural-Gas-Fired Generation		New Nuclear Generation		Combination of Alternatives	
			Surry Power Station	Greenfield Site[a]	Surry Power Station	Greenfield Site[a]	Surry Power Station	Greenfield Site[a]	Surry Power Station	Greenfield Site[a]
Land Use	SMALL	SMALL	MODERATE	MODERATE to LARGE	MODERATE to LARGE	MODERATE to LARGE	MODERATE	MODERATE to LARGE	MODERATE to LARGE	MODERATE to LARGE
Ecology	SMALL	SMALL	MODERATE to LARGE	MODERATE to LARGE	MODERATE to LARGE	MODERATE to LARGE	MODERATE	MODERATE to LARGE	MODERATE to LARGE	MODERATE to LARGE
Water Use and Quality	SMALL	SMALL	SMALL	SMALL to MODERATE	SMALL	SMALL to MODERATE	SMALL	SMALL to MODERATE	SMALL	SMALL to MODERATE
Air Quality	SMALL	SMALL	MODERATE	MODERATE	MODERATE	MODERATE	SMALL	SMALL	MODERATE	MODERATE
Waste	SMALL	SMALL	MODERATE	MODERATE	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL
Human Health[b]	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL
Socio-economics	SMALL	LARGE	SMALL to LARGE	SMALL to LARGE	MODERATE	MODERATE to LARGE	MODERATE to LARGE	MODERATE to LARGE	MODERATE	MODERATE to LARGE
Aesthetics	SMALL	SMALL	MODERATE to LARGE	MODERATE to LARGE	MODERATE	SMALL to LARGE	SMALL	SMALL to LARGE	MODERATE	SMALL to LARGE
Historic and Archaeo-logical Resources	SMALL	SMALL to MODERATE	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL
Environ-mental Justice	SMALL	MODERATE to LARGE	MODERATE	MODERATE to LARGE	MODERATE	MODERATE to LARGE	SMALL	MODERATE to LARGE	MODERATE	MODERATE to LARGE

(a) A greenfield site is assumed, for the purpose of bounding potential impacts, to be an undeveloped site with no previous construction.
(b) Excludes collective offsite radiological impacts from the fuel cycle and from HLW and spent-fuel disposal, for which single significance levels were not assigned. See Chapter 6 for details.

9.4 References

10 CFR Part 51. Code of Federal Regulations, *Title 10, Energy,* Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions."

10 CFR Part 54. Code of Federal Regulations, *Title 10, Energy,* Part 54, "Requirements for Renewal of Operating Licenses for Nuclear Power Plants."

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