2.4 Hydrologic Engineering

To ensure that one or more nuclear power plants can be safely operated on the applicant's proposed site and in accordance with the Nuclear Regulatory Commission's (NRC's) regulations, the NRC staff evaluates the hydrologic site characteristics of the proposed site. These site characteristics included the maximum flood elevation of surface water, associated static and dynamic characteristics, and the maximum elevation of groundwater. The characteristic ability of the site to attenuate a postulated accidental release of radiological material into surface water and groundwater before it reaches a receptor is also described.

The staff prepared Sections 2.4.1 through 2.4.14 of this safety evaluation report (SER) in accordance with the review procedures described in NUREG-0800, "Standard Review Plan [SRP] for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," using information presented in Section 2.4, "Hydrologic Engineering," of the V.C. Summer Nuclear Station (VCSNS) Units 2 and 3 combined license (COL) Final Safety Analysis Report (FSAR) Revision 2; the AP1000 Design Control Document (DCD), Revision 17; responses to staff requests for additional information (RAIs); and generally available reference materials (e.g., those cited in applicable sections of NUREG-0800).

The ultimate heat sink of the AP1000 design is the atmosphere. Therefore, hydrologic characteristics associated with conditions that would result in a loss of external water supply (e.g., low water, channel diversions) are not relevant for this particular design. Also, seismic design considerations of water supply structures are not relevant for this particular design. Therefore, Regulatory Guide (RG) 1.27, "Ultimate Heat Sink for Nuclear Power Plants," and RG 1.29, "Seismic Design Classification," were not a necessary part of the regulatory basis for this Section 2.4 review.

2.4.1 Hydrologic Description

2.4.1.1 Introduction

FSAR Section 2.4.1 of the VCSNS COL application described the site and all safety-related elevations, structures and systems from the standpoint of hydrologic considerations and provided a topographic map showing the proposed changes to grading and to natural drainage features.

Section 2.4.1 of this SER provides a review of the following specific areas: (1) interface of the plant with the hydrosphere including descriptions of site location, major hydrologic features in the site vicinity, surface water and groundwater characteristics, and the proposed water supply to the plant; (2) hydrologic causal mechanisms that may require special plant design bases or operating limitations with regard to floods and water supply requirements; (3) current and likely future surface and groundwater uses by the plant and water users in the vicinity of the site that may impact safety of the plant; (4) available spatial and temporal data relevant for the site review; (5) alternate conceptual models of the hydrology of the site that reasonably bound hydrologic conditions at the site; (6) potential effects of seismic and nonseismic data on the postulated design bases and how they relate to the hydrology in the vicinity of the site and the site region; and (7) any additional information requirements prescribed in the "Contents of Application" sections of the applicable subparts to Title 10 of the *Code of Federal Regulations* (10 CFR) Part 52.

Based on information in Section 2.5.2 of this SER, which discusses “Vibratory Ground Motion,” the staff determined that seismic events that could impact hydrology at the VCSNS site are not likely due to: 1) the distance of the site from active sources including the design earthquake (the Updated Charleston Seismic Zone), 2) the lack of site features resulting from previous seismic activity (i.e. liquefaction features), 3) the lack of capable seismic structures at or near the site, and 4) the hard rock lithology underlying the site. As a result, a detailed evaluation of item (6) above was not performed by the staff as part of this section.

2.4.1.2 <u>Summary of Application</u>

This section of the VCSNS COL FSAR describes the site and all safety-related elevations, structures and systems from the standpoint of hydrologic considerations and provides a topographic map showing the proposed changes to grading and to natural drainage features. The applicant addressed these issues as follows:

<u>AP1000 COL Information Item</u>

- VCS COL 2.4-1

In addition, this section addresses the following COL Information Item 2.4-1 (COL Action Item 2.6.1) identified in Section 2.4.1.1 of the DCD.

> Combined License applicants referencing the AP1000 certified design will describe major hydrologic features on or in the vicinity of the site including critical elevations of the nuclear island and access routes to the plant.

VCS COL 2.4-1 adds VCSNS COL FSAR Section 2.4.1 in its entirety.

2.4.1.3 <u>Regulatory Basis</u>

The acceptance criteria associated with the relevant requirements of the Commission regulations for the identification of floods and flood design considerations, and the associated acceptance criteria, are given in Section 2.4.1 of NUREG-0800.

The applicable regulatory requirements for identifying site location and description of the site hydrosphere are:

- 10 CFR Part 100, as it relates to identifying and evaluating hydrologic features of the site.

- 10 CFR 100.20(c), regarding requirements to consider physical site characteristics in site evaluations.

- 10 CFR 52.79(a)(1)(iii), as it relates to the hydrologic characteristics of the proposed site with appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area and with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

The related acceptance criteria are as follows:

- RG 1.59, "Design Basis Floods for Nuclear Power Plants," Revision 2, as supplemented by best current practices

- RG 1.102, "Flood Protection for Nuclear Power Plants," Revision 1

2.4.1.4 Technical Evaluation

The NRC staff reviewed Section 2.4.1 of the VCSNS COL FSAR and checked the referenced DCD to ensure that the combination of the DCD and the COL application represents the complete scope of information relating to this review topic.[1] The NRC staff's review confirmed that the information in the application and incorporated by reference addresses the required information relating to the site hydrological description. The results of the NRC staff's evaluation of the information incorporated by reference in the VCSNS COL application are documented in the "Final Safety Evaluation Report Related to Certification of the AP1000 Standard Design,"NUREG-1793 and its supplements.

The staff reviewed the information in the VCSNS COL FSAR:

AP1000 COL Information Item

- VCS COL 2.4-1

2.4.1.4.1 Site and Facilities

Information Submitted By the Applicant

The applicant stated in FSAR Section 2.4.1 that the VCSNS Units 2 and 3 site is located to the south of Monticello Reservoir on a hilltop about 1 mi east of the Broad River near Parr Shoals Dam. VCSNS Unit 1 is located and currently operating north of the proposed locations of Units 2 and 3 near the Monticello Reservoir (VCSNS COL FSAR Figure 2.4-201). The site grade elevation for the proposed units is 400 ft North American Vertical Datum, 1988 (NAVD88), which is equivalent to the AP1000 DCD plant floor elevation of 100 ft. (The applicant reported that 400 ft NAVD88 is equivalent to 400.7 ft National Geodetic Vertical Datum, 1929 (NGVD29)). VCSNS Units 2 and 3 will be located on a hilltop at about 150 ft above the normal pool elevation of Parr Reservoir/Broad River flood plain and 25 ft below the maximum operating pool elevation of Monticello Reservoir.

VCSNS COL FSAR Figure 1.1-201 is a site location map that depicts the spatial relationship between the major surface hydrologic features. A finer scale figure focusing on just the major surface hydrologic features is shown in FSAR Figure 2.4-202. The topography near VCSNS Units 2 and 3 is depicted in VCSNS COL FSAR Figure 1.1-202 and VCSNS COL FSAR Figure 2.4-201. The applicant stated that the VCSNS site is about 1 mile (mi) from Monticello Reservoir. The existing Unit 1 lies between Monticello Reservoir and the proposed Units 2 and 3 as shown on VCSNS COL FSAR Figure 2.4-202.

The applicant stated that all safety-related water to AP1000 units would be supplied by onsite engineered storage tanks. VCSNS Units 2 and 3 will draw makeup water from Monticello Reservoir at a maximum rate of 61,600 gallons per minute (gpm) for normal operations, a portion of which is consumptively used for evaporative cooling. Water is exchanged between Parr Reservoir and Monticello Reservoir though the Fairfield Pumped Storage Facility (FPSF).

NRC Staff's Technical Evaluation

Based on the staff's site audit and the review of United States Geological Survey (USGS) topographic maps, the staff confirmed the location and approximate elevations of the site and adjacent water features. The staff compared the information presented by the applicant in VCSNS COL FSAR Section 2.4.1 with publicly available maps and data regarding the VCSNS site and it surrounding region. The staff estimated that the site is located about 3.5 kilometers (km) (2.2 mi) northwest of Jenkinsville, South Carolina, 9.3 km (5.8 mi) east northeast from Pomaria, South Carolina, 5.3 km (3.3 mi) north of Peak, South Carolina, and about 225 km (140 mi) northwest from the Atlantic Ocean. The staff determined that the current land elevation at the site varies from 117 to 128 meters (m) (385 to 420 ft) NAVD88 (USGS National Map Viewer website). Based on the staff's evaluation of the AP1000 DCD in NUREG-1793, Section 22.5.6, "Post-72-Hour Actions and Equipment," the staff concurs with the applicant's determination that the plant is not dependent on the adjacent or the underlying hydrological environment for water as makeup for safety-related needs.

2.4.1.4.2 Overview of Hydrosphere

Information Submitted by the Applicant

The applicant described surface water bodies in the vicinity of the VCSNS Units 2 and 3 site, including descriptions of the Broad River Basin, Parr and Monticello Reservoirs and Mayo Creek, adjacent drainage basins, and surface water use.

NRC Staff's Technical Evaluation

The applicant stated that elevations reported in NAVD88 datum are 0.2 meters (m) (0.7 ft) less than when reported in NGVD29 datum.

Hydrological features of hydrologic relevance include the dikes and dams that confine Monticello Reservoir and Parr Reservoir. The staff relied on the description of these structures in the VCSNS COL FSAR. All dams that impound Frees Creek to form Monticello Reservoir have crest elevations of 132.3 m (434 ft) NGVD29. Parr Shoals Dam has a crest elevation of 81.1 m (266 ft) NGVD29 with an earth dike on the west side of the dam that has crest elevation of SI (272.1 ft) and concrete non-overflow section on the east with a crest elevation of 82.9 m (271.1 ft) NGVD29. The staff used this information in subsequent technical evaluation sections of this SER Section 2.4.

The staff conducted a site audit during the period of November 17-19, 2008. The staff toured the site and observed key hydrologic features including the Monticello Reservoir; the Parr Reservoir on the Broad River; the FPSF; the watersheds draining away from the proposed site; and the topography in the area at the site. The staff also observed an unnamed creek southwest of the VCSNS Unit 3 site and the Mayo Creek east of the VCSNS Units 2 and 3 site. Mayo Creek is a small creek that flows from east to west south of the Monticello Reservoir, the

VCSNS Unit 1 site, and the VCSNS Units 2 and 3 site. It drains into the Broad River downstream of the Parr Shoals Dam. The staff used their observations to understand the hydrologic setting and interfaces of the VCSNS Units 2 and 3 site with the environment.

No long-term continuous streamflow measurements are available for either the Mayo Creek or the unnamed creek. The staff requested additional information from the applicant regarding Mayo Creek in RAI 2.4.13-9 related to the calculation of the 100-year low annual mean flow using limited available data. The applicant responded to this RAI on October 8, 2009. The applicant described limited flow observations in the Mayo Creek. Five flow measurements were made between October 1984 and July 1986 with discharges ranging from 0.01 to 0.05 cubic meters per second (m^3/s) (0.36 to 1.70 cubic feet per second (cfs)). The technical evaluation of RAI 2.4.13-9 is in Section 2.4.13 of this SER.

2.4.1.4.3 Hydrosphere

An accurate description of the interface of the plant with the hydrosphere is needed by the staff in order to perform safety assessment of the plant's structures, systems, and components (SSC) and to consider the effects of any accidental release of radioactive effluent on public health and safety. The staff reviewed the information provided by the applicant in FSAR Section 2.4.1. The staff's independent review and determinations regarding the hydrosphere are described below.

The plant water demands are described in Section 3.3 of the Environmental Report (ER) of the application.

2.4.1.4.3.1 Rivers and Streams

Information Submitted by the Applicant

The applicant described the Broad River above the VCSNS site. The Broad River and its watershed (above the proposed VCSNS Units 2 and 3) are shown in VCSNS COL FSAR Figure 2.4-204. The watershed above the site was estimated to have an area of 4,750 square miles (sq mi). The headwaters of the Broad River extend into North Carolina. The applicant reported that the average annual precipitation in the watershed is about 45 inches (in) and the average annual runoff is about 17.8 in. USGS streamflow gauges downstream from the site are at Alston (USGS Gauge 02161000) and Richtex (USGS Gauge 02161500). The closest upstream USGS stream flow gauge is at Carlisle (USGS Gauge 02156500). The locations of the stations are shown in VCSNS COL FSAR Figure 2.4-204. The applicant summarized the streamflow data from these stations in FSAR Section 2.4.1.2.1. The period of record for these stations included data from 1896 to 2005; of which streamflow data was available 41 to 60 years for these stations during the period of record. The applicant synthesized the flow records to obtain a longer and continuous record of flow characterized as being representative of flow in the Broad River near the VCSNS site. The applicant used the flows at Alston to characterize streamflow because this station is closest to the VCSNS Units 2 and 3 site.

NRC Staff's Technical Evaluation

The Broad River flows southward about one mile west of the site. The staff identified the USGS streamflow gage upstream from the site at Carlisle (USGS Gage 02156500) and two gages downstream from the site at Richtex and Alston (USGS Gages 02161500 and 02161000, respectively). The staff evaluated the streamflow at these stations to characterize the flow in the Broad River adjacent to the VCSNS Units 2 and 3 site.

The staff examined the USGS streamflow summary for Carlisle (02156500) using the USGS Water Data Report 2009. The USGS report included: (1) the location of the Carlisle gage; (2) the drainage area above this gage, which is 7226 sq km (2,790 sq mi); and (3) the daily water discharges for October 1938 to present. The lowest, mean, and highest annual mean flow for years 1939 to 2009 were 34.6, 107.0, and 169.3 m^3/s, respectively (1,221, 3,780 and 5,977 cfs). Annual runoff during this period was 46.7 centimeters (cm) (18.4 in). Ten percent of the flow exceeded 185.2 m^3/s (6,540 cfs), 50 percent exceeded 78.2 m^3/s (2,760 cfs), and 90 percent exceeded 33.7 m^3/s (1,190 cfs) over this period. (USGS, 2009).

The staff examined the USGS streamflow summary for Alston (02161000, HUC 03050106) using the USGS Water Data Report 2009. The USGS report included: (1) the location of the Alston gage; (2) the drainage area above this gage, which is 12,406 sq km (4,790 sq mi); and (3) the daily water discharges for October 1896 to 1907 and October 1980 to present. USGS reported that records from 1897 to 1908 water years were of low quality. The lowest, mean, and highest annual mean flow for years 1981 to 2009 were (50.5, 150.5, 273.2 m^3/s, respectively (1,782, 5,316 and 9,649 cfs). Annual runoff during this period was 38.4 cm (15.1 in). Ten percent of the flow exceeds 300.2 m^3/s (10,600 cfs), 50 percent exceed 101.7 m^3/s (3,590 cfs), and 90 percent exceed 34.3 m^3/s (1,210 cfs) over this period. (USGS, 2009).

The staff examined the USGS streamflow summary for Richtex (02161500) using information made available by the USGS. The USGS report included: (1) the location of the Alston gage in Fairfield County at Latitude 34 11 05 and 81 11 48 NAD27; (2) the drainage area above this gage, which is 12,561 sq km (4,850 sq mi); and (3) the daily water discharges for October 1925 to 1983. The lowest, mean, and highest annual mean flow for years 1925 to 1983 were 96.4, 174.4, and 265.8 m^3/s (3,403, 6,158 and 6,158 cfs). Ten percent of the flow exceeds 320.0 m^3/sec (11,300 cfs), 50 percent exceed SI 120.3 m^3/s (4,250 cfs), and 90 percent exceed 53.5 m^3/s (1,890 cfs) over this period (USGS, 2004).

2.4.1.4.3.2 Lakes and Reservoirs

Information Submitted by the Applicant

The applicant described the Monticello Reservoir as having a watershed area of 17.4 mi^2 and created by the construction of four dams, which drown Frees Creek. The crest elevation of all four dams is 434 ft NGVD29. The reservoir has a storage volume of 400,000 acre-feet and surface area of 6,800 acres at the normal maximum pool elevation of 425.0 ft NGVD29. The surface area is reduced to 6,500 acres when the pool elevation is 420.5 ft NVGD29. This represents a change in 29,000 acre-feet of storage which is the maximum daily withdrawal for power generating purposes.

The applicant stated that the Parr Reservoir was formed by the construction in 1914 of Parr Shoals Dam on the Broad River. The reservoir has a normal pool volume of 29,000 acre-feet. Normal pool elevation of the Parr Shoals Dam is 266 ft NGVD29. The Parr Shoals Dam is composed of concrete and earthen sections with the non-overflow sections with crest elevation 272.1 ft NVGD29 and 271.1 ft NGVD29 on the west and east respectively. The Parr Shoals

Dam has a top-of-gate elevation of 266 ft NGVD29. Parr Reservoir receives inflow from the Broad River and from Monticello Reservoir via the FPSF. The dam has a surface area of about 4,400 acres and 29,000 acre-feet of usable storage at this top-of-gate elevation. At minimum pool elevation (256 ft NGVD29), the reservoir surface area is 1,400 acres and has a non-usable storage of 2,500 acre-feet.

The applicant described several reservoirs on the Broad River, both upstream and downstream of the VCSNS Units 2 and 3 site. The applicant reported the properties of these reservoirs in VCSNS COL FSAR Table 2.4-204 and their locations are shown in VCSNS COL FSAR Figure 2.4-207.

The applicant identified a future possible impoundment within the Broad River called Clinchfield Dam. The dam would be located in the upper reaches of the Broad River about 100 mi upstream of VCSNS as shown on FSAR Figure 2.4-208. The dam feasibility study was completed in 1969 by the U.S. Army Corps of Engineers (USACE). No further plans to build Clinchfield Dam were found by the applicant.

NRC Staff's Technical Evaluation

The staff relied on information provided by the applicant in the FSAR regarding the details of operation of the FPSF and the Monticello and Parr Reservoirs. The FPSF is used to exchange water between these two reservoirs under the Federal Energy Regulatory Commission (FERC) project 1894 (Dam Safety Analysis for FPSF) as described in VCSNS COL FSAR Section 2.4.1.2.2.

The Parr Reservoir is used to for hydropower generation. The staff's review of the Parr Reservoir is needed due to its proximity to the VCSNS Units 2 and 3 site and because the Parr Reservoir would impound water if upstream dams or storm events led to flooding in the Broad River. The Parr Reservoir will be further analyzed in subsequent sections of this SER Section 2.4.

The Monticello Reservoir is used as a source of cooling water for VCSNS Unit 1 and is proposed by the applicant as the source of the cooling water for VCSNS Units 2 and 3. The Monticello Reservoir is also used to store water for hydropower generation. The staff's review of the Monticello Reservoir is needed due to its proximity to the VCSNS Units 2 and 3 site and because it is operated with pool elevations that exceed the site grade elevation of the proposed units. The Monticello Reservoir will be further analyzed in subsequent sections of this SER Section 2.4.

2.4.1.4.3.3 Surface Water Users

Information Submitted by the Applicant

The applicant describes, using 2005 data received by the South Carolina Department of Health and Environmental Control (SCDHEC), the surface water users downstream from the VCSNS Units 2 and 3 site. The locations of these users are shown in VCSNS COL FSAR Figure 2.4-209. The nearest downstream user is the Columbia Canal Water Plant located 28 mi downstream of VCSNS Units 2 and 3.

NRC Staff's Technical Evaluation

Surface water use is described in the draft NRC ER for VCSNS Units 2 and 3. In the review of downstream water used, the staff identified the city of Columbia as the closest downstream large user of surface water. Other identified downstream surface water users were the town of Winnsboro, the city of Newberry, and the town of Whitmire. VCSNS Unit 1 and the Parr Shoal Dam are the other reported users.

2.4.1.4.3.4 Groundwater Users

Information Submitted by the Applicant

The applicant identified 16 public groundwater supply wells with 6 miles of the VCSNS site in the FSAR. The applicant noted that 15 of these wells are located on the opposite sides of either Parr or Monticello Reservoir from the Units 2 and 3 site. The remaining well is located near Parr Hydro. The applicant stated that no local groundwater is planned for use for the operation of VCSNS Units 2 and 3 and the nearest that water supply well could be placed to the site was about 0.75 mi.

NRC Staff's Technical Evaluation

The NRC staff relied on the information supplied in Section 2.3.2.2 of the VCSNS Draft Environmental Impact Statement (DEIS) for identification of local groundwater use.
Table 2.3-26 of the VCSNS ER summarizes groundwater use for counties within an 80.5 km (50 mi) radius of the VCSNS site in 2004. Public water-supply wells within 9.7 km (6 mi) of the VCSNS site are listed in VCSNS COL FSAR Table 2.4-215 based on the SCDHEC database and Environmental Protection Agency's (EPA's) Safe Drinking Water Information System (SDWIS) database for population served. The table lists 14 active public water-supply wells in the area screened in the Piedmont physiographic province bedrock aquifer. The ER states that "the nearest large groups of wells are located approximately 1.5 mi east of the site along SC 215 and in Jenkinsville approximately 2.5 miles southeast of the site" which serve "private residences and stores" (SCE&G 2009a). The ER also lists the Jenkinsville Water Company that has nine wells, three wells within 3.2 km (2 mi) of the VCSNS site.

2.4.1.5 Post Combined License Activities

There are no post-COL activities related to this section.

2.4.1.6 Conclusion

The staff reviewed the application and confirmed that the applicant has demonstrated that the characteristics of the site fall within the site parameters specified in the design certification (DC) rule, and that no outstanding information is expected to be addressed in the VCSNS COL FSAR related to this section.

As set forth above, the applicant has presented and substantiated information to establish the site description. The staff has reviewed the information provided and, for the reasons given above, concludes that the applicant has provided sufficient details about the site description to allow the staff to evaluate, as documented in Section 2.4.1 of this SER, whether the applicant has met the relevant requirements of 10 CFR Part 52.79(a)(1)(iii) and 10 CFR Part 100 with respect to determining the acceptability of the site. This addresses COL Information Item 2.4-1. In conclusion, the applicant has provided sufficient information for satisfying 10 CFR Part 52 and 10 CFR Part 100.

2.4.2 Floods

2.4.2.1 Introduction

FSAR Section 2.4.2 of the VCSNS COL application discusses the historical flooding at the proposed site or in the region of the site. The information summarizes and identifies the individual types of flood-producing phenomena, and combinations of flood-producing phenomena, considered in establishing the flood design bases for safety-related plant features. The discussion also covers the potential effects of local intense precipitation.

Section 2.4.2 of this SER provides a review of the following specific areas: (1) local flooding on the site and drainage design; (2) stream flooding; (3) surges; (4) seiches; (5) tsunami; (6) dam failures; (7) flooding caused by landslides; (8) effects of ice formation on water bodies; (9) combined event criteria; (10) other site-related evaluation criteria; and (11) any additional information requirements prescribed in the "Contents of Application" sections of the applicable subparts to 10 CFR Part 52.

2.4.2.2 Summary of Application

This section of the VCSNS COL FSAR addresses information on site-specific flooding. The applicant addressed the information as follows:

AP1000 COL Information Item

- VCS COL 2.4-2

In addition, this section addresses the following COL Information Item 2.4-2 (COL Action Item 2.4.1-2) identified in Section 2.4.1.2 of the DCD.

> Combined License applicants referencing the AP1000 design will address the following site specific information on historical flooding and potential flooding factors, including the effects of local intense precipitation.
>
> - Probable Maximum Flood on Streams and Rivers – Site-specific information that will be used to determine design basis flooding at the site. This information will include the probable maximum flood on streams and rivers.
> - Dam Failures – Site specific information on potential dam failures.
> - Probable Maximum Surge and Seiche Flooding – Site-specific information on probable maximum surge and seiche flooding.
> - Probable Maximum Tsunami Loading – Site-specific information on probable maximum tsunami loading.

- Flood Protection Requirements – Site-specific information on flood protection requirements or verification that flood protection is not required to meet the site parameter of flood level.

No further action is required for sites within the bounds of the site parameter for flood level.

VCS COL 2.4-2 adds VCSNS COL FSAR Section 2.4.2 in its entirety.

This section of the SER relates to the historical flooding and local intense precipitation part of COL Information Item 2.4-2.

2.4.2.3 Regulatory Basis

The acceptance criteria associated with the relevant requirements of the Commission regulations for the identification of floods and flood design considerations are given in Section 2.4.2 of NUREG-0800.

The applicable regulatory requirements for identifying floods are:

- 10 CFR Part 100, as it relates to identifying and evaluating hydrological features of the site. The requirement to consider physical site characteristics in site evaluations is specified in 10 CFR 100.20(c).

- 10 CFR 52.79(a)(1)(iii), as it relates to the hydrologic characteristics of the proposed site with appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area and with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

The related acceptance criteria are as follows:

- RG 1.59, Revision 2, as supplemented by best current practices
- RG 1.102, Revision 1

2.4.2.4 Technical Evaluation

The NRC staff reviewed Section 2.4.2 of the VCSNS COL FSAR and checked the referenced DCD to ensure that the combination of the DCD and the COL application represents the complete scope of information relating to this review topic.[1] The NRC staff's review confirmed that the information in the application and incorporated by reference addresses the required information relating to the site-specific flooding description. The results of the NRC staff's evaluation of the information incorporated by reference in the VCSNS COL application are documented in NUREG-1793 and its supplements.

The staff reviewed the information in the VCSNS COL FSAR:

AP1000 COL Information Item

- VCS COL 2.4-2

2.4.2.4.1 Flood History

Information Provided by Applicant

The applicant stated that flooding near the VCSNS site from natural events can be caused by flooding in the Broad River, local intense precipitation, and dam and levee breaches.

The applicant stated that examination of the historical streamflow records at Alston and Richtex indicated a Broad River flood season in the spring and another in the fall. The floods in the fall were associated with hurricanes. Fall floods tended to be larger than spring floods. The applicant provided a table of the historical high flows and water elevations at Richtex. The largest observed flow at Richtex was 228,000 cfs on October 3, 1929. The water elevation of 215.5 ft NGVD29 at Richtex was observed on this date. The applicant estimated the flow and water elevation at the Parr Shoals Dam on this date to be 223,299 cfs and 266.2 ft NGVD29. These estimates assumed that the Parr Shoals Dam was operated in a manner consistent with the requirements for high flow conditions. The applicant stated that flood flow observations since 1977 may have been impacted by the operation of the FPSF.

The applicant stated that the Monticello Reservoir, an off-stream pond, has a historical pool elevation range of 420.5 to 425.0 ft NGVD29. The pool elevation in the Monticello Reservoir is controlled by the FPSF. Natural runoff into the Monticello Reservoir is limited due to the small watershed area.

NRC Staff's Technical Evaluation

The staff reviewed the data presented by the applicant in the VCSNS COL FSAR Section 2.4.2 regarding historical flooding. The staff independently obtained annual peak flow data for the Aston and Richtex USGS streamflow gauges. The historical peak flow data for the two gauges is plotted in SER Figures 2.4-1 and 2.4-2.

Based on this data, staff determined that the maximum historical annual peak discharges at the Aston and Richtex USGS gauges were 140,000 cfs and 228,000 cfs and occurred on June 7, 1903 and October 3, 1929, respectively. These discharge values were estimated based on recorded stages at each gauging station where the stages were 240.2 ft and

214.8 ft NAVD88 respectively. The ten highest peak discharge and water levels for Alston, Richtex and Carlisle are presented below.

Ten highest water levels recorded at the Alston USGS gauge 02161000

Water Year	Date	Peak Discharge (cfs)	Water Level (ft, NAVD88)
1903	Jun. 07, 1903	140,000	240.2
1991	Oct. 14, 1990	119,000	238.2
1987	Mar. 03, 1987	108,000	237.1
1995	Aug. 30, 1995	99,100	236.1
1901	May. 23, 1901	106,000	236.0
1902	Dec. 31, 1901	105,000	235.9
2003	Mar. 22, 2003	96,600	235.9
2004	Sep. 10, 2004	93,600	235.6
1900	Apr. 22, 1900	95,100	234.6
1990	Oct. 03, 1989	79,500	233.9

Ten highest water levels recorded at the Richtex USGS gauge 02161500

Water Year	Date	Peak Discharge (cfs)	Water Level (ft, NAVD88)
1930	Oct. 03, 1929	228,000	214.8
1928	Aug. 17, 1928	222,000	214.2
1936	Apr. 08, 1936	157,000	209.1
1977	Oct. 11, 1976	146,000	207.8
1940	Aug. 16, 1940	120,000	205.2
1933	Oct. 18, 1932	101,000	203.9
1965	Oct. 18, 1964	102,000	203.4
1964	Apr. 09, 1964	99,500	203.1
1945	Sep. 19, 1945	96,600	202.8
1949	Nov. 30, 1948	95,700	202.7

Ten highest water levels recorded at the Carlisle USGS gauge 02156500

Water Year	Date	Peak Discharge (cfs)	Water Level (ft, NAVD88)
1977	Oct. 10, 1976	123,000	321.6
1940	Aug. 15, 1940	103,000	319.5
1991	Oct. 14, 1990	78,200	316.7
1965	Oct. 18, 1964	79,900	315.9
1987	Mar. 02, 1987	72,100	315.9
1945	Sep. 19, 1945	78,500	315.8
2004	Sep. 10, 2004	71,200	315.4
2003	Mar. 21, 2003	69,400	315.1
1995	Jan. 16, 1995	65,800	314.5
1964	Apr. 08, 1964	69,500	314.0

2.4.2.4.2 Flood Design Considerations

Information Submitted by Applicant

The applicant stated that the design-basis flood elevation at the VCSNS site was determined from several scenarios, including the effects of local intense precipitation, probable maximum flood (PMF) on streams and rivers, potential dam failures, and ice effects. These flood scenarios are described in their respective VCSNS COL FSAR sections. Combinations of appropriate conditions with flooding scenarios, such as wind-generated waves, were considered.

The maximum flood water surface elevation at the VCSNS site was estimated from the effects of local intense precipitation and was determined to be the design-basis flood elevation at the site. The design-basis flood elevation of 399.4 ft NAVD88 is below ground-floor elevation of safety-related SSC at the VCSNS site.

NRC Staff's Technical Evaluation

The staff reviewed the description of flooding mechanisms provided by the applicant in VCSNS COL FSAR Sections 2.4.2, "Floods," 2.4.3,"PMF [Probable Maximum Flood] on Streams and Rivers," 2.4.4,"Potential Dam Failures," 2.4.5, "Probable Maximum Surge and Seiche Flooding," 2.4.6, "Probable Maximum Tsunami Hazards," and 2.4.7, "Ice Effects." The staff's review of these individual flooding mechanisms and their flooding potential is described in detail in the associated sections of the SER. The staff determined that the design basis flood is the flooding from local intense precipitation that is discussed in the following section.

2.4.2.4.3 Effects of Local Intense Precipitation

Information Submitted by the Applicant

Probable Maximum Precipitation (PMP) Depths

The applicant stated the design-basis for local intense precipitation is the all-season, 1-mi^2, PMP, which was obtained from the U.S. National Weather Service (NWS) Hydro-meteorological Reports (HMR) No. 51 and 52 (Schreiner L.C. and J.T. Riedel, 1978 and Hansen et al., 1982). The values of PMP depths presented in VCSNS COL FSAR Table 2.4.2-207 are reproduced below.

Local Intense precipitation at the VCSNS Units 2 and 3 site
(adapted from FSAR Table 2.4.2-207)

Duration	PMP Depth cm(in)
5 minutes	15.7 (6.2)
15 minutes	24.6 (9.7)
30 minutes	35.8(14.1)
1 hour	48.3 (19.0)
6 hours	77.2 (30.4)

Local Drainage Components and Subbasins

The applicant divided the VCSNS Units 2 and 3 into four discrete subbasins, each of which has one or more distinct drainage outlets as shown in VCSNS COL FSAR Figure 2.4-210. Subbasin 1 covers the western part of the site including Unit 3. Subbasin 2 covers the eastern part of the site including Unit 2. Subbasin 3 covers the northern part of the site, including the parking lot. Subbasin 4 covers the southern part of the site including the cooling tower pad. Two additional drainage areas (i.e., Subbasin A to the east and Subbasin B to the north), located outside the main plant site area, may contribute runoff to the adjoining Subbasin 2 during an extreme storm event such as the PMP. For simplicity, the applicant assumed that during the PMP event, the entire runoff from Subbasin A flows into Subbasin 2 and that the culvert under the railroad to the south is blocked as in accordance with American National Standards Institute (ANSI)/American Nuclear Society (ANS) 2.8-1992. The runoff from Subbasin B may be blocked by the road coming out of the site and going towards the north so that it does not contribute to Subbasin 2. The applicant stated that only Subbasins 1, 2 and 3 cover areas near safety-related structures.

Peak Discharges

The applicant stated that PMP peak discharges were computed using the Rational Method for each of four subbasins. Subbasin 1 drains the southern portion of the site, Subbasin 2 drains the northern section of the site, Subbasin 3 drains the western portion of the site, and Subbasin 4 drains the eastern portion of the site. Subbasin 4 lies to the east of the safety related structures. The applicant estimated peak runoff flows for Subbasins 1 to 4 were 56.5, 128.7, 53.3, 135.8 m^3/s(1996, 4546, 1883 and 4796 cfs), respectively.

Hydraulic Model Setup

The applicant delineated discharge channels and divided each into 5 to 15 cross-sections having the peak discharges at each cross-section in each of the four subbasins. The applicant assumed critical depth at the reach outlets. The applicant assumed the Manning's n equal to 0.04 and contraction/expansion coefficient equal to 0.1/0.3. The input parameters used by the applicant for the HEC model were provided electronically in a letter dated January 4, 2010 in response to a verbal request for additional information (RAI tracking number 2.4.13-13).

Flood Elevations

The applicant stated that the highest estimated water surface elevation at the site was less than the proposed site grade of 121.92 m (400 ft) NAVD88. The maximum water surface elevation for each case was 121.86 m (399.8 ft) NAVD88. The highest water surface elevation near safety-related structures (Subbasins 1, 2 and 3) was 121.74 m (399.4 ft) NAVD88.

An accurate description of flooding mechanisms and combinations of these is required for staff to perform its safety assessment. The staff reviewed the description of flooding mechanisms provided by the applicant in VCSNS COL FSAR Section 2.4.2. The staff's review of these individual flooding mechanisms and their flooding potential is described in appropriate sections of the SER Section 2.4.

NRC Staff's Technical Evaluation

Probable Maximum Precipitation Depths

The staff reviewed the description of the local PMP performed by the applicant. The staff determined that the method used by the applicant is acceptable as this method is recommended in NUREG-0800 Section 2.4.2. The staff performed an independent estimation of the local PMP from HMR 51 and 52 and obtained values comparable to the values presented by the applicant in VCSNS COL FSAR Section 2.4.2. The staff agrees with the applicant-estimated local PMP depths.

Local Drainage Components and Subbasins

Staff verbally requested additional information (RAI 2.4.13-13) from the applicant related to obtaining the HEC-RAS cross-sections, the rationale for characterization of flow paths, and a description of the 121.92 m (400 ft) NAVD88 elevation contour at the VCSNS Units 2 and 3 site. The applicant provided a response on January 4, 2010, which:

- Provided an electronic file of the cross-section geometry data and locations of the channel cross-sections used in the HEC-RAS hydraulic models.

- Clarified that the VCSNS site is divided into north and south sides by an owner-controlled railroad line, which follows the crest of the site and runs from west to east across the site at an elevation of 400 feet. No runoff crosses the railroad, which acts as a watershed divide. The VCSNS Units 2 and 3 site area has been divided into four subbasins. Subbasin 2 drains into Storm Water Basin 1, which is located in the north-central part of this subbasin. Storm Water Basin 1 drains off the project site to the north. Subbasin 4 drains into Storm Water Basin 3, which is located in the southeastern Part of this subbasin. Storm Water Basin 3 drains off the project site to the southeast. Specifically, Subbasins 2 and 4 are located on opposite sides of the site drainage divide defined by the railroad embankment and the 400-ft contour. Therefore, since Subbasins 2 and 4 drain in different directions via different routes, it is not appropriate to combine their runoff at any of the drainage outlets or storm water basins.

- Clarified that the 400-ft elevation contour appears in several locations on the VCSNS Units 2 and 3 site. It encloses an area at the southwest end of the site, to the west of the cooling towers, south of the railroad, a narrow area along the cooling tower access road, and borders a part of the site to the east of the cooling towers. It also parallels each side of the railroad grade from west to east across most of the Units 2 and 3 site. In addition, near the eastern side of the site, it branches to the north and south away from the railroad grade. Finally, the 400-ft contour also traverses the northern edges of the parking lot at the north end of the site.

Since the applicant provided the requested HEC-RAS files, provided a detailed description of the flow paths, and clarified the location of the 400-ft contour at the site, the NRC staff finds the applicant's response acceptable and, therefore, considers RAI 2.4.13-13 closed.

Peak Discharges

The NRC staff used the peak precipitation rates from the PMP analysis to estimate the peak discharges using the Rational Method. The equation in the Rational Method has the form of

$$Q=C_f \cdot C \cdot i \cdot A$$

where Q = peak rate of flow (cfs), C_f = frequency factor, C = runoff coefficient, i = intensity of precipitation (in/hr), and A = drainage area (acres). The applicant used the conservative coefficient value (C_f C = 1). A conservative application of the Rational Method is to assume that all precipitation immediately runs off at a rate indicated by the rainfall intensity. The staff used this method and produced PMP peak flows from Subbasins 1 to 4 of 56.5 m^3/s, 128.7 m^3/s, 53.3 m^3/s, and 135.8 m^3/s(1996 cfs, 4546 cfs, 1883 cfs, and 4796 cfs), respectively. Since these discharges are the same as those calculated by the applicant, the NRC staff finds the applicant's peak discharges to be acceptable.

Hydraulic Model Setup

The staff reviewed the input parameters used by the applicant to set up the hydraulic model that were provided electronically and described in the applicant's January 4, 2010 response to RAI 2.4.13-13. The staff determined the hydraulic model was appropriately configured.

The staff, however, determined that the values of Manning's roughness coefficients for grass and for gravel used by the applicant in the HEC-RAS simulations did not represent the upper limit of what could be expected for the site. The applicant used a value of 0.04 for Manning's roughness coefficient in doing HEC-RAS modeling for the gravel and grass covered channels. In the reference, "Open Channel Hydraulics" (Chow 1959), it is suggested that the value of Manning's roughness coefficient range from 0.017-0.036 for gravel, from 0.025 to 0.035 for short grass, and from 0.030 to 0.050 for high grass. The staff conservatively selected a value of 0.05 and did a sensitivity analysis and found the maximum floodwater surface elevation near safety-related structures increased less than 1.5 cm (0.05 ft) (from 121.73 to 121.75 m (399.39 to 399.43 ft) NAVD88). The staff finds that the applicant's analysis of the local intense precipitation flooding is appropriate.

Flood Elevations

The staff's confirmatory analysis and independent sensitivity analysis yield maximum water surface elevation resulting from local intense precipitation to be 121.74 m (399.4 ft). This occurred at the upstream end of the channels draining Subbasins 1, 2, and 3. These estimates are lower than the design ground floor elevations for safety-related structures at the VCSNS Units 2 and 3 site.

No conceptual model is conceived where floods on the Broad River could rise to the level of the VCSNS Units 2 and 3 safety-related structures. Local intense precipitation events are conceived as potentially impacting the safety-related structures and so are further analyzed in detail in this technical evaluation. Flooding of the Broad River and the Frees Creek (which directly discharges into the Monticello Reservoir) due to PMP events is evaluated. Wind generated setup in the Monticello Reservoir is also considered as a potential flooding mechanism that could impact the safety-related structures. Flooding due to dam failures, either on the Broad River or on the Frees Creek is evaluated as a possible impact on the safety-related structures. These failures are also considered in terms of loss of water supply and operation of safety-related functions. The conceptual model for the site is that uncontrolled releases from the Monticello Reservoir would flow into high-capacity creeks between the reservoir and the VCSNS Units 2 and 3 and these waters would pass into the Broad River. No conceptual model is conceived where tsunamis or ice blockage of the Broad River could impact VCSNS Units 2 and 3 safety-related structures. The safe shutdown of the AP1000 does not rely on externally supplied water and so icing and other low water conditions do not pose safety-related risks.

The VCSNS safety-related structures are located at an elevation of 121.92 m (400 ft) NAVD88 approximately 45.7 m (150 ft) above the floodplain of the Broad River/Parr Shoals Reservoir.

The staff determined that a flood in the Broad River would need to raise the water level in Parr Shoal 45.7 m (150 ft) in order to reach site grade. VCSNS Units 2 and 3 site grade is 7.8 m (25.7 ft) below the normal pool level of the Monticello Reservoir. Local drainage paths indicated by topography suggest Frees Creek thalweg elevations surrounding the VCSNS site range from 91.4 to 109.7 m (300 to 360 ft). The design elevation of the VCSNS safety-related structures is 121.92 m (400 ft) NAVD88.

The staff confirmed that the VCSNS COL FSAR includes a complete scope of information relating to flood risk. In this technical evaluation, a flood risk due to local intense precipitation is further reviewed and analyzed by the staff.

The applicant provided the hydraulic model HEC-RAS files to be used for the staff's independent verification. VCSNS COL FSAR Section 2.4.2.3 describes the network of drainage ditches at the site that are designed to convey local surface water runoff away from the safety-related structures. The staff's review includes verification about whether the applicant's analysis was appropriate. The analyses of the local intense precipitation event and the routing of the floodwaters through the drainage system, described in the VCSNS COL FSAR, show the applicant's design basis for handling floodwaters in the vicinity of the power block. As such, the applicant must provide commitments in the VCSNS COL FSAR that the drainage system will function as designed throughout the operating life of the power station.

Key aspects for reviewing the applicant's hydraulic analyses that affect local intense precipitation flood included: (1) appropriate representation of the drainage system of the site in the HEC-RAS model setup; (2) estimation of local PMP peak runoff; and (3) sensitivity of hydraulic analysis to bed roughness, contraction and expansion coefficient, and boundary conditions, including regional flooding impact. Therefore, the NRC staff focused on these aspects to evaluate potential flood risk.

The staff's review of the HEC-RAS input files found them to conform to the applicant's statements in the VCSNS COL FSAR. The applicant identified the elevation of 121.92 m (400 ft) NAVD88 as the plant safety elevation. The applicant developed the HEC-RAS model cross-sections from topographic data for the overbank area and the proposed geometric configurations for the channels. The staff compared the HEC-RAS model cross-sections with the topographic information provided in the VCSNS COL FSAR.

In the VCSNS COL FSAR, the applicant included the overall site map of the VCSNS site showing the plant site drainage basins and flow paths (FSAR Figure 2.4-210). The applicant's analysis used the HEC-RAS model to determine water surface elevations at the site. An important aspect of the HEC-RAS model is that it uses cross sections to define the geometry of the drainage area. A map with the locations of these cross-sections was not provided to the staff in the VCSNS COL FSAR. Therefore, in RAI 2.4.13-14, the staff requested that the applicant provide a map with HEC-RAS cross-sections and clear identification of the safety-related structures and the design basis flood elevation. Based on the basin map identified in RAI 2.4.13-14, the staff confirmed that the applicant's HEC-RAS model cross-sections adequately represent the drainage system in the site. In response to RAI 2.4.13-14, the applicant committed to add the cross-section map to a future FSAR revision, therefore, this will be tracked as **Confirmatory Item 2.4.2-1**.

The HEC-RAS model for the site includes the following drainage areas as shown in VCSNS COL FSAR Figure 2.4-210:

- Subbasin A to the north of the site, which drains into Subbasin 2
- Subbasin B to the northwest of the site, which drains away from the site
- Subbasin 2 covering the north portion of the site, receiving flow from Subbasin A and discharging to the west of the site
- Subbasin 3 draining the southwest quadrant of the site and discharging along the west and south boundaries of the site
- Subbasin 1 covering the south central portion of the site and discharging along its southern boundary
- Subbasin 4 covering the southeastern portion of the site with discharge along the eastern boundary.

The railroad line coincides with the flow divide for Subbasins 1 and 4. The power block area forms another significant divide for subbasins 1 and 3 as well as Subbasins 2 and 3.
An additional drainage area (Subbasin 5) was used by the NRC for the examination of flow effects at Storm Water Basin 3 within Subbasin 4. This additional drainage area is depicted in SER Figure 2.4-3, "Plant Site Drainage Basins and Flow Paths."

Culverts installed at the VCSNS site are conservatively treated using cross-sections aligned with the access roads and assuming that they are completely blocked. Culverts treated in this manner are found in the basin map provided by the applicant as a part of RAI 2.4.13-14. In response to RAI 2.4.13-14, the applicant committed to add the basin map to a future FSAR revision; therefore, this will be tracked as part of **Confirmatory Item 2.4.2-1**. Handling culvert cross-sections in this manner results in overflow of the plant access road in Subbasin 1. This particular access road is modeled with three cross-sections. This approach accounts for the effect of culvert blockage as a result of debris build-up resulting from a local-intense precipitation event.

The staff used the peak flows from the PMP analysis estimated using the Rational Method as described in the technical evaluation for peak discharages. This method produced PMP peak flows from Subbasins 1 to 4 of 56.5 m^3/s, 128.7 m^3/s, 53.3 m^3/s, 135.8 m^3/s(1996 cfs, 4546 cfs, 1883 cfs, and 4796 cfs), respectively. These flows were input into the HEC-RAS hydraulic model assuming a steady-state. These flows were distributed in proportion to drainage area upstream of each cross-section in the HEC-RAS model. The steady state approach produces a conservative result.

The staff conducted a series of sensitivity analysis on bed roughness, contraction/expansion coefficients, and boundary conditions to determine their effect on the maximum water levels from the HEC-RAS model. These parameters were selected based on a review of the VCSNS COL FSAR and the applicant's HEC-RAS model. Summary results showing the impact of these sensitivity tests on flood levels are shown in SER Table 2.4-1.

According to VCSNS COL FSAR Section 2.4.2.3, the applicant set up the HEC-RAS model using Manning's roughness coefficient (n) of 0.04 for areas associated with main channel and overbank sections. This value is typical for coarse cobbled natural channels and flood plains covered with light brush. The staff confirmed that the VCSNS COL FSAR and the HEC-RAS input file were consistent with regard to the roughness characterization.

The staff conducted a sensitivity test for the model inputs including systematic variations of the channel and overbank roughness Increasing Manning's n to 0.075 (heavy brush) in all cross-sections increased the water surface elevations within each drainage area. The maximum water surface elevation at the upstream end was more dependent on the flow regime change due to combination of bed roughness variation and channel slope. The water surface elevation remained below the safety-related elevation of 121.92 m (400 ft) for Subbasins 1, 2, and 3, with a maximum water surface elevation of 121.77 m (399.5) ft. For Subbasin 4, the maximum water surface elevation was 122.20 m (400.91 ft), which slightly exceeded the elevation of the railroad embankment (121.92 m (400 ft) NAVD88). The staff's analysis indicates the importance of site maintenance and ensuring that the drainage channels are able to convey floodwaters for the design basis storm through the operational life of the plant. As discussed in the next paragraph, the applicant has made commitments that resolve this issue.

RAI 2.4.2-1 and RAI 2.4.13-14 requested the applicant to provide a description of the VCSNS program to ensure drainage channels remain free from obstructions in the event of a heavy precipitation event. The applicant provided a description of the administrative controls and surveillance requirements in response to RAI 2.4.2-1; therefore, RAI 2.4.2-1 is closed. In response to RAI 2.4.13-14, the applicant committed to perform a walk-down prior to heavy rain events to look for potential sources of blockage or other inhibitors to proper storm water drainage. The incorporation of this commitment in a future VCSNS COL FSAR revision is being tracked as part of **Confirmatory Item 2.4.2-1**

The staff conducted a sensitivity test for the increased contraction and expansion coefficients to assess the effect of debris causing hydraulic energy loss, which generally resulted in increased water surface elevation. The applicant used contraction and expansion coefficients of 0.1 and 0.3 typical for gradual transition of channel. Typical coefficient values for abrupt transitions are 0.6 to 1.0. The Manning's n values were unchanged from the value used by the applicant. The staff's analyses assuming the abrupt transition produced no significant change of the maximum water surface elevation. The highest water surface elevation of 121.88 m (399.88 ft) in Subbasin 4 remained below the railroad elevation.

The staff confirmed the validity of the downstream boundary conditions. The applicant's HEC-RAS model used critical depth as the downstream boundary condition. The staff considered this a suitable boundary condition as long as runoff exits in the subbasins through a highly-sloped (i.e., 3:1) fill, which forces the flow into a supercritical regime.

The impact on the downstream boundary condition along Mayo Creek due to flooding from a potential dam break of the Monticello Reservoir was also examined. The estimated potential flood level near the discharge point of Subbasin 4 from the dam break was 119.44 m (391.85 ft) NAVD88. After applying this water surface elevation as the downstream boundary condition of Subbasin 4 in the HEC-RAS model, the staff found that the maximum water surface elevation remained unchanged. The effect of the high water surface elevation at the boundary does not propagate upstream due to the supercritical flow region at the downstream cross-sections of the model (30.48 m (100 ft) NAVD88~91.44 m (300 ft) from the downstream boundary). Consequently, the Mayo Creek flooding will not affect the flood level at the site.

The applicant did not consider the runoff from the drainage (northeast portion of plant site) adjoined with Subbasins 2 and 4. The topography map of the drainage area indicates flooding water drains into a storm water basin (SWB 3) that also receives the runoff from Subbasin 4. The staff considered whether the combined runoff might affect the storage and discharge capacity of the storm water basin, by increasing the downstream water surface elevation and potentially affect the upstream water surface elevation. The staff investigated the effect of PMP runoff from the unaccounted drainage area on the flood level in Subbasin 4. Conservatively, the PMP runoff ($Q = i\,A = 57.1\ m^3/s$ (2015 cfs)) estimated by the staff for the drainage was added to the cumulative inflow (4796 cfs) at the downstream cross-section in the HEC-RAS analysis of Subbasin 4. The result showed the maximum water surface elevation unchanged from the applicant's estimation. Therefore, no risk was associated with the effect of the additional drainage flow on the maximum water surface elevation in Subbasin 4. This is attributed to the supercritical flow occurring at the downstream cross-sections of the model due to the relatively high bed slope.

2.4.2.5 Post Combined License Activities

There are no post-COL activities related to this section.

2.4.2.6 Conclusion

The staff reviewed the application and confirmed that the applicant has addressed the information related to individual types of flood-producing phenomena, and combinations of flood-producing phenomena, considered in establishing the flood design bases for safety-related plant features. The information also covered the potential effects of local intense precipitation. The staff also confirmed that no outstanding information is expected to be addressed in the COL FSAR related to this section.

As set forth above, the applicant has presented and substantiated information to establish the site description. The staff has reviewed the information provided and, pending resolution of **Confirmatory Items 2.4.2-1**, for the reasons given above, concludes that the applicant has provided sufficient details about the site description to allow the staff to evaluate, as documented in Section 2.4.2, of this SER, whether the applicant has met the relevant requirements of 10 CFR Part 52.79(a)(1)(iii) and 10 CFR Part 100 with respect to determining the acceptability of the site. This addresses COL information item VCS COL 2.4 2. In conclusion, the applicant has provided sufficient information for satisfying 10 CFR Part 52 and 10 CFR Part 100.

2.4.3 Probable Maximum Flood On Streams And Rivers

2.4.3.1 Introduction

VCSNS COL FSAR Section 2.4.3 describes the hydrological site characteristics affecting any potential hazard to the plant's safety-related facilities as a result of the effect of the PMF on streams and rivers.

Section 2.4.3 of this SER provides a review of the following specific areas: (1) design basis for flooding in streams and rivers; (2) design basis for site drainage; (3) consideration of other site-related evaluation criteria; and (4) any additional information requirements prescribed in the "Contents of Application" sections of the applicable subparts to 10 CFR Part 52.

2.4.3.2 Summary of Application

This section of the VCSNS COL FSAR addresses the site-specific information on PMF on streams and rivers. The applicant addressed the information as follows:

AP1000 COL Information Item

- VCS COL 2.4-2

In addition, this section addresses the following COL Information Item 2.4-2 (COL Action Item 2.4.1-2) identified in Section 2.4.1.2 of the DCD.

> Combined License applicants referencing the AP1000 design will address the following site specific information on historical flooding and potential flooding factors, including the effects of local intense precipitation.
>
> - Probable Maximum Flood on Streams and Rivers – Site-specific information that will be used to determine design basis flooding at the site. This information will include the probable maximum flood on streams and rivers.
> - Dam Failures – Site specific information on potential dam failures.
> - Probable Maximum Surge and Seiche Flooding – Site-specific information on probable maximum surge and seiche flooding.
> - Probable Maximum Tsunami Loading – Site-specific information on probable maximum tsunami loading.

- Flood Protection Requirements – Site-specific information on flood protection requirements or verification that flood protection is not required to meet the site parameter of flood level.

No further action is required for sites within the bounds of the site parameter for flood level.

VCS COL 2.4-2 adds VCSNS COL FSAR Section 2.4.3 in its entirety.

This section of the SER relates to the PMFs on streams and rivers part of COL Information Item 2.4-2.

2.4.3.3 Regulatory Basis

The acceptance criteria associated with the relevant requirements of the Commission regulations for the identification of floods and flood design considerations are given in Section 2.4.3 of NUREG-0800.

The applicable regulatory requirements for identifying probable maximum flooding on streams and rivers are:

- 10 CFR Part 100, as it relates to identifying and evaluating hydrological features of the site. The requirements to consider physical site characteristics in site evaluations are specified in 10 CFR 100.20(c).

- 10 CFR 100.23(d) sets forth the criteria to determine the siting factors for plant design bases with respect to seismically induced floods and water waves at the site.

- 10 CFR 52.79(a)(1)(iii), as it relates to identifying hydrologic site characteristics with appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area and with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

The related acceptance criteria are as follows:

- RG 1.59, Revision 2, as supplemented by best current practices.
- RG 1.102, Revision 1

2.4.3.4 Technical Evaluation

The NRC staff reviewed Section 2.4.3 of the VCSNS COL FSAR and checked the referenced DCD to ensure that the combination of the DCD and the COL application represents the complete scope of information relating to this review topic.[1] The NRC staff's review confirmed that the information in the application and incorporated by reference addresses the required information relating to the site-specific PMF on streams and rivers. The results of the NRC staff's evaluation of the information incorporated by reference in the VCSNS COL application are documented in NUREG-1793 and its supplements.

The staff reviewed the information in the VCSNS COL FSAR:

AP1000 COL Information Item

- VCS COL 2.4-2

2.4.3.4.1 Probable Maximum Precipitation

Information Submitted by the Applicant

The PMP was estimated on the Broad River and Frees Creek watersheds. These estimates were based on HMRs 51, 52, and 53. The characteristics used to develop the estimates are tabulated below.

	Broad River	**Frees Creek**
Drainage Area (sq mi)	4,850	17.4
72-hr PMP (in)	22.1	48.6

The 72-hr PMP are given above but these are provided in 6-hr increments with VCSNS COL FSAR Tables 2.4-209 and 2.4-210.

NRC Staff's Technical Evaluation

For Broad River (Parr Reservoir), the staff independently estimated the PMP over the Broad River basin using the HMR 52 software developed by the USACE (1991) and confirmed the applicant's PMP estimate of 56.1 cm (22.1 in) and the watershed area (4850 sq mi).
The area of the Frees Creek watershed is 45.1 sq km (17.4 sq mi) of which 27.5 sq km (10.6 sq mi) is the Monticello Reservoir leaving 17.6 sq km (6.8 sq mi) to drain into the Monticello Reservoir. The staff estimated the 72-hr PMP for the watershed area of 25.9 sq km (10 sq mi) to be between 121.9 and 127.0 cm (48 and 50 in) (HMR 51, Figure 22). By examining the location of the Frees Creek watershed, the staff was able to confirm the applicant's 123.4 cm (48.6 in) 72-hr PMP estimate by linear interpolation but decided to use the larger number (127.0 cm (50 in)) as a more conservative approach.

2.4.3.4.2 Precipitation Losses

Information Submitted by the Applicant

For the Broad River (Parr Reservoir), the applicant developed the flood hydrograph of the PMF at Richtex using the rainfall-runoff model HEC-HMS. The applicant modeled precipitation losses using the "Initial and Constant" method in HEC-HMS. The applicant set the initial rainfall loss equal to zero and used a constant rainfall loss rate of 0.06 in/hr in the model. For the Frees Creek (Monticello Reservoir), the 0.06 in/hr rainfall loss rate was also used and no initial rainfall loss was considered.

NRC Staff's Technical Evaluation

The staff reviewed the method followed by the applicant to estimate precipitation loss for the PMF estimate in the Broad River basin (Parr Reservoir) and the Frees Creek basin (Monticello

Reservoir). The staff determined that no initial loss applied to the PMP storm was a conservative approach, the method used to estimate loss rate is an approach that is commonly used in practice, and using the 0.15 cm/hr (0.06 in/hr) rainfall loss rate is appropriate.

2.4.3.4.3 Runoff and Stream Course Models

Information Submitted by the Applicant

Based on the 1940 unit hydrograph (based on a storm hydrograph recorded for two storms that occurred on August 16, 1940 and October 14, 1990), the applicant developed the PMP Broad River unit hydrograph with adjustments to the peak flow and the time to peak (increasing the hydrograph peak by 20 percent, from 1,789 to 2,146 m^3/s (63,175 to 75,800 cfs) and decreasing the time to peak by 25 percent from 48 to 36 hours). The applicant set the base flow in the Broad River equal to the average flow.

For the Frees Creek (Monticello Reservoir), the applicant used a simpler and more conservative method than the unit hydrograph based on a rainfall-runoff approach to determine the PMF flood elevation in the reservoir. The applicant calculated the PMF flood stage by adding the volume associated with the direct 72-hour PMP depth over the reservoir area (27.5 sq km (10.6 sq mi)) and the surface runoff volume of total PMP depth less 0.06 in/hr loss rate from the remaining watershed area (6.8 sq mi) of the Frees Creek. This volume was then added to the full-pool volume of 397,000 acre-feet to yield a total of 440,500 acre-feet.

NRC Staff's Technical Evaluation

The staff found the adjustments made by the applicant to the unit hydrograph developed from the recorded storms to be acceptable. The increase of 20 percent in the peak flow and the reduction in the time to peak of 25 percent is within the range of current practice for these adjustments.

The staff agreed the method used by the applicant is a simpler and more conservative method than the unit hydrograph-based rainfall-runoff approach used to determine the PMF flood elevation in the reservoir and confirmed the applicant's 72-hour PMP estimate of 123.4 cm (48.6 in).

2.4.3.4.4 Probable Maximum Flood Flow

Information Submitted by the Applicant

Using HEC-HMS with an antecedent flow conditions of a 40 percent 72-hour PMP followed by 3 days without precipitation, the applicant estimated the PMP peak flow to be 1,132,879 cfs at Richtex and the corresponding peak flow at Parr Reservoir to be 1,109,521 cfs by multiplying the peak PMF discharge of 1,132,879 cfs at Richtex with the ratio of the two drainage areas (4,750/4,850).

NRC Staff's Technical Evaluation

For the Broad River (Parr Reservoir), in RAI 2.4.2-2, the staff requested that the applicant provide additional details about the flow calculations used to estimate PMP flood flows over Parr Shoals Dam. A response was provided on October 9, 2009. The response included the

specific weir equations appropriate for use at the Parr Shoals Dam. The staff determined that the applicant has provided sufficient information for staff to proceed with its review.
The gates of the Parr Shoals Dam on the Broad River have a top elevation of 81.08 m (266 ft) when raised and 78.33 m (257 ft) when lowered (NGVD29). The staff used the higher of the two as the downstream condition, and treated the dam as a set of three weirs yielded PMF levels of 88.85 m (291.5 ft) NGVD29. The applicant used the following weir equation to estimate the flow over sections of the dam:

$$Q = C_d L H^{2/3}$$

where Q is discharge (cfs), L is the length of the dam sections (ft), H is the Head above crest of weir, and C_d is the weir coefficient.

Three sections of the dam were identified for discharge points on Parr Reservoir, as follows:

- lengths of 609.6, 91.4, and 27.4 m (2000, 300, and 90 ft)
- weir base elevations of 81.8, 82.9, and 82.6 m (266, 272.1, and 271.1 ft) (NGVD29)
- weir coefficients (no units) of 3.9, 3.1, and 3.1.

The weir equations were used for these three dam sections along with the PMF peak elevation of 88.85 m (291.5 ft) NGVD29 to confirm the total discharge of these three locations as reported in the VCSNS COL FSAR. For water surface elevation of 88.85 m (291.5 ft) NGVD29, the discharge estimates for each of the three weirs was estimated to be 28,441, 2,250, 728 m^3/s(1,004,396 cfs, 79,467 cfs, and 25,707 cfs), respectively. The total discharge was estimated to be 31,419 m^3/s(1,109,569 cfs), which confirms the applicant's estimate of 31,418 m^3/s(1,109,521 cfs).

The watershed area above the Parr Reservoir is 12,561 sq km (4850 mi^2). The 72-hour PMP is 56.1 cm (22.1 in). The NRC staff conservatively assumed that the entire flow passes through Parr Reservoir in 72 hours without any infiltration. The staff examined the hydrographs presented for the storms identified as 1940, 1976, and 1990 in VCSNS COL FSAR Figures 2.4.3-211, 2.4.3-212, and 2.4.3-213. Based upon the observed shape of these hydrographs, the staff determined that representing the PMP hydrograph as having a duration of 72 hours with symmetric rising and falling arms was reasonable. The staff used the 72-hour runoff volume and this shape of the hydrograph to estimate the PMP peak flow through Parr Shoals Dam and produced peak PMP flow estimate of 54,408 m^3/s (1,921,390 cfs). While this peak flow value exceeds that reported by the applicant, it is designed to determine whether more detailed analysis was warranted and not refute the more detailed assessment described in the VCSNS COL FSAR.

2.4.3.4.5 Water Level Determinations

Information Submitted by the Applicant

Using weir equations to represent flow over the Parr Shoals Dam with the standard weir equation, the applicant calculated a PMF elevation of 291.5 ft NGVD29 at the Parr Reservoir.

Using the stage-volume relationship for the Monticello Reservoir, the applicant estimated the PMF still water surface elevation in the Monticello Reservoir to be 431 ft NGVD29.

NRC Staff's Technical Evaluation

Using the same weir equations but replacing the applicant's peak discharge value with the one estimated by staff yields a peak water surface elevation estimate of 92.35 m (303 ft) NGVD29. A rough doubling of the peak flow value yields an increase in peak water surface elevation from 88.85 m to 92.35 m (291.5 ft to 303 ft) NGVD29. Both the staff's and applicant's estimates show that the PMF elevation at Parr Reservoir is about 30.48 m (100 ft) below the design site grade elevation of 121.92 m (400 ft) NAVD88 (122.13 m (400.7 ft) NGVD29). For the Frees Creek (Monticello Reservoir), the staff conservatively assumed that no water would be released by the FPSF during the PMP event and that the pool would rise due to direct PMP delivery to the Monticello Reservoir and by runoff from the Frees Creek watershed upstream.

The staff used an infiltration rate of 0.15 cm/hr (0.06 in/hr) in the Frees Creek watershed area not covered by the Monticello Reservoir. The net total runoff into the Monticello Reservoir represented an effective 72-hour PMP of 127 cm (50 in). The staff combined this effective PMP with the PMP on the non-reservoir watershed area of 17.6 sq km (6.8 mi^2) after subtracting infiltration to compute a rise in the Monticello Reservoir of 74.4 cm (29.3 inches). This was added to the full PMP amount delivered directly to the surface of the Monticello Reservoir. The staff estimated that runoff from the watershed and direct precipitation to the Monticello Reservoir would increase the pool elevation by 201.4 cm (79.3 in) or 2.01 m (6.6 ft). Assuming a normal pool elevation of 129.54 m (425 ft) NGVD29 prior to the PMP event, the staff estimated the post-event pool elevation to be 131.55 m (431.6 ft) NGVD29. Although this elevation exceeds the proposed site grade of 122.13 m (400.7 ft) NGVD29, the proposed VCSNS Units 2 and 3 are located outside the watershed of the Monticello Reservoir and are protected.

2.4.3.4.6 Coincident Wind Wave Activity

Information Submitted by the Applicant

For the Broad River (Parr Reservoir), using a 2-year wind speed of 50 miles per hour (mph), measured 30 ft above the ground surface over land as the design wind speed and the fetch length of 15,820 ft, the applicant estimated the maximum wave height to be 5.16 ft and the wave run-up to be 6.68 ft. The applicant also calculated a wind setup to be 0.17 ft for the reservoir site using the calculation procedures described in USACE Design Guideline EM 1110-2-1420. The total PMF elevation is estimated to be 431 + 6.68 + 0.17 ft or 437.85 ft NGVD29. According to the applicant, this elevation value is below a 438-ft NGVD29 dike crest elevation for the Monticello Reservoir, which will protect VCSNS Units 2 and 3 from water spilled from the Monticello Reservoir.

Because the PMF elevation at Parr Reservoir is well below the design site grade elevation of 400 ft NAVD88, the applicant conducted no analysis for wave action coincident with the PMF peak elevation for the Frees Creek (Monticello Reservoir).

NRC Staff's Technical Evaluation

For the Broad River (Parr Reservoir), the staff used a 22.4-m/s 9.1-m (50-mph 30-ft) elevation wind speed, a PMP modified average depth, and a fetch length of 27.4 km (17 mi), and estimated a combined wind setup and wave run-up water level rise to be 4.42 m (14.5 ft), which yields a maximum water elevation of 96.77 m (317.5 ft) NGVD29 (303 + 14.5 ft)—well below the minimum slab elevation of 121.92 m (400 ft) NAVD88.

For the Frees Creek (Monticello Reservoir), using the Coastal Engineering Manual (EM-1110-2-1100), a 22.4-m/s 9.1-m (50-mph 30-ft) elevation wind speed, a PMP modified average depth, and a fetch length of 9.7 km (6 mi), the staff calculated the combined wind setup and wave runup to be 1.92 m(6.3 ft) for the Monticello Reservoir. Adding this value to the PMP elevation for the Monticello Reservoir yields a maximum elevation of 131.55 + 1.92 m (431.6 + 6.3 ft) NGVD29 or 133.47 m (437.9 ft) NGVD29, slightly more than the applicant's estimate of 133.46 m (437.85 ft) NGVD29 and still below the 133.50 m (438 ft) NGVD29 dike crest elevation for the Monticello Reservoir. By examining the site topography, the staff agreed with the applicant that the VCSNS site will be protected by the dike (north berm) along the shoreline of the Monticello Reservoir north of VCSNS Unit 1, which is located between the VCSNS Units 2 and 3 site and the Monticello Reservoir.

2.4.3.5 Post Combined License Activities

There are no post-COL activities related to this section.

2.4.3.6 Conclusion

The staff reviewed the application and confirmed that the applicant has addressed the information relevant to PMF on streams and rivers, and that there is no outstanding information required to be addressed in the VCSNS COL FSAR related to this section.

As set forth above, the applicant has presented and substantiated information to establish the site description. The staff has reviewed the information provided and, for the reasons given above, concludes that the applicant has provided sufficient details about the site description to allow the staff to evaluate whether the applicant has met the relevant requirements of 10 CFR Part 52.79(a)(1)(iii) and 10 CFR Part 100 with respect to determining the acceptability of the site. This addresses the part of COL Information Item 2.4-2 related to PMFs on streams and rivers.

2.4.4 Potential Dam Failures

2.4.4.1 Introduction

FSAR Section 2.4.4 of the VCSNS COL application addresses potential dam failures to ensure that any potential hazard to safety related structures due to failure of onsite, upstream, and downstream water control structures is considered in the plant design.

Section 2.4.4 of this SER presents a review of the specific areas related to dam failures. The specific areas of review are as follows: (1) flood waves resulting from severe dam breaching or failure, including those due to hydrologic failure as a result of overtopping for any reason, routed to the site and the resulting highest water surface elevation that may result in the flooding of SSCs important to safety; (2) successive failures of several dams in the path to the plant site caused by the failure of an upstream dam due to plausible reasons, such as a PMF, landslide-induced severe flood, earthquakes, or volcanic activity and the effect of the highest water surface elevation at the site under the cascading failure conditions; (3) dynamic effects of dam failure-induced flood waves on SSCs important to safety; (4) failure of a dam downstream of the plant site that may affect the availability of a safety-related water supply to the plant; (5) effects of sediment deposition or erosion during dam failure-induced flood waves that may result in blockage or loss of function of SSCs important to safety; (6) failure of onsite water control or storage structures such as levees, dikes, and any engineered water storage facilities that are located above site grade and may induce flooding at the site; (7) the potential effects of seismic and non-seismic data on the postulated design bases and how they relate to dam failures in the vicinity of the site and the site region; and (8) any additional information requirements prescribed in the "Contents of Application" sections of the applicable subparts to 10 CFR Part 52.

2.4.4.2 Summary of Application

This section of the VCSNS COL FSAR addresses the site-specific information on potential dam failures. The applicant addressed the information as follows:

AP1000 COL Information Item

- VCS COL 2.4-2

In addition, this section addresses the following COL Information Item 2.4-2 (COL Action Item 2.4.1-1) identified in Section 2.4.1.2 of the DCD.

> Combined License applicants referencing the AP1000 design will address the following site specific information on historical flooding and potential flooding factors, including the effects of local intense precipitation.
>
> - Probable Maximum Flood on Streams and Rivers – Site-specific information that will be used to determine design basis flooding at the site. This information will include the probable maximum flood on streams and rivers.
> - Dam Failures – Site specific information on potential dam failures.
> - Probable Maximum Surge and Seiche Flooding – Site-specific information on probable maximum surge and seiche flooding.
> - Probable Maximum Tsunami Loading – Site-specific information on probable maximum tsunami loading.
> - Flood Protection Requirements – Site-specific information on flood protection requirements or verification that flood protection is not required to meet the site parameter of flood level.
>
> No further action is required for sites within the bounds of the site parameter for flood level.

VCS COL 2.4-2 adds VCSNS COL FSAR Section 2.4.4 in its entirety.

This section of the SER relates to the dam failures part of COL Information Item 2.4-2.

2.4.4.3 Regulatory Basis

The acceptance criteria associated with the relevant requirements of the Commission regulations for the identification of floods, flood design considerations and potential dam failures are given in Section 2.4.4 of NUREG-0800.

The applicable regulatory requirements for identifying the effects of dam failures are:

- 10 CFR Part 100, as it relates to identifying and evaluating hydrological features of the site. The requirement to consider physical site characteristics in site evaluations is specified in 10 CFR 100.20(c).

- 10 CFR 100.23(d) sets forth the criteria to determine the siting factors for plant design bases with respect to seismically induced floods and water waves at the site.

- 10 CFR 52.79(a)(1)(iii), as it relates to identifying hydrologic site characteristics with appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area and with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

Appropriate sections of the following Regulatory Guides are used by the staff for the identified acceptance criteria:

- RG 1.59, Revision 2, as supplemented by best current practices
- RG 1.102, Revision 1

2.4.4.4 Technical Evaluation

The NRC staff reviewed Section 2.4.4 of the VCSNS COL FSAR and checked the referenced DCD to ensure that the combination of the DCD and the COL application represents the complete scope of information relating to this review topic.[1] The NRC staff's review confirmed that the information in the application and incorporated by reference addresses the required information relating to the potential dam failure. The results of the NRC staff's evaluation of the information incorporated by reference in the VCSNS COL application are documented in NUREG-1793 and its supplements.

The staff reviewed the information in the VCSNS COL FSAR:

AP1000 COL Information Item

- VCS COL 2.4-2

In Section 2.4.4 of the FSAR, the applicant described an assessment of the maximum flood water elevation of a multiple dam failure scenario on the Broad River. The staff in their independent review also considered a breach of the levee on the Monticello Reservoir and subsequent flows on the Mayo Creek adjacent to the site. The staff determined that both of these scenarios were conservative and neither scenario would exceed the design basis flood elevation. The design basis flood elevation was determined to result from the locally intense precipitation scenario discussed in Section 2.4.2 of this SER. The applicant and the staff used the guidance provided in ANSI/ANS-2.8-1992 to quantify flood water elevations at the site resulting from postulated dam failures.

2.4.4.4.1 Dam Failure on Broad River

Information Submitted by the Applicant

The applicant provided rating curves that related the Parr Reservoir pool elevations to storage and weir equations that relate the Parr Reservoir pool elevations to flood flows over the Parr Shoals Dam. The applicant provided the postulated storage capacity of the proposed Clinchfield Dam.

NRC Staff's Technical Evaluation

The staff used a conservative approach to independently estimate the depth behind the Parr Shoals Dam after potential dam failures. The Parr Shoals Dam was assumed to not release any water and to be held at the 88.85 m (291.5 ft) NGVD29 PMF pool level established in Section 2.4.3.4 of this SER. Then all of the significant water impounded on the main stem of the Broad River above the Parr Shoals Dam was assumed to fail with timing, such that the total volume is transferred to the Parr Shoals Dam at the same time. The staff used the storage-pool elevation relationship provided by the applicant for the Parr Shoals Dam to then estimate the associated pool elevation for the dam failure water volume (VCSNS COL FSAR Figure 2.4-216). The water volumes used to develop the dam failure total water volume are given in VCSNS COL FSAR Table 2.4-211. These volumes generally agree with the information independently obtained from the National Inventory of Dams (NID), as briefly discussed below. When the storage associated with the PMF pool elevation was used (instead of the normal pool elevation the dam failure water volume is 1.885 km^3 (1,528,513 acre-feet)), the still water pool elevation was estimated to be 110.3 m (362 ft) NGVD29 or a maximum depth of 33.8 m (111 ft). The PMF storage on the Parr Reservoir and the storage associated with the Clinchfield Dam account for 97 percent of this volume estimate, and including this volume in the staff's assessment is conservative. The staff identified no plans to build the Clinchfield Dam.

Using the NID database, the staff independently determined that the maximum combined storage for dams, including and upstream of the Parr Shoal Dam, is 0.986 km^3 (799,572 acre-feet) as compared to the VCSNS COL FSAR total of 0.846 km^3 (685,516 acre-feet). The staff determined that use of the Clinchfield Dam storage volume of 1.573 km^3 (1,275,000 acre-feet) represented a plausible upper limit of upstream storage for the dam failure analysis.

Wind setup and wave run-up were estimated using 22 m/s (50 mph) and a maximum fetch distance of 27 km (17 mi) (ANS/ANSI-2.8-1992 and VCSNS COL FSAR Figure 2.4-217, respectively). Based upon the staff's independent review of the topography, the staff found that the fetch distance was conservatively estimated by the applicant. Under the dam break case, the maximum depth of the Parr Reservoir under these conditions is 33.8 m (111 ft). Using the wind speed, fetch distance, and reservoir depth, the wind setup was estimated to be 9 cm (0.3 ft) and wave run-up was estimated to be 4.4 m (14.5 ft). The combined dam break peak water surface elevation at the Parr Reservoir is 114.8 m (376.8 ft) NGVD29. Based on the staff's review, there is no indication that a breach of the Parr Reservoir would produce a water surface elevation approaching the site grade elevation. Therefore, the staff finds that a breach of the Parr Reservoir would not flood the VCSNS Units 2 and 3 site.

2.4.4.4.2 Levee Failure on Monticello Reservoir

Information Submitted by the Applicant

The applicant did not consider the levee failure as a plausible potential flooding event. The pool elevations and bathymetric information on the Monticello Reservoir were provided in the VCSNS ER and FSAR. Additionally, the storage volume and pool elevation information was provided by the applicant in the VCSNS COL FSAR.

NRC Staff's Technical Evaluation

The staff analyzed the impact of the potential failure of the levee at the south of the Monticello Reservoir, which can introduce flood water into the Mayo Creek located on the east side of the VCSNS site. The Monticello Reservoir has an estimated still water elevation of 131.4 m (431 ft) NGVD29 and total storage volume of 0.543 km^3 (440,500 acre-feet) under PMP conditions as described in Section 2.4.3. If the portion of the berm surrounding the Monticello Reservoir near the intake structure for VCSNS Unit 1 were to fail, water would enter the Mayo Creek drainage and flow southward from the Monticello Reservoir to the east of the VCSNS Units 2 and 3 site before it turns to the west to discharge into the Broad River downstream of the Parr Shoals Dam.

The staff estimated the peak discharge from the postulated breach of the berm at this location. The bed elevation in the Monticello Reservoir near the intake structure is about 109.7 m (405 ft) NAVD88. The total storage of the Monticello Reservoir at this water surface elevation is about 0.308 km^3 (250,000 acre-feet). The storage difference between the PMP pool elevation and the 405-ft storage elevation is 0.235 km^3 (190,500 acre-feet). The peak discharge range for observations of embankment and dam failure that would spill this volume of water is about 24,777 m^3/s (875,000 cfs) according to data presented in Figure 14 of DSO-98-004, "Prediction of Embankment Dam Breach Parameters: A Literature Review and Needs Assessment" (DSO-980-004 Wahl, T. L. 1998. Prediction of Embankment Dam Breach Parameters: A Literature Review and Needs Assessment. Dam Safety Office Water Resource Research Laboratory. U.S. Department of the Interior. Bureau of Reclamation).

The staff calculated the maximum water elevation at the site using the HEC-RAS hydraulic model and cross-section data extracted by the staff from digital topographic datasets. The staff assumed that the upstream boundary condition was a steady-state reservoir elevation based on the Monticello pool elevation at PMP. The staff assumed the downstream boundary conditions was the elevation of the Broad River during PMF flooding.

The approach was to conduct a bounding scenario analysis that assumed steady upstream boundary conditions. To evaluate the flood level due to failure, the staff conducted the following steps of analysis:

- Extract the cross-sectional information from the topography data covering the Mayo Creek valley, which contributes to the routing and storage of flood waters.

- Set up the HEC-RAS hydraulic model using the extracted cross-sectional information. The upstream boundary was located at the upstream valley of the Mayo Creek near the south levee of the Monticello Reservoir. The downstream boundary was extended to the Parr Reservoir.

- Assume the maximum possible amount of spilling water to be about the maximum storage capacity (0.555 km^3 (450,000 acre-feet)) of the Monticello Reservoir.

- Assume that the total amount of reservoir water would be spilled over a 12-hr period. Assume the peak flow to be 3 times of the average flow rate (12,849 m^3/s (453,750 cfs)). The estimated peak flow rate was 38,546 m^3/s (1,361,250 cfs), which is conservatively set to be larger than that suggested by the Dam Safety Office and discussed above.

- Assume a steady-state hydraulic using the peak flow rate at the upstream boundary.

- Set Manning's roughness value to 0.1 (dense brush or tree logs) and use the normal depth downstream boundary condition using the estimated bed slope.

The 3-times average flow scenario (38,546 m^3/s (1,361,250 cfs)) produced a flood level of 391.85 ft NAVD88 near the VCSNS Unit 2 location. The estimated flood level is 8.15 ft below the design safety grade level. A sensitivity analysis showed that an approximate flow rate of 2,000,000 cfs is required to reach the design safety grade level. This amount of water spill due to the levee failure is unrealistically high.

Based on the staff's review, none of the cases evaluated indicated that a breach of the Monticello Reservoir would produce a water surface elevation approaching the site grade elevation.

2.4.4.5 Post Combined License Activities

There are no post-COL activities related to this section.

2.4.4.6 Conclusion

The staff reviewed the application and confirmed that the applicant has addressed the information relevant to potential dam failures, and that no outstanding information is expected to be addressed in the VCSNS COL FSAR related to this section.

As set forth above, the applicant has presented and substantiated information to establish the site description. The staff has reviewed the information provided and, for the reasons given above, concludes that the applicant has provided sufficient details about the site description to allow the staff to evaluate, as documented in Section 2.4.4 of this SER, whether the applicant has met the relevant requirements of 10 CFR Part 52.79(a)(1)(iii) and 10 CFR Part 100 with respect to determining the acceptability of the site. This addresses the part of COL Information Item 2.4-2 related to dam failures.

2.4.5 Probable Maximum Surge and Seiche Flooding

2.4.5.1 Introduction

FSAR Section 2.4.5 of the VCSNS COL application addresses the probable maximum surge and seiche flooding to ensure that any potential hazard to the safety-related SSCs at the proposed site has been considered in compliance with the Commission's regulations.

Section 2.4.5 of this SER presents evaluation of the following topics based on data provided by the applicant in the VCSNS COL FSAR and information available from other sources: (1) probable maximum hurricane (PMH) that causes the probable maximum surge as it approaches the site along a critical path at an optimum rate of movement; (2) probable maximum wind storm (PMWS) from a hypothetical extratropical cyclone or a moving squall line that approaches the site along a critical path at an optimum rate of movement; (3) a seiche near the site, and the potential for seiche wave oscillations at the natural periodicity of a water body that may affect flood water surface elevations near the site or cause a low water surface elevation affecting safety-related water supplies; (4) wind-induced wave run-up under PMH or PMWS winds; (5) effects of sediment erosion and deposition during a storm surge and seiche-induced waves that may result in blockage or loss of function of SSCs important to safety; (6) the potential effects of seismic and non-seismic information on the postulated design bases and how they relate to a surge and seiche in the vicinity of the site and the site region; (7) any additional information requirements prescribed in the "Contents of Application" sections of the applicable subparts to 10 CFR Part 52.

2.4.5.2 Summary of Application

This section of the VCSNS COL FSAR addresses the site-specific information on probable maximum surge and seiche flooding in terms of impacts on structures and water supply. The applicant addressed these issues as follows:

AP1000 COL Information Item

- VCS COL 2.4-2

In addition, this section addresses the following COL Information Item 2.4.2 (COL Action Item 2.4.1-2) identified in Section 2.4.1.2 of the DCD.

> Combined License applicants referencing the AP1000 design will address the following site specific information on historical flooding and potential flooding factors, including the effects of local intense precipitation.
>
> - Probable Maximum Flood on Streams and Rivers – Site-specific information that will be used to determine design basis flooding at the site. This information will include the probable maximum flood on streams and rivers.
>
> - Dam Failures – Site specific information on potential dam failures.

- Probable Maximum Surge and Seiche Flooding – Site-specific information on probable maximum surge and seiche flooding.

- Probable Maximum Tsunami Loading – Site-specific information on probable maximum tsunami loading.

- Flood Protection Requirements – Site-specific information on flood protection requirements or verification that flood protection is not required to meet the site parameter of flood level.

No further action is required for sites within the bounds of the site parameter for flood level.

VCS COL 2.4-2 adds VCSNS COL FSAR Section 2.4.5 in its entirety.

This section of the SER relates to the surge and seiche part of COL Information Item 2.4.2.

2.4.5.3 Regulatory Basis

The acceptance criteria associated with the relevant requirements of the Commission regulations for consideration of the effects of probable maximum surge and seiche are given in Section 2.4.6 of NUREG-0800.

The applicable regulatory requirements for identifying surge and seiche hazards are:

- 10 CFR Part 100, as it relates to identifying and evaluating hydrological features of the site. The requirement to consider physical site characteristics in site evaluations is specified in 10 CFR 100.20(c).

- 10 CFR 100.23(d) sets forth the criteria to determine the siting factors for plant design bases with respect to water levels at the site.

- 10 CFR 52.79(a)(1)(iii), as it relates to identifying hydrologic site characteristics with appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area and with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

2.4.5.4 Technical Evaluation

The NRC staff reviewed Section 2.4.5 of the VCSNS COL FSAR and checked the referenced DCD to ensure that the combination of the DCD and the COL application represents the complete scope of information relating to this review topic.[1] The NRC staff's review confirmed that the information in the application and incorporated by reference addresses the required information relating to the probable maximum surge and seiche flooding. The results of the NRC staff's evaluation of the information incorporated by reference in the VCSNS COL application are documented in NUREG-1793 and its supplements.

The staff reviewed the information in the VCSNS COL FSAR

2.4.5.5 Technical Evaluation

The NRC staff reviewed Section 2.4.5 of the VCSNS COL FSAR and checked the referenced DCD to ensure that the combination of the DCD and the COL application represents the complete scope of information relating to this review topic.[1] The NRC staff's review confirmed that the information in the application and incorporated by reference addresses the required information relating to the site hydrological description. The results of the NRC staff's evaluation of the information incorporated by reference in the VCSNS COL application are documented in NUREG-1793 and its supplements.

The staff reviewed the information in the VCSNS COL FSAR:

AP1000 COL Information Item

- VCS COL 2.4-2

Information Submitted by the Applicant

In the VCSNS COL FSAR, the applicant provided information related to the probable maximum surge and seiche flooding on the Monticello Reservoir. The applicant described the Monticello Reservoir in terms of location relative to VCSNS Unit 1 and VCSNS Units 2 and 3, and in terms of elevation and surrounding local topography. The applicant determined that the topography between the Monticello Reservoir and the VCSNS Units 2 and 3 site made it implausible for surges and seiches on the reservoir to inundate the VCSNS site.

NRC Staff's Technical Evaluation

The staff reviewed the topography of the site and confirmed that, if a surge or seiche was to occur in the Monticello Reservoir, it would be implausible for water that overtops the dam on the Monticello Reservoir to inundate the VCSNS Units 2 and 3 site. The staff independently verified topographic information in Section 2.4.1. The staff further examined the capacity of the Mayo Creek to carry a substantial portion of the volume of the Monticello Reservoir in the event of dike failure and found that such an event would not inundate VCSNS Units 2 and 3. The staff's determination is discussed in Section 2.4.3. The staff determined that the release of water from the Monticello Reservoir due to surge or seiches would be minimal in comparison and, therefore, finds that VCSNS Units 2 and 3 site flooding from these phenomena is implausible. The normal pool elevation in the Parr Reservoir is about 40.8 m (134 ft) and the Parr Shoals Dam is about 39.0 m (128 ft) below the VCSNS Units 2 and 3 safety-related site grade. The staff determined that any surge or seiches in the Parr Reservoir would not overtop the Parr Shoals Dam. Based on the maximum recorded surge and seiche heights from around the world, the staff determined that it was implausible for surges and seiches on the Parr Reservoir to flood the VCSNS Units 2 and 3 site.

The staff also determined that the proposed plant design does not rely on safety-related water for safe shutdown and, therefore, low water events caused by a surge or seiches in the Parr Reservoir or the Monticello Reservoir would not affect the safety of the plant.

2.4.5.6 Post Combined License Activities

There are no post-COL activities related to this section.

2.4.5.7 Conclusion

The staff reviewed the application and confirmed that the applicant has addressed the information relevant to probable maximum surge and seiche flooding, and that there is no outstanding information required to be addressed in the VCSNS COL FSAR related to this section.

As set forth above, the applicant has presented and substantiated information to establish the site description. The staff has reviewed the information provided and, for the reasons given above, concludes that the applicant has provided sufficient details about the site description to allow the staff to evaluate, as documented in Section 2.4.5, of this SER, whether the applicant has met the relevant requirements of 10 CFR Part 52.79(a)(1)(iii) and 10 CFR Part 100 with respect to determining the acceptability of the site. This addresses the part of COL Information Item 2.4-2 related to probable maximum surge and seiche flooding.

2.4.6 Probable Maximum Tsunami Hazards

2.4.6.1 Introduction

FSAR Section 2.4.6 of the VCSNS COL application addresses the probable maximum tsunami hazards to ensure that any potential tsunami hazard to the safety-related SSCs at the proposed site has been considered in compliance with the Commission's regulations.

Section 2.4.6 of this SER presents an evaluation of the following topics based on data provided by the applicant in the VCSNS COL FSAR and information available from other sources: (1) historical tsunami data, including paleotsunami mappings and interpretations, regional records and eyewitness reports, and more recently available tide gauge and real-time bottom pressure gauge data; (2) probable maximum tsunami (PMT) that may pose hazards to the site; (3) tsunami wave propagation models and model parameters used to simulate the tsunami wave propagation from the source toward the site; (4) extent and duration of wave run-up during the inundation phase of the PMT event; (5) static and dynamic force metrics including the inundation and drawdown depths, current speed, acceleration, inertial component, and momentum flux that quantify the forces on any safety-related SSCs that may be exposed to the tsunami waves; (6) debris and water-borne projectiles that accompany tsunami currents and may impact safety-related SSCs; (7) effects of sediment erosion and deposition caused by tsunami waves that may result in blockage or loss of function of safety-related SSCs; (8) potential effects of seismic and non-seismic information on the postulated design bases and how they relate to tsunami in the vicinity of the site and the site region; (9) any additional information requirements prescribed in the "Contents of Application" sections of the applicable subparts to 10 CFR Part 52.

2.4.6.2 Summary of Application

This section of the VCSNS COL FSAR addresses the site-specific information on PMT hazards in terms of impacts on structures and water supply. The applicant addressed the information as follows:

AP1000 COL Information Item

- VCS COL 2.4-2

In addition, this section addresses the following COL Information Item 2.4.2 (COL Action Item 2.4.1-1) identified in Section 2.4.1.2 of the DCD.

> Combined License applicants referencing the AP1000 design will address the following site specific information on historical flooding and potential flooding factors, including the effects of local intense precipitation.
>
> - Probable Maximum Flood on Streams and Rivers – Site-specific information that will be used to determine design basis flooding at the site. This information will include the probable maximum flood on streams and rivers.
> - Dam Failures – Site specific information on potential dam failures.
> - Probable Maximum Surge and Seiche Flooding – Site-specific information on probable maximum surge and seiche flooding.
> - Probable Maximum Tsunami Loading – Site-specific information on probable maximum tsunami loading.
> - Flood Protection Requirements – Site-specific information on flood protection requirements or verification that flood protection is not required to meet the site parameter of flood level.
>
> No further action is required for sites within the bounds of the site parameter for flood level.

VCS COL 2.4-2 adds VCSNS COL FSAR Section 2.4.6 in its entirety.

This section of the SER relates to the tsunamis part of COL Information Item 2.4.2.

2.4.6.3 Regulatory Basis

The acceptance criteria associated with the relevant requirements of the Commission regulations on consideration of the effects of probable maximum tsunami hazards are given in Section 2.4.6 of NUREG-0800.

The applicable regulatory requirements for tsunami hazards are:

- 10 CFR Part 100, as it relates to identifying and evaluating hydrological features of the site. The requirement to consider physical site characteristics in site evaluations is specified in 10 CFR 100.20(c).
- 10 CFR 100.23(d) sets forth the criteria to determine the siting factors for plant design bases with respect to water levels at the site.

- 10 CFR 52.79(a)(1)(iii), as it relates to identifying hydrologic site characteristics with appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area and with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

2.4.6.4 Technical Evaluation

The NRC staff reviewed Section 2.4.6 of the VCSNS COL FSAR and checked the referenced DCD to ensure that the combination of the DCD and the COL application represents the complete scope of information relating to this review topic.[1] The NRC staff's review confirmed that the information in the application and incorporated by reference addresses the required information relating to the probable maximum tsunami hazards. The results of the NRC staff's evaluation of the information incorporated by reference in the VCSNS COL application are documented in NUREG-1793 and its supplements.

The staff reviewed the information in the VCSNS COL FSAR:

AP1000 COL Information Item

- VCS COL 2.4-2

Information Submitted by the Applicant

In the VCSNS COL FSAR the applicant assessed the potential for oceanic tsunamis to flood the VCSNS Units 2 and 3 site and concluded that none existed due to the distance from and elevation of the site relative to the ocean. The applicant provided the floor elevation for the safety-related structures at VCSNS Units 2 and 3 and the location of the site to support this determination (SCE&G 2010). The applicant did not assess the potential for tsunami-like phenomena to flood safety-related structures at the VCSNS Units 2 and 3 site.

The applicant described the normal pool and dam crest elevations for the Monticello Reservoir; the difference in these elevations is 9 ft (SCE&G 2010).

NRC Staff's Technical Evaluation

The NRC staff reviewed the applicant-provided information about potential flooding at VCSNS Units 2 and 3 site as a result of tsunamis. The staff's determined that given the site's distance from the Atlantic Ocean and the site grade elevation (as discussed in Section 2.4.1), it is implausible for an oceanic tsunami to cause flooding at the VCSNS site.

The staff queried the National Oceanic and Atmospheric Administration (NOAA) Tsunami Event and Runup Database maintained by NOAA/NGDC for historical tsunami events on the east coast of the United States between 1800 and 2010. Of the 22 events found, the closest one to the VCSNS site occurred in Charleston, South Carolina, in 1886 and was associated with an earthquake. No tsunami run-up value was given for this event in the database. However, the maximum run-up associated with this event was 51 cm (20 in) above mean sea level (South Carolina Emergency Management Division 2009), which is over 119 m (390 ft) below the site grade elevation.

The staff determined that a tsunami or a tsunami-like wave in the vicinity of the site is an implausible event. Therefore, a more detailed tsunami analysis is not needed. Hazards related to high water or flooding from a tsunami or a tsunami-like wave at the site are also unlikely.

The staff also considered the occurrence of two tsunami-like events in the Monticello Reservoir. The first event considered was a landslide in the reservoir triggering a tsunami-like phenomenon. The staff determined that this is not a plausible conceptual model because the majority of the Frees Creek watershed is already covered by the reservoir and the staff found no evidence of a saturation-induced slide. The second event considered was a landslide of the embankment around the FPSF. The staff determined that this is not a plausible concept model for flooding of the VCSNS site because the postulated slide would cause the Monticello Reservoir to drain into the Parr Reservoir (i.e., away from VCSNS site).

Tsunami-like waves are amplified as they pass from deep water to shallow water. The amplification of the wave height is inversely proportional to the quarter-root of the water depth (Knauss 1978). This relationship neglects the loss of wave energy due to frictional losses and so yields higher wave heights than would be obtained by including frictional effects. The maximum depth of the Monticello Reservoir is 38 m, and a nominal nearshore depth of 2 m implies a rough doubling of the tsunami wave height as it passes from deep to nearshore areas. The staff estimated that a tsunami-like event would have to create a wave greater than 1.2 m (4 ft) high in the deepest part of the Monticello Reservoir to generate a wave that would overtop the Monticello Reservoir dams under normal pool elevations. Furthermore, this calculation is conservative because it neglects the friction and spreading of the wave as it propagates. The staff determined that there is no plausible conceptual model that would lead to flooding at VCSNS Units 2 and 3 due to tsunami-like events.

The staff also determined that the proposed plant design does not rely on safety-related water for safe shutdown and, therefore, low water events caused by a PMT or a tsunami-like wave in the Broad River, Parr Reservoir, or Monticello Reservoir would not affect the safety of the plant.

The staff reviewed Section 2.4.6 of the VCSNS Units 2 and 3 COL FSAR. The staff's review confirmed that the information in the application and incorporated by reference addresses the relevant information related to PMT hazards with the exception of the assessment of tsunami-like events. The staff's independent technical review of this application included an assessment of the oceanic tsunamis and non-oceanic tsunami-like phenomena.

2.4.6.5 Post Combined License Activities

There are no post-COL activities related to this section.

2.4.6.6 Conclusion

The staff reviewed the application and confirmed that the applicant has addressed the information relevant to PMT hazards, and that there is no outstanding information required to be addressed in the VCSNS COL FSAR related to this section.

As set forth above, the applicant has presented and substantiated information to establish the site description. The staff has reviewed the information provided and, for the reasons given above, concludes that the applicant has provided sufficient details about the site description to allow the staff to evaluate, as documented in Section 2.4.6, of this SER, whether the applicant has met the relevant requirements of 10 CFR Part 52.79(a)(1)(iii) and 10 CFR Part 100 with respect to determining the acceptability of the site. This addresses the part of COL Information Item 2.4-2 related to PMT hazards.

2.4.7 Ice Effects

2.4.7.1 Introduction

FSAR Section 2.4.7 addresses the ice effects to ensure that safety-related facilities and water supply are not affected by ice-induced hazards.

Section 2.4.7 of this SER presents an evaluation of the following topics based on data provided by the applicant in the VCSNS COL FSAR and information available from other sources: (1) regional history and types of historical ice accumulations (i.e., ice jams, wind-driven ice ridges, floes, frazil ice formation, etc.); (2) potential effects of ice-induced, high- or low-flow levels on safety-related facilities and water supplies; (3) potential effects of a surface ice-sheet to reduce the volume of available liquid water in safety-related water reservoirs; (4) potential effects of ice to produce forces on, or cause blockage of, safety-related facilities; (5) potential effects of seismic and non-seismic data on the postulated worst-case icing scenario for the proposed plant site; (6) any additional information requirements prescribed in the “Contents of Application” sections of the applicable subparts to 10 CFR Part 52.

2.4.7.2 Summary of Application

This section of the VCSNS COL FSAR addresses the site-specific information on ice effects. The applicant addressed the information as follows:

AP1000 COL Information Item

- VCS COL 2.4-3

In addition, this section addresses the following COL Information Item 2.4.3 (COL Action Item 2.4.2-1) identified in Section 2.4.1.3 of the DCD.

> Combined License applicants will address the water supply sources to provide makeup water to the service water system cooling tower.

VCS COL 2.4-3 adds VCSNS COL FSAR Section 2.4.7 in its entirety.

This section of the SER relates to ice potential to cause flooding.

2.4.7.3 Regulatory Basis

The acceptance criteria associated with the relevant requirements of the Commission regulations for the identification and evaluation of ice effects are given in Section 2.4.7 of NUREG-0800.

The applicable regulatory requirements for identifying ice effects are:

- 10 CFR Part 100, as it relates to identifying and evaluating hydrological features of the site. The requirement to consider physical site characteristics in site evaluations is specified in 10 CFR 100.20(c).

- 10 CFR 100.23(d) sets forth the criteria to determine the siting factors for plant design bases with respect to water levels at the site.

- 10 CFR 52.79(a)(1)(iii), as it relates to identifying hydrologic site characteristics with appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area and with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

The related acceptance criteria are provided in the following Regulatory Guides:

- RG 1.59, Revision 2, as supplemented by best current practices
- RG 1.102, Revision 1

2.4.7.4 Technical Evaluation

The NRC staff reviewed Section 2.4.7 of the VCSNS COL FSAR and checked the referenced DCD to ensure that the combination of the DCD and the COL application represents the complete scope of information relating to this review topic.[1] The NRC staff's review confirmed that the information in the application and incorporated by reference addresses the required information relating to the site-specific ice effects. The results of the NRC staff's evaluation of the information incorporated by reference in the VCSNS COL application are documented in NUREG-1793 and its supplements.

The staff reviewed the information in the VCSNS COL FSAR:

AP1000 COL Information Item

- VCS COL 2.4-3

Information Submitted by the Applicant

The applicant evaluated the water temperatures in the river close to the VCSNS site and found the minimum recorded water temperature was 3.5°Celsius (C) (38.3°Fahrenheit [F]) using the water temperature data between October 1959 and December 1975 at Carlisle, Alston, and Richtex stations on the Broad River. The applicant calculated the maximum Accumulated Freezing Degree Days to be 5.8°C (42.5°F) days and suggested that ice formation in the Monticello Reservoir is unlikely. In the unlikely event that thin ice forms at the surface of the Monticello Reservoir, it would not affect the water supply at the Units 2 and 3 intakes, which are located approximately 3.1 m (12.8 ft) below the lowest operating reservoir water surface elevation. The applicant suggested formation of frazil or anchor ice is considered highly unlikely because the water temperature never approaches the freezing point.

NRC Staff's Technical Evaluation

The staff examined daily water temperature records reported by the USGS for the Carlisle Station on the Broad River for the entire period when temperatures were reported from 1983 to 2009, and air temperature records for 1946 to 2009 reported by the NOAA/National Climatic Data Center (NCDC) for the Parr climate station. The data show a seasonal trend where winter low water temperatures are typically 0.56°C (33°F) or higher. The lowest daily minimum water temperature in the data set is 0.50 C (32.9°F) (January, 3, 2001 and January 4, 2001) and on both days the daily maximum water temperatures are 2.17°C (35.6°F). The staff agreed that no frazil or anchor ice would grow under such water temperature conditions. The lowest daily air temperature reported for the Parr Reservoir is -9.4°C (15°F) in the period from January 1948 to June 2009. There were 44 instances of three of more days when the average air temperature was below freezing and two instances of eight consecutive days at or below freezing when the average air temperatures were -1.67°C (29°F) (December 15-22, 1963) and -2.78°C (27°F) (January 17-24, 1977). The staff estimated the maximum accumulated freezing degree days to be around 40°F days compared to the 5.83°C (42.5°F) days reported in the FSAR and the ice thickness to be less than 10.1 cm (4 in). The staff agreed with the applicant that with such a low number of accumulated freezing degree days, ice formation in large bodies of water, such as the Parr Reservoir and the Monticello Reservoir, is unlikely and in the unlikely event that thin ice forms at the surface of the Monticello Reservoir, the water supply at the VCSNS Units 2 and 3 intakes would not be affected.

Ice formation can block the plant site drainage system, which could cause flooding on safety-related structures. The staff has reviewed this issue in Section 2.4.2.4 and determined that no flooding will affect the safety-related structures. Therefore, the staff finds that there are no risks to safety-related facilities posed by ice effects.

2.4.7.5 Post Combined License Activities

There are no post-COL activities related to this section.

2.4.7.6 Conclusion

The staff reviewed the application and confirmed that the applicant has addressed site characteristics and other hydrometeorological parameters related to ice formation at or near the plant site, and that there is no outstanding information required to be addressed in the VCSNS COL FSAR related to this section.

As set forth above, the applicant has presented and substantiated information to establish the site description. The staff has reviewed the information provided and, for the reasons given above, concludes that the applicant has provided sufficient details about the site description to allow the staff to evaluate, as documented in Section 2.4.7, of this SER, whether the applicant has met the relevant requirements of 10 CFR Part 52.79(a)(1)(iii) and 10 CFR Part 100 with respect to determining the acceptability of the site. This addresses COL Information Item 2.4-3 related to ice effects.

2.4.8 Cooling Water Canals and Reservoirs

2.4.8.1 Introduction

VCSNS COL FSAR Section 2.4.8 addresses the cooling water canals and reservoirs used to transport and impound water supplied to the safety-related SSCs.

Section 2.4.8 of this SER presents an evaluation of the following topics to verify their hydraulic design basis: (1) design bases postulated and used by the applicant to protect structures such as riprap, inasmuch as they apply to safety-related water supply; (2) design bases of canals pertaining to capacity, protection against wind waves, erosion, sedimentation, and freeboard and the ability to withstand a PMF (surges, etc.), inasmuch as they apply to a safety-related water supply; (3) design bases of reservoirs pertaining to capacity, PMF design basis, wind wave and run-up protection, discharge facilities (e.g., low-level outlet, spillways, etc.), outlet protection, freeboard, and erosion and sedimentation processes inasmuch as they apply to a safety-related water supply; (4) potential effects of seismic and non-seismic information on the postulated hydraulic design bases of canals and reservoirs for the proposed plant site; and (5) any additional information requirements prescribed in the "Contents of Application" sections of the applicable subparts to 10 CFR Part 52.

2.4.8.2 Summary of Application

AP1000 COL Information Item

- VCS COL 2.4-3

This section addresses the following COL Information Item 2.4.3 (COL Action Item 2.4.2-1) identified in Section 2.4.1.3 of the DCD.

> Combined License applicants will address the water supply sources to provide makeup water to the service water system cooling tower.

VCS COL 2.4-3 adds VCSNS COL FSAR Section 2.4.8 in its entirety.

2.4.8.3 Regulatory Basis

The acceptance criteria associated with the relevant requirements of the Commission regulations for the identification of design considerations for cooling water canals and reservoirs are given in Section 2.4.8 of NUREG-0800.

The applicable regulatory requirements for cooling water canals and reservoirs are:

- 10 CFR Part 100, as it relates to identifying and evaluating hydrological features of the site. The requirement to consider physical site characteristics in site evaluations is specified in 10 CFR 100.20(c).

- 10 CFR 100.23(d) sets forth the criteria to determine the siting factors for plant design bases with respect to water levels at the site.

- 10 CFR 52.79(a)(1)(iii), as it relates to identifying hydrologic site characteristics with appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area and with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

The related acceptance criteria are provided in the following Regulatory Guides:

- RG 1.59, Revision 2, as supplemented by best current practices
- RG 1.102, Revision 1

2.4.8.4 Technical Evaluation

The NRC staff reviewed Section 2.4.8 of the VCSNS COL FSAR and checked the referenced DCD to ensure that the combination of the DCD and the COL application represents the complete scope of information relating to this review topic.[1] The NRC staff's review confirmed that the information in the application and incorporated by reference addresses the required information relating to the cooling water canals and reservoirs. The results of the NRC staff's evaluation of the information incorporated by reference in the VCSNS COL application are documented in NUREG-1793 and its supplements.

The staff reviewed the information in the VCSNS COL FSAR:

AP1000 COL Information Item

- VCS COL 2.4-3

Information Submitted by the Applicant

In Section 2.4.8 of the VCSNS COL FSAR, the applicant described the data for and analysis of the cooling water canals and reservoirs. The applicant asserted that there were no cooling water canals or reservoirs that supply safety-related cooling in the VCSNS Units 2 and 3 design; therefore, no further related safety-risk assessment was warranted.

NRC Staff's Technical Evaluation

The staff independently determined that there is no plausible conceptual model including cooling canals and reservoirs that pose flooding to or low water for safety-related facilities. The staff based its determination on the fact that VCSNS Units 2 and 3 are not supplied with safety-related water from the canals and reservoirs, but rather from storage tanks that are designed according to specifications described in the AP1000 DCD.

2.4.8.5 Post Combined License Activities

There are no post-COL activities related to this section.

2.4.8.6 Conclusion

The staff reviewed the application and confirmed that the scope of 2.4.8 is not relevant to the VCSNS COL.

2.4.9 Channel Diversions

2.4.9.1 Introduction

VCSNS COL FSAR Section 2.4.9 addresses channel diversions. It evaluates plant and essential water supplies used to transport and impound water supplies to ensure that they will not be adversely affected by stream or channel diversions. The evaluation includes stream channel diversions away from the site (which may lead to a loss of safety-related water) and stream channel diversions toward the site (which may lead to flooding). In addition, in such an event, it must be ensured that alternate water supplies are available to safety-related equipment.

Section 2.4.9 of this SER presents an evaluation of the following specific areas: (1) historical channel migration phenomena including cutoffs, subsidence, and uplift; (2) regional topographic evidence that suggests a future channel diversion may or may not occur (used in conjunction with evidence of historical diversions); (3) thermal causes of channel diversion, such as ice jams, which may result from downstream ice blockages that may lead to flooding from backwater or upstream ice blockages that can divert the flow of water away from the intake; (4) potential for forces on safety-related facilities or the blockage of water supplies resulting from channel migration-induced flooding (flooding not addressed by hydrometeorological-induced flooding scenarios in other sections); (5) potential of channel diversion from human-induced causes (i.e., land-use changes, diking, channelization, armoring, or failure of structures); (6) alternate water sources and operating procedures; (7) potential effects of seismic and nonseismic information on the postulated worst-case channel diversion scenario for the proposed plant site; (8) any additional information requirement prescribed in the "Contents of Application" sections of the applicable subparts to 10 CFR Part 52.

2.4.9.2 Summary of Application

AP1000 COL Information Item

- VCS COL 2.4-3

This section addresses the following COL Information Item 2.4.3 (COL Action Item 2.4.2-1) identified in Section 2.4.1.3 of the DCD.

> Combined License applicants will address the water supply sources to provide makeup water to the service water system cooling tower.

VCS COL 2.4-3 adds VCSNS COL FSAR Section 2.4.9 in its entirety.

2.4.9.3 Regulatory Basis

The acceptance criteria associated with the relevant requirements of the Commission regulations for the identification and evaluation of channel diversions are given in Section 2.4.9 of NUREG-0800.

The applicable regulatory requirements for identifying and evaluating channel diversions are:

- 10 CFR Part 100, as it relates to identifying and evaluating hydrological features of the site. The requirement to consider physical site characteristics in site evaluations is specified in 10 CFR 100.20(c).

- 10 CFR 100.23(d) sets forth the criteria to determine the siting factors for plant design bases with respect to water levels at the site.

- 10 CFR 52.79(a)(1)(iii), as it relates to identifying hydrologic site characteristics with appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area and with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

The related acceptance criteria are provided in the following Regulatory Guides:

- RG 1.59, Revision 2, as supplemented by best current practices
- RG 1.102, Revision 1

2.4.9.4 Technical Evaluation

The NRC staff reviewed Section 2.4.9 of the VCSNS COL FSAR and checked the referenced DCD to ensure that the combination of the DCD and the COL application represents the complete scope of information relating to this review topic.[1] The NRC staff's review confirmed that the information in the application and incorporated by reference addresses the required information relating to the channel diversions. The results of the NRC staff's evaluation of the information incorporated by reference in the VCSNS COL application are documented in NUREG-1793 and its supplements.

The staff reviewed the information in the VCSNS COL FSAR:

AP1000 COL Information Item

- VCS COL 2.4-3

Information Submitted by the Applicant

In Section 2.4.9 of the VCSNS COL FSAR, the applicant described the data for and analysis of channel diversions. The applicant considered the local geology and topography of the Broad River and the Monticello Reservoir. The Monticello Reservoir was determined to not be subject to upstream channel diversions because the formation of the reservoir drowned much of the small watershed and little of the Frees Creek remains. For the Broad River, the applicant examined historical charts of the river course by comparing the USGS geographical information system (GIS) digital elevation maps files of the topography with an 1838 map by Bradford and a 1773 map by Cook. The applicant found no significant channel diversions, leading to the applicant's conclusion that the Broad River is stable and, therefore, a channel diversion is unlikely to affect the supply of water to the site.

Based on the examination of historical water and air temperatures, the applicant determined that ice build-up is not a viable scenario leading to the diversion of water from the existing channel.

The applicant reviewed plans for further significant diversions of water upstream on the Broad River from the VCSNS site. One study concluded that only one location for an additional dam was feasible on the Broad River. The Clinchfield Dam was proposed at this site in 1969, but has not yet been built. If it were built at the former proposed location, it would be well upstream of the VCSNS site and would not pose a risk for diversion of the Broad River near the VCSNS site.

NRC Staff's Technical Evaluation

The NRC staff reviewed Section 2.4.9 of the VCSNS COL FSAR and checked the referenced DCD to ensure that the combination of the DCD and the COL application represents the complete scope of information related to this review topic. Given that the AP1000 does not require makeup water from offsite for safety-related equipment, the staff determined that the scope of Section 2.4.9 is not relevant for the VCSNS COL.

2.4.9.5 Post Combined License Activities

There are no post-COL activities related to this section.

2.4.9.6 Conclusion

The staff reviewed the application and confirmed that the applicant has addressed the information to demonstrate that the characteristics of the site fall within the site parameters specified in the DC rule, and that there is no outstanding information required to be addressed in the VCSNS COL FSAR related to this section.

As set forth above, the applicant has presented and substantiated information to establish the site description ensuring that the plant and essential water supplies will not be adversely affected. The staff has reviewed the information provided and, for the reasons given above, concludes that the applicant has provided sufficient details about the site description to allow the staff to evaluate, as documented in Section 2.4.9, of this SER, whether the applicant has met the relevant requirements of 10 CFR Part 52.79(a)(1)(iii) and 10 CFR Part 100 with respect to determining the acceptability of the site. This addresses the part of COL Information Item 2.4-3 related to channel diversions.

2.4.10 Flooding Protection Requirements

2.4.10.1 Introduction

VCSNS COL FSAR Section 2.4.10 addresses the locations and elevations of safety-related facilities and those of structures and components required for protection of safety-related facilities. These requirements are then compared with design-basis flood conditions to determine whether flood effects need to be considered in the plant's design or in emergency procedures.

Section 2.4.10 of this SER presents an evaluation of the following specific areas:
(1) safety-related facilities exposed to flooding; (2) type of flood protection (e.g., "hardened facilities," sandbags, flood doors, bulkheads, etc.) provided to the SSCs exposed to floods;
(3) emergency procedures needed to implement flood protection activities and warning times available for their implementation reviewed by the organization responsible for reviewing issues related to plant emergency procedures; (4) potential effects of seismic and non-seismic information on the postulated flooding protection for the proposed plant site; and (5) any

additional information requirements prescribed in the “Contents of Application” sections of the applicable subparts to 10 CFR Part 52.

2.4.10.2 Summary of Application

This section of the COL FSAR addresses the needs for site specific information on flooding protection requirements. The applicant addressed the information as follows:

AP1000 COL Information Item

- VCS COL 2.4-2

In addition, this section addresses the following COL Information Item 2.4.2 (COL Action Item 2.4.1-2) identified in Section 2.4.1.2 of the DCD)

> Combined License applicants referencing the AP1000 design will address the following site specific information on historical flooding and potential flooding factors, including the effects of local intense precipitation.
>
> - Probable Maximum Flood on Streams and Rivers – Site-specific information that will be used to determine design basis flooding at the site. This information will include the probable maximum flood on streams and rivers.
> - Dam Failures – Site specific information on potential dam failures.
> - Probable Maximum Surge and Seiche Flooding – Site-specific information on probable maximum surge and seiche flooding.
> - Probable Maximum Tsunami Loading – Site-specific information on probable maximum tsunami loading.
> - Flood Protection Requirements – Site-specific information on flood protection requirements or verification that flood protection is not required to meet the site parameter of flood level.
>
> No further action is required for sites within the bounds of the site parameter for flood level.

This section of the SER relates to the flood protection requirements part of COL Information Item 2.4.2.

- VCS COL 2.4-6

In addition, this section addresses the following COL Information Item 2.4.6 (COL Action Item 2.4.1-1) identified in Section 2.4.1.6 of the DCD.

> Combined License applicants referencing the AP1000 certified design will address any flood protection emergency procedures required to meet the site parameter for flood level.

VCS COL 2.4.6 adds VCSNS COL FSAR Section 2.4.10 in its entirety.

2.4.10.3 Regulatory Basis

The acceptance criteria related to the relevant requirements of the Commission regulations for the identification and evaluation of flooding protection requirements are given in Section 2.4.10 of NUREG-0800.

The applicable regulatory requirements for identifying and evaluating flooding protection requirements are:

- 10 CFR Part 100, as it relates to identifying and evaluating hydrological features of the site. The requirement to consider physical site characteristics in site evaluations is specified in 10 CFR 100.20(c).

- 10 CFR 100.23(d) sets forth the criteria to determine the siting factors for plant design bases with respect to water levels at the site.

- 10 CFR 52.79(a)(1)(iii), as it relates to identifying hydrologic site characteristics with appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area and with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

The related acceptance criteria are provided in the following:

- RG 1.59, Revision 2, as supplemented by best current practices
- RG 1.102, Revision 1

2.4.10.4 Technical Evaluation

The NRC staff reviewed Section 2.4.10 of the VCSNS COL FSAR and checked the referenced DCD to ensure that the combination of the DCD and the COL application represents the complete scope of information relating to this review topic.[1] The NRC staff's review confirmed that the information in the application and incorporated by reference addresses the required information relating to the flood protection requirements. The results of the NRC staff's evaluation of the information incorporated by reference in the VCSNS COL application are documented in NUREG-1793 and its supplements.

The staff reviewed the information in the VCSNS COL FSAR:

AP1000 COL Information Items

- VCS COL 2.4-2
- VCS COL 2.4-6

Information Submitted by the Applicant

The applicant states Section 2.4.3 of the VCSNS COL FSAR establishes that the site is dry and flood protection is not required.

NRC Staff's Technical Evaluation

Based on the fact that the NRC staff has established that the design basis flood of the local intense precipitation discussed in Section 2.4.2 of this SER, the staff determined that flood protection is not required.

2.4.10.5 Post Combined License Activities

There are no post-COL activities related to this section.

2.4.10.6 Conclusion

The staff reviewed the application and confirmed that the applicant has addressed the information to demonstrate that the characteristics of the site fall within the site parameters specified in the DC rule, and that there is no outstanding information required to be addressed in the VCSNS COL FSAR related to this section.

As set forth above, the applicant has presented and substantiated information relative to the flood protection measures important to the design and siting of this plant. The staff finds that the applicant has considered the appropriate site phenomena in establishing the flood protection measures for SSCs. The staff has reviewed the information provided and, for the reasons given above, concludes that the applicant has provided sufficient details about the site description to allow the staff to evaluate, as documented in Section 2.4.10, of this SER, whether the applicant has met the relevant requirements of 10 CFR Part 52.79(a)(1)(iii) and 10 CFR Part 100 with respect to determining the acceptability of the site. This addresses the part of COL Information Item 2.4-2 related to flood protection requirements and COL Information Item 2.4.6.

2.4.11 Low Water Considerations

2.4.11.1 Introduction

VCSNS COL FSAR Section 2.4.11 addresses natural events that may reduce or limit the available safety-related cooling water supply. The applicant ensures that an adequate water supply will exist to shut down the plant under conditions requiring safety-related cooling.

Section 2.4.11 of this SER presents an evaluation of the following specific areas: (1) low water conditions due to the worst drought considered reasonably possible in the region; (2) effects of low water surface elevations caused by various hydrometeorological events and a potential blockage of intakes by sediment, debris, littoral drift, and ice because they can affect the safety-related water supply; (3) effects of low water on the intake structure and pump design bases in relation to the events described in safety analysis report (SAR) Sections 2.4.7, 2.4.8, 2.4.9, and 2.4.11, which consider the range of water supply required by the plant (including minimum operating and shutdown flows during anticipated operational occurrences and emergency conditions) compared with availability (considering the capability of the ultimate heat sink [UHS] to provide adequate cooling water under conditions requiring safety-related cooling); (4) use limitations imposed or under discussion by Federal, State, or local agencies authorizing the use of the water; (5) potential effects of seismic and non-seismic information on the postulated worst-case low water scenario for the proposed plant site; and (6) any additional information requirements prescribed in the “Contents of Application” sections of the applicable subparts to 10 CFR Part 52.

2.4.11.2 Summary of Application

This section of the COL FSAR addresses the impacts of low water on water supply. The applicant addressed the information as follows:

AP1000 COL Information Item

- VCS COL 2.4-3

In addition, this section addresses the following COL Information Item 2.4.3 (COL Action Item 2.4.1-1) identified in Section 2.4.1.3 of the DCD.

> Combined License applicants will address the water supply sources to provide makeup water to the service water system cooling tower.

VCS COL 2.4-3 adds VCSNS COL FSAR Section 2.4.11 in its entirety.

2.4.11.3 Regulatory Basis

The acceptance criteria associated with the relevant requirements of the Commission regulations for the low water considerations are described in Section 2.4.11 of NUREG-0800.

The applicable regulatory requirements for identifying the effects of low water are:

- 10 CFR Part 100, as it relates to identifying and evaluating hydrological features of the site. The requirement to consider physical site characteristics in site evaluations is specified in 10 CFR 100.20(c).

- 10 CFR 100.23(d) sets forth the criteria to determine the siting factors for plant design bases with respect to seismically induced floods and water waves at the site.

- 10 CFR 52.79(a)(1)(iii), as it relates to identifying hydrologic site characteristics with appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area and with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

2.4.11.4 Technical Evaluation

The NRC staff reviewed Section 2.4.11 of the VCSNS COL FSAR and checked the referenced DCD to ensure that the combination of the DCD and the COL application represents the complete scope of information relating to this review topic.[1] The NRC staff’s review confirmed that the information in the application and incorporated by reference addresses the required information relating to the low water considerations. The results of the NRC staff's evaluation of the information incorporated by reference in the VCSNS COL application are documented in NUREG-1793 and its supplements.

The staff reviewed the information in the VCSNS COL FSAR:

AP1000 COL Information Item

- VCS COL 2.4-3

Information Submitted by the Applicant

The applicant stated that the passive cooling system of the AP1000 design does not rely on the Broad River as a source of water and, therefore, no safety-related facilities of the VCSNS would be affected by low water conditions in the river.

For nonsafety-related uses, which are reported to have a maximum demand of 137.2 cfs, the applicant determined they can be adequately supplied by the 10-year, 7-day average low flow (850 cfs) or the 100-year, 7-day average low flow (430 cfs) at the Parr Shoals Dam combined with the storage at the Monticello and Parr Reservoirs. Using a more conservative assessment, the applicant estimated that the Monticello Reservoir could supply makeup water for VCSNS Units 2 and 3 for 42 days if the FPSF is unavailable and there is no inflow of water to the Monticello Reservoir from direct precipitation or runoff.

The applicant stated that the effects of surges, seiches, and tsunami are not applicable to this site (as discussed in FSAR Sections 2.4.5 and 2.4.6) and no ice conditions are expected to affect flows in either the Broad River or the Monticello Reservoir (as described in FSAR Section 2.4.7.)

The applicant used 149 cfs at Richtex on October 13, 1935 and on September 2, 1957 and 156 cfs at Alston on August 13, 2002 (excluding the 1.4 m^3/s (48 cfs) record on September 12, 2002, because it was influenced by the upstream flow diversion from the Parr Reservoir to the FPSF) as the lowest flow in the low flow analysis.

The applicant reported that there are no future uses or controls planned for the Monticello Reservoir water and none of the identified future uses of the Broad River above the Parr Shoals Reservoir would affect VCSNS Units 2 and 3 safely-related facilities.

NRC Staff's Technical Evaluation

The staff reviewed the AP1000 DCD to evaluate the impact of low water conditions in the vicinity of the VCSNS site on the safety of the VCSNS units. Since no external water source (for VCSNS this is the Parr or Monticello Reservoirs) is required for safe emergency shutdown, the staff determined that low water conditions would have no impact on the safety of the VCSNS units. There are no site characteristics in the DCD associated with low water conditions.

2.4.11.5 Post Combined License Activities

There are no post-COL activities related to this section.

2.4.11.6 Conclusion

The staff reviewed the application and confirmed that the applicant has addressed the information required and that no site characteristic related to low water conditions apply to the AP1000 design.

As set forth above, the applicant has presented and substantiated information relative to the low water effects important to the design and siting of this plant. The staff finds that the applicant has considered the appropriate site phenomena in establishing the design bases for SSCs. The staff has reviewed the information provided and, for the reasons given above, concludes that the applicant has provided sufficient details about the site description to allow the staff to evaluate, as documented in Section 2.4.11, of this SER, whether the applicant has met the relevant requirements of 10 CFR Part 52.79(a)(1)(iii) and 10 CFR Part 100 with respect to determining the acceptability of the site. This addresses COL Information Item 2.4-3 related to low water considerations.

2.4.12 Groundwater

2.4.12.1 Introduction

VCSNS COL FSAR Section 2.4.12 describes the hydrogeological characteristics of the site. The most significant objective of groundwater investigations and monitoring at this site is to evaluate the effects of groundwater on plant foundations. The evaluation is performed to assure that the maximum groundwater elevation remains below the DCD site parameter value. The other significant objectives are to examine whether groundwater provides any safety-related water supply; to determine whether dewatering systems are required to maintain groundwater elevation below the required level; and to measure characteristics and properties of the site needed to develop a conceptual site model of groundwater movement, and to estimate the direction and velocity of movement of potential radioactive contaminants.

Section 2.4.12 of this SER presents an evaluation of the following specific areas:
(1) identification of the aquifers, types of onsite groundwater use, sources of recharge, present withdrawals and known and likely future withdrawals, flow rates, travel time, gradients (and other properties that affect the movement of accidental contaminants in groundwater), groundwater levels beneath the site, seasonal and climatic fluctuations, monitoring and protection requirements, and manmade changes that have the potential to cause long-term changes in local groundwater regime; (2) effects of groundwater levels and other hydrodynamic effects of groundwater on design bases of plant foundations and other SSCs important to safety; (3) reliability of groundwater resources and related systems used to supply safety-related water to the plant; (4) reliability of dewatering systems to maintain groundwater conditions within the plant's design bases; (5) potential effects of seismic and non-seismic information on the postulated worst-case groundwater conditions for the proposed plant site[2]; and (6) any additional information requirements prescribed in the "Contents of Application" sections of the applicable subparts to 10 CFR Part 52.

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[2] See Section 2.4.1.1 for a discussion of why seismic effects on groundwater conditions were not discussed.

2.4.12.2 Summary of Application

This section of the VCSNS COL FSAR addresses groundwater conditions in terms of impacts on structures and water supply. The applicant addressed these issues as follows:

AP1000 COL Information Item

- VCS COL 2.4-4

In addition, this section addresses the following COL Information Item 2.4.4 (COL Action Item 2.4.1-1) identified in Section 2.4.1.4 of the DCD.

> Combined License applicants referencing the AP1000 certified design will address site-specific information on groundwater. No further action is required for the sites within the bounds of the site parameter for ground water.

VCS COL 2.4-4 adds VCSNS COL FSAR Section 2.4.12 in its entirety.

Potential safety impacts resulting from on-site groundwater conditions were also considered in other sections of the FSAR and resultant SER. These are summarized below.

- VCS COL 3.4-1

COL Information Item 3.4-1 in Sections 3.4.1.3 and 3.4.3 of the DCD discussed the need for a permanent dewatering system and protective measures to prevent flooding based on site specific maximum operational groundwater levels.

To address this COL item, VCSNS FSAR Section 3.4.1.3 added the following text to the end of DCD Section 3.4.1.3

> No permanent dewatering system is required because site groundwater levels are 20 feet below site grade level as described in FSAR Section 2.4.12.5.

And the following text was added to the end of DCD Subsection 3.4.3.

> VCSNS site-specific water levels provided in FSAR Section 2.4 satisfy the AP1000 site interface requirements described in DCD Section 2.4.

- VCS COL 2.5-8

COL Information Item 2.5-8 was provided to resolve COL Action Item 2.4.1-1. This addresses the groundwater conditions relative to the foundation stability of the safety-related structures at the site. The applicant performed an analysis of foundation stability using the maximum groundwater level (380 ft) and maximum differential water head and this analysis was confirmed by NRC staff and found to be acceptable.

- VCS COL 2.5-11

COL Information Item 2.5-11 was provided to resolve COL Action Item 2.5.2-2. This addresses the impact of hydrostatic groundwater pressures on the safety-related structures at the site. The applicant performed an analysis of uplift forces on foundation and buried piping due to groundwater levels at the maximum operational groundwater level (380 ft) and at plant grade (400 ft) and this analysis was confirmed by NRC staff and found to be acceptable.

The conclusions related to these COL information items rely on the characterization of groundwater levels across the site and the assumption that maximum operational groundwater level for the site will be 380 ft. The technical validity of this characterization and assumption was independently evaluated and the results are presented in Section 2.4.12.4 of this SER.

2.4.12.3 Regulatory Basis

The acceptance criteria associated with the relevant requirements of the Commission regulations for groundwater are described in Section 2.4.12 of NUREG-0800.

The applicable regulatory requirements are:

- 10 CFR Part 100, as it relates to identifying and evaluating hydrological features of the site. The requirement to consider physical site characteristics in site evaluations is specified in 10 CFR 100.20(c).

- 10 CFR 100.23(d) sets forth the criteria to determine the siting factors for plant design bases with respect to seismically induced floods and water waves at the site.

- 10 CFR 52.79(a)(1)(iii), as it relates to identifying hydrologic site characteristics with appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area and with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

2.4.12.4 Technical Evaluation

The NRC staff reviewed Section 2.4.12 of the VCSNS COL FSAR and checked the referenced DCD to ensure that the combination of the DCD and the COL application represents the complete scope of information relating to this review topic.[1] The NRC staff's review confirmed that the information in the application and incorporated by reference addresses the required information relating to groundwater. The results of the NRC staff's evaluation of the information incorporated by reference in the VCSNS COL application are documented in NUREG-1793 and its supplements.

The staff reviewed the information in the VCSNS COL FSAR:

AP1000 COL Information Item

- VCS COL 2.4-4
- VCS COL 3.4-1
- VCS COL 2.5-8
- VCS COL 2.5-11

Information Submitted by the Applicant

In Section 2.4.12 of the VCSNS COL FSAR, the applicant presented information and data describing the regional hydrology, groundwater sources and usage, site hydrogeology, monitoring and safeguards, and the design bases for dewatering and hydrostatic loading. The applicant described the VCSNS site as being within the Piedmont physiographic province, which consists of metamorphic and igneous rock overlain by a layer of saprolite. The saprolite layer is a mixture of sand and clay that is essentially the weathered remains of the Piedmont bedrock. The applicant identified two zones of bedrock. The upper zone is the shallow bedrock, which is partially weathered and may have some fracturing. Groundwater in the partially weathered rock is associated with the groundwater conditions in the saprolite. The lower zone is the deep bedrock, which may have some fracturing that decreases with depth. Groundwater wells in the deep bedrock aquifers of the Piedmont typically only provide 5 to 15 gpm. In contrast, wells in the Coastal Plain province to the southeast can sustain pumping rates as high as 3,000 gpm (South Carolina Department of Natural Resources [SCDNR] 2004).

The applicant provided data from the SCDHEC that showed South Carolina used groundwater to provide only 17.3 percent of its consumptive water use in 2005. In Fairfield County, groundwater provides only 10 percent. In VCSNS COL FSAR Table 2.4-215, the applicant provided data for groundwater use for public water supply within 6 mi of the VCSNS site. All of the water systems extracted groundwater from the deep bedrock aquifer. The design yields for the wells ranged from 5 to 29 gpm. The populations served ranged from 25 to 1969.

The applicant characterized the hydrogeology of the VCSNS Units 2 and 3 site using groundwater observations, well tests, laboratory tests, and site topography and geology.

The applicant installed 31 observation wells (22 wells in the saprolite/shallow bedrock zone and 9 in the deep bedrock) and monitored water levels monthly from June 2006 to June 2007. The applicant used the data to construct groundwater surface maps that show that groundwater in the saprolite/shallow bedrock flows in all directions away from the ridgetop where Units 2 and 3 will be constructed. The applicant noted that the surface of the groundwater in the saprolite/shallow bedrock aquifer is similar to the topographic surface and that the topographic data show that all surface water drainages lead to the Broad River. The applicant stated that the deep bedrock aquifer was recharged from the shallow aquifer and that the deep aquifer flows directly to the Broad River.

Using the groundwater levels observed during the 13-month monitoring period, the applicant calculated horizontal gradients of 0.001 to 0.003 on top of the ridge and 0.037 to 0.05 on the ridge flanks. In the deep bedrock, the applicant reported horizontal gradients of 0.011 to 0.012 on top of the ride and 0.06 to 0.08 on the ridge flanks.

The applicant estimated vertical gradients between the saprolite/shallow bedrock aquifer and the deep bedrock aquifer using 10 of the observation wells. The applicant installed the 10 wells in a configuration of five well pairs so that each pair would provide an observation of water level in both aquifers at each of the five pair locations. The applicant determined that the two aquifers were directly connected on the ridgetop and the gradient was nearly zero. Away from the ridgetop, the vertical gradient increased. The applicant calculated vertical downward gradients of 1.58 and 2.07 in the drainage swale.

The applicant conducted slug tests in most of the observation wells to determine saturated conductivity. The values for the saprolite/shallow bedrock ranged from 0.0017 to 18 ft/day. The values for the deep bedrock ranged from 0.0088 to 0.38 ft/day. The applicant also conducted packer tests in two zones of each of four geotechnical borings in the deep bedrock. The results of the packer tests ranged from 0 to 1.14 ft/day.

The applicant analyzed seven samples of residual soil and 23 samples of saprolite to determine porosity, grain size, moisture content and specific gravity. The porosity of the residual soil ranged from 0.465 to 0.631. The porosity of the saprolite ranged from 0.401 to 0.632. The applicant assumed that the porosity of saprolite could be used to represent the porosity of the saprolite/shallow bedrock zone.

The applicant indicated that regional bedrock geology yields calcium carbonate-type groundwater. According to SCDHEC (2005), the dominant cations in the regional aquifer are calcium and sodium. Analyses reported by SCDHEC (2005) indicate that the water samples from 2004 display great similarity in composition, and are suitable for most purposes, with minor exceptions (related to the levels of iron, manganese, and total dissolved solids). The applicant indicated that the Jenkinsville Water Company reported the presence of naturally occurring radionuclides radium-226 and its daughter products in several of its wells, which the water company subsequently abandoned. The company is located 10 mi northeast of the Monticello Reservoir, and thus, hydraulically isolated from the VCSNS site.

The applicant stated that groundwater is not used for VCSNS Unit 1 and would not be used for the proposed Units 2 and 3.

The applicant stated that the existing monitoring program for VCSNS Unit 1 will be evaluated with respect to the addition of Units 2 and 3 to determine if modifications are needed to the existing radioactive effluent and environmental monitoring program for Unit 1 to also monitor the effect of Units 2 and 3 on groundwater. This is discussed further in Section 11.5 of this SER.

The applicant estimated the maximum groundwater level would be 380 ft, which is 20 ft below site grade. For the estimation, the applicant used the maximum level of 375.1 ft observed during the 13-month preconstruction monitoring period and the maximum seasonal groundwater fluctuation of 2.3 ft observed during the same period. By doubling the observed fluctuation, adding it to the maximum observed level, and rounding up, the applicant calculated the maximum water level to be 380 ft. The applicant examined well data collected from VCSNS Unit 1 between 1998 and 2006 and determined the fluctuations were less than the value used for the maximum water level calculation. Based on this estimated maximum groundwater level, the applicant determined that no permanent dewatering system is required.

<u>NRC Staff's Technical Evaluation</u>

The NRC staff issued RAI 2.4.12-1, RAI 2.4.12-2, and RAI 2.4.12-3 to obtain additional information on current and future groundwater use in the vicinity of the VCSNS site. In its response, the applicant explained the source of the groundwater supply data, provided private well data for the towns of Jenkinsville, Peak, Monticello, and Pomaria, which are the towns that are located nearest to the VCSNS site, and provided information on potential future groundwater use in the vicinity of the VCSNS site.

The applicant obtained population data from the EPA's SDWIS database and the remainder of the information from the SCDHEC database. The applicant noted that half of the water systems showed population values that differed from the SDWIS, but the applicant was unable to identify the source of those different numbers. The applicant stated that because the differences were small and the groundwater withdrawals were small, the impact to groundwater was minimal.

In regards to private well data, the applicant noted that the data do not include pumping rates and do not include data for private wells that do not have permits. The applicant also noted that the permitted private well data are maintained by the SCDHEC and can only be viewed on a "need to know" basis.

The applicant provided information on potential future groundwater use in the vicinity of the VCSNS site using information from Butler (2007). According to the applicant, population in Fairfield County is predicted to increase 12 percent by 2025 and groundwater use will increase in a similar fashion. The applicant stated that there are no plans to use local groundwater for construction or operation of VCSNS Units 2 and 3. The applicant plans to obtain water for construction from the Monticello Reservoir and the Jenkinsville Water Company. The applicant also plans to construct a water treatment plant to treat water from the Monticello Reservoir to provide the plant with potable water in the future.

The staff checked the SWDIS database on March 1, 2010. Some of the values match those in VCSNS COL FSAR Table 2.4-215 and some do not. For 10 of the 11 water systems, the population numbers are less than 50 regardless of the source. The 11th system, the Jenkinsville Water system, serves a population of either 1969 (FSAR Table 2.4-215) or 2217 (SDWIS); the SDWIS number is 13 percent higher. In either case, the population numbers are small and would not affect the analysis.

The staff reviewed the well data and examined the location of each town relative to the site. Monticello, Peak, and Pomaria are more than 3.2 km (2 mi) from the site and in alternate environmental settings. Peak and Pomaria are on the west side of the Parr Reservoir; the VCSNS site is located east of the reservoir. Monticello is on the eastern side of the Monticello Reservoir; the VCSNS site is on the south side. The staff concluded that groundwater at the VCSNS site would not be affected by the water systems in these towns because the Broad River and the Monticello Reservoir hydraulically isolate the VCSNS site from the water supply systems. The fourth town, Jenkinsville, is about 3.2 km (2 mi) southeast and at a nominal elevation of 141 m (463 ft), which is 19 m (63 ft) above the VCSNS site grade of 118 m (400 ft). The area between the plant site and Jenkinsville is drained by the Mayo Creek, which flows north to south. At its closest approach, the Mayo Creek passes the reactor buildings at a distance of 0.8 km (0.5 mi) to the east. The information provided in response to RAI 2.4.13-10 is consistent with the conceptual model; wherein the flow in Mayo Creek is essentially over bedrock. Because the VCSNS site is separated from Jenkinsville by the Mayo Creek, flow in the Mayo Creek is over bedrock, and bedrock in the area has a low conductivity. The staff concludes that wells in Jenkinsville will not impact the VCSNS site, nor will wells in Jenkinsville be impacted by groundwater changes onsite.

The staff reviewed the South Carolina Water Use Report 2006 Summary, South Carolina, Department of Environmental Control, Bureau of Water, dated July 2007, Butler (2007) reference cited by the applicant and confirmed that the population growth projection for Fairfield County between 2005 and 2025 is 12 percent. Butler (2007) also reported that groundwater in Fairfield County is used solely for water supply, thus, future use is expected to increase

12 percent to match the population increase. Overall, groundwater provided only 9 percent of the total water supply needs of Fairfield County in 2006. Because the applicant will not use groundwater for construction or operation of Units 2 and 3, and because no local well can be sited any closer than 1.2 km (0.75 mi) to the southeast, the staff concluded that the projected increase in groundwater use in Fairfield County will have no impact on Units 2 and 3. The staff reviewed VCSNS COL FSAR and confirmed that Sections 2.4.12.2.2 and 2.4.12.3.3 were revised as described in the responses to RAIs 2.4.12-2 and 2.4.12-3. Accordingly, the staff considers RAI 2.4.12-1, RAI 2.4.12-2, and RAI 2.4.12-3 closed. Section 2.4.13 of this SER further discusses RAI 2.3.13-10.

The NRC staff issued RAI 2.4.12-4 to obtain well test data and examine the analysis used by the applicant to calculate hydraulic conductivity. In a letter dated May 1, 2009, the applicant provided 34 input/output files for the aquifer test analysis model AQTESOLV. The applicant noted a transcription error for one well and identified the appropriate corrections for that error, which have been incorporated in the VCSNS COL FSAR.

The staff reviewed the AQTESOLV files to confirm the applicant's analysis. Slug-test data provided by the applicant showed good reproducibility between the rising and falling test responses as indicated by similar saturated hydraulic conductivity values for both the rising and falling head tests. When the rising and falling test values did not agree, the applicant used the larger more conservative estimate. For two well tests in the saprolite/shallow bedrock, the staff analysis yielded saturated hydraulic conductivity values that were 20 percent higher than the applicant's values. Although the staff values increased the geometric mean Ks value by 2 percent, the staff values did not affect the transport analysis in VSCNS COL FSAR Section 2.4.13 because the applicant used the 75th percentile Ks value of 1.7 ft/day, which was not affected by the updated Ks values. The staff reviewed VCSNS COL FSAR and confirmed that the applicant made the proposed changes. Accordingly, the staff considers RAI 2.4.12-4 closed.

The NRC staff issued RAI 2.4.12-5 to obtain local precipitation data for the period covering the groundwater monitoring program. In its response, the applicant provided precipitation data from the Parr climate station for the months of October 2006 through December 2007, which covers the period of groundwater monitoring. The applicant also provided groundwater elevation data for 8 wells for the period of July 2007 to November 2008.

The staff reviewed the precipitation data and the well responses. From January to May 2006, precipitation was 18 cm (7.1 in) below average for the Parr climate station (averages are for the period 1946 to 2009). From June to December 2006, which coincides with the first half of the monitoring period, precipitation was 39.1 cm (15.4 in) above average. The highest monthly precipitation, 29.8 cm (11.74 in), occurred in June 2006. From January to June 2007, precipitation was 9.7 cm (3.8 in) below average. Overall, precipitation from January 2006 through June 2007 was about 11.2 cm (4.4 in) above average. During the monitoring period (June 2006 to June 2007), there was very little response to seasonal changes in precipitation; in most wells, the response was less than 0.9 m (3 ft). This result is consistent with the significant depth below ground surface (about 15 m (50 ft)) in the vicinity of the reactor buildings. In all wells, the highest water table recorded was 114.3 m (375.1 ft). The data provided by the applicant showed that the existing groundwater was not sensitive to seasonal precipitation extremes. Accordingly, the staff considers RAI 2.4.12-5 closed.

The NRC staff issued RAI 2.4.12-6 to obtain a description of the impact of post-construction and operations on water table elevations and subsurface pathways. The information sought included site grading, land cover, recharge rates, and fill material properties. In its response, the applicant provided specifications for the common and structural fill for the foundation and for the drainage on the east that will be filled to provide an area for the cooling towers. The applicant acknowledged the uncertainty of recharge conditions and suggested the impacts will be local and that existing groundwater pathways will not be significantly impacted. The applicant confirmed that alternate flow paths to the east will be evaluated and presented in responses to RAIs related to VCSNS COL FSAR Section 2.4.13. The NRC staff held a conference call with the applicant on April 7, 2010, to discuss the nature of the surface conditions around the reactors that would affect recharge rates and thus groundwater levels. Subsequent to the call, the applicant provided detailed information in a letter dated May 27, 2010, on how precipitation falling on structures will be captured in gutters and routed to the surface water drainage system, such that it would not become recharged near the reactor buildings. On June 7 and 10, 2010, the NRC staff held two conference calls with the applicant to discuss the issue. The applicant explained that no topsoil would be used (it would just be fill material). The applicant described the fractional area occupied by the four main surface features within the protected zone (which is primarily the fenced area that surrounds the reactor buildings): a) buildings on the reactor basemat; b) buildings, roads, and pavement not above the basemat; c) grass-covered soil; and d) graveled compacted soil. The applicant described the graveled compacted soil as impervious so that it promotes runoff and minimizes plant growth. The applicant identified the maximum water level possible in the storm water basins and explained that the basins would be subject to South Carolina storm water management regulations and would be emptied within 72 hr of a storm event. The applicant provided a supplemental letter that documented the information provided on the phone calls. The applicant proposed to update the FSAR with a summary of this information. This is being tracked as **Confirmatory Item 2.4.12-1**.

The staff reviewed the applicant's response by examining VCSNS COL FSAR Figures 2.5.4-119 to 2.5.4-223, which show the cross-sections of the fill placement, and VCSNS COL FSAR Figure 2.4.5-245, which is the site grading plan. The grading plan shows that the final grade in the vicinity of the reactor complex slopes down from a plant grade elevation of 122 m (400 ft) to an elevation of 121 m (396 ft) on all four sides of the complex within about 46 m (150 ft) of the nearest structure.

VCSNS COL FSAR states that the maximum groundwater elevation will be 116 m (380 ft). This value was derived from well observations between June 2006 and June 2007. The maximum observed level was 114 m (375 ft) and the maximum observed fluctuation was 0.7 m (2.3 ft). A value of 1.5 m (5 ft) (roughly twice the observed fluctuation) was added to the maximum observed level to arrive at the maximum expected elevation of 115.8 m (380 ft). All of these values were derived for conditions before the site is constructed. They do not account for construction related changes to the site that could determine what the maximum operational groundwater levels will be. These include the large scale manipulations of the topography (e.g., losing up to 7.6 m (25 ft) in some locations and gaining up to 18.3 m (60 ft) in other areas), installation of massive infrastructure, removal of vegetation, and alteration of soil and fill surrounding the reactor buildings.

The site grading plan shows what appears to be a surface drainage swale at the 46-m (150-ft) distance. Such a feature could convey surface water away quickly, such that groundwater at that location would not exceed 121 m (396 ft). What happens to the water table elevation adjacent to the reactor buildings depends on the soil, vegetation, topography, and facility conditions (e.g., catch basins; drainage pipes) between the buildings and the drainage swale at 46 m (150 ft). As an example, the applicant estimated the hydraulic conductivity of the structural fill to be 1.0E-3 cm/second (s) (3.3E-5 feet per second (fps)) and the common fill to be 5.0E-5 cm/s (1.6E-6 fps). Figures 2.5.4-120 to 2.5.4-123 indicate that common fill would surround the structural fill. If precipitation infiltrates the structural fill, lateral flow away from the facility would be impeded by the common fill (because of its much lower conductivity).

Following construction, runoff will be significantly reduced as slopes are lowered from 3-10 percent to 1 percent and transpiration will be significantly reduced by the removal of trees and shrubs (and potentially grasses in the case of graveled surfaces). Reductions in runoff or transpiration could lead to significantly increased recharge rates depending on the nature of the post-construction surfaces. But the staff finds that the procedure described by the applicant for collecting all precipitation that falls on buildings and routing it to the surface water collection system will convey the water offsite and preclude the enhancement of recharge to groundwater around the reactor buildings that could cause the groundwater level to rise above the DCD level.

According to the applicant, the storm water basins would not hold water except during the period (up to 72 hr) following a storm event. Because the basins would generally be dry, the staff concludes that the basins would not be constant contributors to recharge that could raise the groundwater level higher than expected.

The applicant explained that the surface features within the protected area are not conducive to recharge. The buildings, roads, and pavement will route precipitation to the drainage swales and on to the storm water management system. The grassed area will be confined to the perimeter of the protected area and coincide with the drainage system. The graveled compacted soil will be emplaced to maximize runoff to the drainage system. The staff concludes that conditions within the protected area, which surrounds the reactor buildings, will not be conducive to recharge rates that could raise the groundwater level above the DCD level. Given the actions proposed by the applicant to reduce recharge, the staff concludes that the maximum groundwater level will likely not exceed the applicant's estimate of 380 ft. As a result, the staff concludes that 380 ft is an acceptable estimation of maximum groundwater levels to use in calculations performed in related SER sections (2.5 and 3.4) and that no permanent dewatering system will be required to maintain groundwater levels below the DCD requirement of 2 feet below site specific plant grade (400ft).

The applicant proposed to provide information on the land cover details in the protected areas. This is identified as **Confirmatory Item 2.4.12-1**. Once the expected information is received, the staff will be able to consider RAI 2.4.12-6 closed.

2.4.12.5 Post Combined License Activities

There are no post-COL activities related to this section.

2.4.12.6 Conclusion

The staff has reviewed the application and has confirmed that the applicant addressed the information relevant to groundwater, and that no outstanding information is expected to be addressed in the COL FSAR related to this section. As set forth above, the applicant presented and substantiated information to establish the site description. The staff has reviewed the information provided and, pending resolution of **Confirmatory Item 2.4.12-1**, concludes that the applicant has provided sufficient details about the site description to allow the staff to evaluate, as documented in Section 2.4.12, of this SER, whether the applicant has met the relevant requirements of 10 CFR Part 52.79(a)(1)(iii) and 10 CFR Part 100 with respect to determining the acceptability of the site. This addresses COL information item VCS COL 2.4-4, VCS COL 2.5-8, VCS COL 2.5-11, and VCS COL 3.4-1. In conclusion, the applicant has provided sufficient information for satisfying 10 CFR Part 52 and 10 CFR Part 100.

2.4.13 Accidental Release Of Radioactive Liquid Effluent In Ground And Surface Waters

2.4.13.1 <u>Introduction</u>

VCSNS COL FSAR Section 2.4.13 provides a characterization of the attenuation, retardation, dilution, and concentrating properties governing transport processes in the surface-water and groundwater environment at the site. This section's goal is not to provide an assessment of the impacts of a specific release scenario but to provide a suitable conceptual model of the hydrological environment for other assessments. Since it would be impractical to characterize all the physical and chemical properties (e.g., hydraulic conductivities, porosity, mineralogy, etc.) of a time-varying and heterogeneous environment, FSAR Section 2.4.13 characterizes the environment in terms of the projected transport of a postulated release of radioactive waste. The accidental release of radioactive liquid effluents in ground and surface waters is evaluated using information of existing uses of groundwater and surface water and their known and likely future uses as the basis for selecting a location to summarize the results of the transport calculation. The source term from a postulated accidental release is reviewed under NUREG-0800 Section 11.2 following the guidance in Branch Technical Position (BTP) 11-6, "Postulated Radioactive Releases Due to Liquid-containing Tank Failures." The source term is determined from a postulated release from a single tank outside of the containment.

Section 2.4.13 of this SER presents an evaluation of the following specific areas: (1) alternative conceptual models of the hydrology at the site that reasonably bound hydrogeological conditions at the site inasmuch as these conditions affect the transport of radioactive liquid effluent in the ground and surface water environment; (2) a bounding set of plausible surface and subsurface pathways from potential points of an accidental release to determine the critical pathways that may result in the most severe impact on existing uses and known and likely future uses of ground and surface water resources in the vicinity of the site; (3) ability of the groundwater and surface water environments to delay, disperse, dilute, or concentrate accidentally released radioactive liquid effluents during transport; and (4) assessment of scenarios wherein an accidental release of radioactive effluents is combined with potential effects of seismic and non-seismic events[2].

2.4.13.2 <u>Summary of Application</u>

This section of the VCSNS COL FSAR addresses the accidental release of radioactive liquid effluents in ground and surface waters. The applicant addressed these issues as follows:

<u>AP1000 COL Information Item</u>

- VCS COL 2.4-5 and VCS COL 15.7-1

In addition, this section addresses the following COL Information Item 2.4.5 (COL Action Item 2.4.1-1) identified in Section 2.4.1.5 of the DCD.

> Combined License applicants referencing the AP1000 certified design will address site-specific information on the ability of the ground and surface water to disperse, dilute, or concentrate accidental releases of liquid effluents. Effects of these releases on existing and known future use of surface water resources will also be addressed.

VCS COL 2.4-5 adds VCSNS COL FSAR Section 2.4.13 in its entirety.

Also, VCSNS COL FSAR Section 15.7.6 states that VCS COL 15.7-1 is addressed in FSAR Section 2.4.13. In FSAR Section 2.4.13, the applicant performed the consequence analysis of a postulated liquid waste tank failure to address COL Information Items 2.4-5 and 15.7.1. This is also evaluated in SER Section 11.2.

The staff does not limit its review to just surface water. The staff considers both surface water and groundwater resources in their independent review.

2.4.13.3 Regulatory Basis

The acceptance criteria associated with the relevant requirements of the Commission regulations for the pathways of liquid effluents in ground and surface waters are described in Section 2.4.13 of NUREG-0800.

The applicable regulatory requirements for liquid effluent pathways for groundwater and surface water are as follows:

- 10 CFR Part 100, as it relates to identifying and evaluating hydrological features of the site. The requirement to consider physical site characteristics in site evaluations is specified in 10 CFR 100.20(c).
- 10 CFR 100.23(d) sets forth the criteria to determine the siting factors for plant design bases with respect to seismically induced floods and water waves at the site.
- 10 CFR 52.79(a)(1)(iii), as it relates to identifying hydrologic site characteristics with appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area and with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

Appropriate sections of the following documents are used for the related acceptance criteria:

- BTP 11-6 provides guidance in assessing a potential release of radioactive liquids following the postulated failure of a tank and its components, located outside of containment, and impacts of the release of radioactive materials at the nearest potable water supply, located in an unrestricted area, for direct human consumption or indirectly through animals, crops, and food processing.

- RG 1.113, “Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I,” Revision 1.

2.4.13.4 Technical Evaluation

The NRC staff reviewed Section 2.4.13 of the VCSNS COL FSAR and checked the referenced DCD to ensure that the combination of the DCD and the COL application represents the complete scope of information relating to this review topic.[1] The NRC staff’s review confirmed that the information in the application and incorporated by reference addresses the required information relating to accidental releases of radioactive liquid effluents in ground and surface waters. The results of the NRC staff’s evaluation of the information incorporated by reference in the VCSNS COL application are documented in NUREG-1793 and its supplements.

The staff reviewed the information in the VCSNS COL FSAR:

AP1000 COL Information Item

- VCS COL 2.4-5 and VCS COL 15.7-1

The technical evaluation addresses four issues: conceptual model, alternative pathways, effective porosity, behavior of well OW-627a, and the dilution factor for the Mayo Creek.

Information Supplied by the Applicant

In Section 2.4.13 of the VCSNS COL FSAR, the applicant presented information and data describing a postulated accidental release of radioactive liquid effluents in groundwater and surface water. In addition to describing the accidental release, the applicant described the conceptual models of the site, the modeling approach, the screening process, accidental release to surface water, and meeting the acceptance criteria in BTP 11-6.

The applicant selected the tank that failed in the accidental release scenario based on information in Table 11.2-2 of the AP1000 DCD. According to the applicant, the scenario is an instantaneous release from one of the two effluent holdup tanks located in the lowest level of the AP1000 auxiliary building. Each effluent holdup tank holds 28,000 gallons. The applicant assumed the contents would be 101 percent of the reactor coolant concentrations of tritium, corrosion products, and other radionuclides identified by the reactor vendor and in accordance with guidance provided in BTP 11-6. The applicant provided the expected concentrations in VCSNS COL FSAR Table 2.4-225. The applicant described the effluent holdup tanks as having the highest potential radionuclide concentration and the largest volume and, therefore, release from one of those tanks would lead to the most adverse contamination of groundwater.

The applicant described the conceptual model of the release. In accordance with BTP 11-6, 80 percent (22,400 gallons) of the tank volume is released instantaneously and flows through floor drains to the sump. The applicant assumed the sump pumps would not work and that a pathway would exist through either the 6-ft-thick concrete floor or the 3-ft-thick concrete walls. The slab of the room containing the effluent tanks is 5 to 7 ft below the groundwater levels measured during the monitoring period and would be 17 ft below the maximum groundwater level. Although groundwater pressure outside the structure would likely cause an influx of groundwater into the structure, the applicant assumed groundwater would not enter and assumed it would not impede the exodus of the leaked effluent tank liquid.

The applicant assumed the leaked liquid would enter the saprolite/shallow bedrock zone and flow down gradient to the nearest discharge points. The applicant identified the primary discharge points as the unnamed creek to the north-northwest of Unit 2 and the unnamed creek to the south-southwest of Unit 3. The two pathways are illustrated in VCSNS COL FSAR Figure 2.4.252.

The applicant considered alternative pathways. In the case of bedrock pathways, the applicant decided that much lower conductivity would yield longer travel times. In the case of discharge to other nearby creeks, the applicant decided that the longer travel pathways would yield longer travel times. The applicant did not consider the alternative pathways in the transport analysis because the longer travel times would yield lower impacts than the primary pathways.

The applicant stated that there were no water supply wells between the release points and the groundwater discharge points. The applicant identified surface water uses on the Broad River downstream of the VCSNS site. The applicant noted that potable water resources exist on South Carolina Electric and Gas (SCE&G) property, are under the control of SCE&G, and will be monitored and controlled in the event of an accidental tank rupture. The applicant did not include the SCE&G potable water supply in the accident release analysis.

For the transport calculation, the applicant used an analytical solution based on the advection-dispersion-reaction equation (Javandel, et al. 1984). The applicant included all progeny that were important from a dose perspective. The applicant used a linear sorption model to represent sorption of contaminants to sediments. With this model, the contaminant-specific K_d parameter relates sorption linearly to groundwater concentration. The applicant neglected hydrodynamic dispersion (which reduces concentrations) to yield a more conservative result.

The applicant identified the parameters used to calculate transport along the primary pathway for each unit. SER Table 2.4-2 summarizes both the parameters and the resulting calculated values of groundwater velocity and travel time.

The applicant analyzed the results in three steps. In the first step, the applicant considered only radioactive decay. Of the original 57 constituents, only 8 exceeded 1 percent of the maximum permissible concentration for the Unit 2 pathway and only 7 for the Unit 3 pathway.

In the second step, the applicant considered both decay and adsorption. The applicant measured K_d values for cobalt, strontium, and cesium on multiple saprolite samples from the VCSNS site. For the transport analysis, the applicant assigned the lowest measured K_d values for cobalt, strontium, and cesium. For the remaining radionuclides (H-3, I-129, Fe-55, and Y-90), the applicant assigned K_d values of zero. The applicant used a bulk density value of 1.41 g/cm3 and an effective porosity value of 0.39 to translate the adsorption values in retardation values. Of the radionuclides evaluated, only hydrogen (H)-3, Iron (Fe)-55 and Iodine(I)-129 exceeded 1 percent of the permissible concentrations for Unit 2 and only H-3 and I-129 exceeded 1 percent for Unit 3.

In the third step, the applicant calculated the groundwater flow rate into the unnamed creeks. The applicant assumed the plume was 10 ft thick and square (in plan view). The applicant assumed the effluent liquid filled the entire effective porosity of 0.39. Using those assumptions and the hydraulic gradients in SER Table 2.4-2, the applicant calculated the flow rate to the unnamed creeks. The applicant noted that uncontaminated flow in the creeks would dilute the effluent, but the applicant did not include this dilution in the analysis. Once flow reached the Broad River, the applicant assumed the effluent would be diluted further. The applicant used the 100-year daily mean low flow value of 125 cfs to calculate a conservative dilution factor. Table 2.4-2 shows that the dilution factor for each unit was roughly 10^{-6}. Conservatively, the applicant did not consider the additional dilution that would occur in the existing water impounded in the Parr Reservoir.

The applicant stated that in the AP1000 design, there are no outdoor tanks containing radioactivity. The unstated conclusion is that there would be no accidental release to surface water. However, most of the groundwater pathways evaluated eventually reach surface water, and it is as surface water concentrations that the radionuclides are considered relative to 10 CFR 20 Appendix B limits as described in BTP 11-6.

The applicant assessed compliance with 10 CFR Part 20 Appendix B limits using the sum-of-fractions approach in which the sum must not exceed 1.0, as explained in BTP 11-6. For each radionuclide, the applicant calculated the ratio of the concentration of that radionuclide at the compliance point to the concentration permitted. The applicant provided those ratios in VCSNS COL FSAR Tables 2.4-235 and 2.4-236. The applicant summed all ratios (i.e., fractions) for each unit and determined the sum was 5.32×10^{-4} for Unit 2 and 3.01×10^{-3} for Unit 3. For both units, the sums are well below the limit of 1.0. The applicant concluded that an accidental release of effluents to groundwater would not exceed the criteria in BTP 11-6.

NRC Staff Technical Evaluation

The NRC staff issued RAIs 2.4.13-2, 2.4.13-7, and 2.4.13-10 to obtain conceptual model information on the subsurface environment, a statement about the use of chelates and complexants, and a description of the Mayo Creek bed.

In response to RAI 2.4.13-2, the applicant provided a description of the process used to define the conceptual site model of the subsurface environment. The applicant used that conceptual site model to postulate two primary pathways and eight plausible alternative pathways. The applicant calculated the travel time along all ten pathways and identified the pathway with the shortest travel time (7.7 years through the saprolite/shallow bedrock from Unit 2 to the unnamed creek to the northwest). The applicant proposed to make changes to the VCSNS COL FSAR to address all ten alternative pathways.

In response to RAI 2.4.13-7, the applicant stated that “Chelates & complexants are not planned to be used for Units 2 and 3.”

In response to RAI 2.4.13-10, the applicant provided the results of a field survey of the Mayo Creek where it passes the outlet of the main eastern surface drainage for the saprolite/shallow bedrock pathway from Units 2 and 3. Over a distance of about 1100 ft, the applicant used visual inspection and hand auguring to characterize stream sediments and substrate. The applicant identified specifics for seven locations. At the three most upstream locations, the augur penetrated some sand and clay, but met resistance and outright hard rock within a couple of feet. At the four locations on the downstream end, rock ledges and outcrops were directly observed. The applicant provided a picture showing water flowing over rock ledges at about the point where the surface drainage from the VCSNS site enters the Mayo Creek. The applicant also provided a USGS topographic map of the Mayo Creek basin showing that the creek is perennial in the section that was sampled and intermittent about 1750 ft upstream.

The staff reviewed the proposed conceptual site model, primary and alternate pathways, and transport calculations. The pathways include transport from Unit 2 and Unit 3 and through the shallow aquifer and the deep bedrock. Endpoints include the Broad River, the Mayo Creek, and a hypothetical private well. The parameters used by the applicant to calculate flow and transport are reasonable. For some parameters, the applicant used conservative values as a means to overcome variability and uncertainty. Examples are the use of the 75th percentile hydraulic conductivity and the lowest of all K_d values measured for each radionuclide.

The staff determined that the applicant's estimation of an effective porosity for the saprolite/shallow bedrock was not conservative with respect to travel time. The applicant estimated an effective porosity of 0.27 based on grain size information. In response to RAI 2.4.13-2, the applicant corrected the estimate to 0.18 to represent the field value assuming the particle size estimate exceeded the field estimate by a factor of 1.50 based on data reported by Stephens et al. (1998). In that reference, the particle-size based estimate exceeded the field estimate by a factor of 1.82. For the VCSNS site, that means the original estimate of 0.27 should be reduced to 0.146. This corrected value is a better estimate of the nominal value and is not necessarily conservative. The staff determined that a conservative value of effective porosity would be something less than 0.146. To demonstrate the impact of a reasonably conservative effective porosity, the nominal value was reduced by 25 percent to yield a conservative effective porosity value of 0.11 (a lower effective porosity value is conservative because it yields a shorter travel time). Using this value, staff calculated travel times that are 39 percent shorter in the saprolite/shallow bedrock than reported by the applicant. The staff determined that using the shorter and more conservative travel time would increase the sum of fractions, but for all pathways, the sum would be less than 0.1, which is well below the allowable limit of 1.0 as described in acceptance criteria in BTP 11-6.

Another parameter value that the staff considered nonconservative was the post-construction water table, which affects groundwater gradients. As discussed in the response to RAI 2.4.12-6, the applicant's post-construction water table does not address post-construction recharge conditions. To be conservative, the staff considered one possibility to be that the water table could be as high as 398 ft, which is the maximum allowable groundwater elevation. Using that elevation to calculate groundwater gradients, the staff determined that the travel times for the two primary pathways would decrease by 53 percent for Unit 2 and 31 percent for Unit 3. For the pathway from either reactor to the Mayo Creek, the travel time reduction would be about 34 percent. The higher groundwater gradients shorten travel times but do not change the ranking of pathways. Using the conservative gradient for the primary pathway (the one with the shortest travel time) yields a travel time of 3.6 years (versus the 7.7 years reported by the applicant). Even though the travel time would be shorter, the dilution by the Broad River lowers concentrations well below the limits identified in 10 CFR Part 20, Appendix B, Table 2, Column 2. For the pathways to the Mayo Creek, the dilution factor is lower by a factor of 2000 relative to the Broad River, which means the sum of fractions will be higher. The applicant reports the highest sum of fractions is 0.054 and it occurs for the pathway through saprolite/shallow bedrock between Unit 3 and the Mayo Creek (in contrast, the sum of fractions for the primary pathway is 0.00011). The staff determined that the larger and more conservative groundwater gradient would increase the sum of fractions to a value just below 0.1, which is still far below the acceptance criteria of 1.0.

The staff considered the possibility that the groundwater level could be somewhat higher than expected based on preconstruction levels (although not exceed the DCD level; see discussion of the applicant's response to RAI 2.4.12-6 in Section 2.4.12.4.4 of this SER). A higher water table could lead to the formation of seeps and springs. Such features could shorten the travel time of contaminants to a surface water body. Pathways that end in the Broad River would still yield sums of fractions below the regulatory limit because of the dilution potential of the river. Pathways toward the Mayo Creek could be shortened significantly. The staff reviewed the site grade plan in VCSNS COL FSAR Figure 2.5.4-245 and determined that common fill material would make up approximately 70 percent of the distance between either Unit 2 or 3 and the Mayo Creek. In response to RAI 2.4.12-6, the applicant stated the hydraulic conductivity of the common fill would be 5.0 x 10-5 cm/s (0.1417 ft/day). This value is 12 times lower than the hydraulic conductivity of the saprolite/shallow bedrock material that comprises the shallow pathways to the Mayo Creek. Because the fill has a much lower value, any seeps and springs that do appear will be from points that are down slope of the fill area. If so, the travel distance, and thus, travel time, to the Mayo Creek would only be shortened by up to 30 percent. The staff determined that the reduced travel time would increase the sum of fractions to a value just below 0.1, which is still far below the acceptance criteria of 1.0.

The staff concluded that because chelating agents and complexants will not be used, there will be no impact to sorption of radionuclides in the groundwater.

The staff reviewed the field observations relative to the Mayo Creek, the locations of the observations relative to the eastern drainage, the picture of the streambed, and the USGS map. The staff concluded that the Mayo Creek is likely a gaining stream fed by groundwater that flows on top of bedrock.

In summary, the conceptual model questions were addressed. The staff confirmed that the proposed changes to the VCSNS COL FSAR were incorporated. Accordingly, the staff considers RAIs 2.4.13-2, 2.4.13-7 and 2.4.13-10 closed.

The NRC staff issued RAIs 2.4.13-3, 2.4.13-4, 2.4.13-5, and 2.4.13-12 to identify and evaluate alternative pathways and parameters. In response, the applicant referred to its response to RAI 2.4.13-2. In that response, the applicant described 10 possible pathways: four in saprolite/shallow bedrock and six in the deep bedrock.

The staff reviewed the 10 alternate pathways and associated parameters. Six bedrock pathways were examined. For each unit, one pathway was west to the Broad River, one was east to the Mayo Creek, and one was east to a hypothetical private well. For all pathways, the hydraulic conductivity of the deep bedrock was 0.4 ft/day. This value is higher than seven of the eight values measured onsite and the staff considers it to be conservative. For all pathways, the effective porosity was set equal to 0.04, which was estimated to be 80 percent of the porosity value of 0.05, which was itself estimated from regional values. The staff considers these values to be reasonable. Travel times for all bedrock pathways ranged from 35 to 69 years. These times are much greater than the 7.7 years for the primary pathway, which is through the saprolite/shallow bedrock between Unit 2 and the unnamed creek to the northwest. The staff considered a more conservative effective porosity value of 0.02, which is half the value used by the applicant. With the conservative value, the travel times for the deep bedrock pathways were reduced by half. Even so, the times were still more than double the travel time of the primary pathway. Because conservative values of conductivity and effective porosity yielded travel times longer than the primary pathway, the staff concluded that the deep bedrock pathways would not yield the most conservative accidental release scenario.

The staff reviewed the eastern pathways in the saprolite/shallow bedrock from Units 2 and 3 toward the Mayo Creek. Even when using more conservative values of effective porosity and hydraulic gradients, travel times are longer than the primary pathway. Because the travel times are longer, the staff concluded that the saprolite/shallow bedrock pathways to the Mayo Creek would not yield the most conservative accidental release scenario.

The staff reviewed the eastern pathway in the deep bedrock from Units 2 and 3 toward the Mayo Creek and the impact to possible receptors at the Mayo Creek and a hypothetical private well. Even when using conservative values of conductivity and effective porosity, travel times are longer than the primary pathway. Because the travel times are longer, the staff concluded the deep bedrock pathways would not yield the most conservative accidental release scenario.

In summary, the staff considered the ten alternative pathways that covered multiple directions and the two primary geologic units and confirmed that the primary pathways identified by the applicant are the primary pathways. The staff confirmed that the proposed changes to the VCSNS COL FSAR were incorporated. Accordingly, the staff considers RAIs 2.4.13-3, 2.4.13-4, 2.4.13-5 and 2.4.13-12 closed.

The NRC staff issued RAI 2.4.13-8 to obtain a description of the conservativeness of the effective porosity parameter. In response, the applicant referred to its response to RAI 2.4.13-2, in which the applicant described the estimation of the effective porosity estimate.

In the staff's evaluation of the applicant's response to RAI 2.4.13-2, the staff noted that the effective porosity for the saprolite/shallow bedrock was reasonable but not necessarily conservative. The staff evaluated a conservative value (half the nominal value) and determined that the result would not change the outcome of the accident release scenario, which is that the site meets criteria identified as 10 CFR Part 20, Appendix B, Table 2, Column 2. In its evaluation of the applicant's response to RAI 2.4.13-3, the staff examined the effective porosity value used for the deep bedrock pathways. Based on that examination, the staff determined that a more conservative value of effective porosity for the deep bedrock pathways would not change the outcome of the accident release scenario, which is that the site meets criteria identified as 10 CFR Part 20, Appendix B, Table 2, Column 2. Accordingly, the staff considers RAIs 2.4.13-2 and 2.4.13-8 closed.

The NRC staff issued RAI 2.4.13-11 to obtain any additional data on bedrock well OW-627a that might explain its anomalous behavior. In its response, the applicant provided one additional water level measurement taken on January 27, 2009, in wells OW-627a (316.3 ft) and OW-627b (315.3 ft) as part of a well abandonment effort. The applicant stated that the measurements by the well abandonment contractor were not conducted under quality control protocol, so those measurements should be considered approximate. The applicant also provided Figure RAI 2.4.13-11-1 that shows the hydrographs for both wells from June 2006 to January 2009.

The staff reviewed the well data and examined MACTEC (2007). Geotechnical borehole B-627 and groundwater monitoring wells OW-627a and OW-627b are located within 15 ft of each other. The water table at this location is approximately 12 to 15 ft below ground surface. The shallow aquifer material is alluvium to a depth of 16.7 ft, saprolite from 16.7 to 46 ft, and partially weathered rock from 46 to 57.5 ft. The top of sound rock is at 61.5 ft (an elevation of 264.8 ft). Well OW-627b is screened across the interface of the saprolite and partially weathered rock. Well OW-627a is screened within sound rock. The water level elevation in this borehole (OW-627a) rose from 250 ft to 316.3 ft between October 2006 and January 2009. The January 2009 level is consistent with the water level in the shallow aquifer. The change in water level in the deep borehole could be caused by either equilibration with the local bedrock aquifer or by communication with the upper shallow aquifer. Either way, the slow response (about 2.5 years) indicates a very low hydraulic conductivity (the applicant estimates it to be 3.0×10^{-8} cm/s) and likely a low fracture density. Because of the low conductance and higher travel times that result, the staff concludes that the deep bedrock pathway to the east, although plausible, is not the most conservative pathway. Accordingly, the staff considers RAI 2.4.13-11 closed.

The NRC staff issued RAI 2.4.13-9 to obtain a description of the process used to estimate the dilution factor for the Mayo Creek. In its response, the applicant described the method used to calculate the 100-year low annual mean flow in the Mayo Creek where it passes beneath Parr Road. The Mayo Creek is not gauged, so the applicant developed a regression equation relating annual flow to drainage area. The equation was based on data from nine gauged watersheds with areas less than 50 sq mi in similar piedmont settings and at least 17 years of data. Two estimates of the 100-year low annual mean flow were derived. Using all the data yielded an estimate of 0.54 cfs. Deleting one outlier datum from the regression improved the regression fit R2 from 0.51 to 0.73. The resulting 100-year low flow was 0.39 cfs. The applicant used the lower estimate of 0.39 cfs for the analysis because it was the more conservative of the two estimates.

The staff reviewed the method and results. Relating annual flow conditions in an ungauged watershed to data from gauged watersheds is an acceptable method for estimating low-flow statistics. As a check, the staff considered a conservative low-flow value of 0.195 cfs, which is half the applicant's value. As a result, the dilution factor for Mayo Creek would be reduced by half and the sum of fractions would be increased to 0.11, which is still well below the maximum allowable value of 1.0. Accordingly, the staff considers RAI 2.4.13-9 closed.

2.4.13.5 Post Combined License Activities

There are no post-COL activities related to this section.

2.4.13.6 Conclusion

The staff has reviewed the application and has confirmed that the applicant addressed the relevant information and there is no outstanding information expected to be addressed in the VCSNS COL FSAR related to this section. As set forth above, the applicant presented and substantiated information to establish the potential effects of accidental releases from the liquid waste management system. The staff has reviewed the information provided and, for the reasons given above, concludes that the applicant has provided sufficient details about the site description, and about the design of the liquid waste management system, to allow the staff to evaluate, as documented in this section, whether the applicant has met the relevant requirements of 10 CFR Part 52.79(a)(1)(iii) and 10 CFR Part 100 with respect to determining the acceptability of the site, and with respect to 10 CFR 20 as it relates to effluent concentration limits. This addresses COL Information Item 2.4-5 and 15.7-1. In conclusion, the applicant provided sufficient information for satisfying 10 CFR Part 20, 10 CFR Part 52, and 10 CFR Part 100.

2.4.14 Technical Specification and Emergency Operation Requirements

2.4.14.1 Introduction

FSAR Section 2.4.14 of the VCSNS COL application describes the technical specifications and emergency operation requirements as necessary. The requirements described implement protection against floods for safety-related facilities to ensure that an adequate supply of water for shutdown and cool-down purposes is available.

Section 2.4.14 of this SER presents an evaluation of the following specific areas: (1) controlling hydrological events, as determined in previous hydrology sections of the FSAR, to identify bases for emergency actions required during these events; (2) the amount of time available to initiate and complete emergency procedures before the onset of conditions while controlling hydrological events that may prevent such action; (3) reviewing technical specifications related to all emergency procedures required to ensure adequate plant safety from controlling hydrological events by the organization responsible for the review of issues related to technical specifications; (4) potential effects of seismic and non-seismic information on the postulated technical specifications and emergency operations for the proposed plant site; and (5) any additional information requirements prescribed in the “Contents of Application” sections of the applicable subparts to 10 CFR Part 52.

2.4.14.2 Summary of Application

This section of the VCSNS COL FSAR addresses technical specifications and emergency operation requirements. The applicant addressed the information as follows:

AP1000 COL Information Item

- VCS COL 2.4-6

In addition, this section addresses the following COL Information Item 2.4.6 (COL Action Item 2.4.1-1) identified in Section 2.4.1.6 of the DCD.

> Combined License applicants referencing the AP1000 certified design will address any flood protection emergency procedures required to meet the site parameter for flood level.

VCS COL 2.4-6 adds VCSNS COL FSAR Section 2.4.14 in its entirety.

2.4.14.3 Regulatory Basis

The acceptance criteria associated with the relevant requirements of the Commission regulations for consideration of emergency protective measures are described in Section 2.4.14 of NUREG-0800.

The applicable regulatory requirements are:

- 10 CFR Part 100, as it relates to identifying and evaluating hydrological features of the site. The requirement to consider physical site characteristics in site evaluations is specified in 10 CFR 100.20(c).

- 10 CFR 100.23(d) sets forth the criteria to determine the siting factors for plant design bases with respect to seismically induced floods and water waves at the site.

- 10 CFR 52.79(a)(1)(iii), as it relates to identifying hydrologic site characteristics with appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area and with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

- 10 CFR 50.36, as it relates to identifying technical specifications related to all emergency procedures required to ensure adequate plant safety from controlling hydrological events by the organization responsible for the review of issues related to technical specifications.

2.4.14.4 Technical Evaluation

The NRC staff reviewed Section 2.4.14 of the VCSNS COL FSAR and checked the referenced DCD to ensure that the combination of the DCD and the COL application represents the complete scope of information relating to this review topic.[1] The NRC staff's review confirmed that the information in the application and incorporated by reference addresses the required information relating to technical specifications and emergency operation requirements. The results of the NRC staff's evaluation of the information incorporated by reference in the VCSNS COL application are documented in NUREG-1793 and its supplements.

The staff reviewed the information in the VCSNS COL FSAR:

AP1000 COL Information Item

- VCS COL 2.4-6

Information Submitted by the Applicant

The applicant states Section 2.4.3 of the FSAR establishes that the site is dry and flood protection is not required.

NRC Staff's Technical Evaluation

Based on the fact that the NRC staff has established that the design basis flood of the local intense precipitation discussed in Section 2.4.2 of this SER, the staff determined that flood neither protection technical specifications or emergency procedures are required.

2.4.14.5 Post Combined License Activities

There are no post-COL activities related to this section.

2.4.14.6 Conclusion

The staff reviewed the application and confirmed that the applicant has addressed the information relevant to technical specification and emergency operations requirements, and there is no outstanding information required to be addressed in the VCSNS COL FSAR related to this section.

As set forth above, the applicant has presented and substantiated information to establish the site description. The staff has reviewed the information provided and, for the reasons given above, concludes that the applicant has provided sufficient details about the site description to allow the staff to evaluate, as documented in Section 2.4.14, of this SER, whether the applicant has met the relevant requirements of 10 CFR Part 52.79(a)(1)(iii) and 10 CFR Part 100 with respect to determining the acceptability of the site. This addresses COL Information Item 2.4.6.

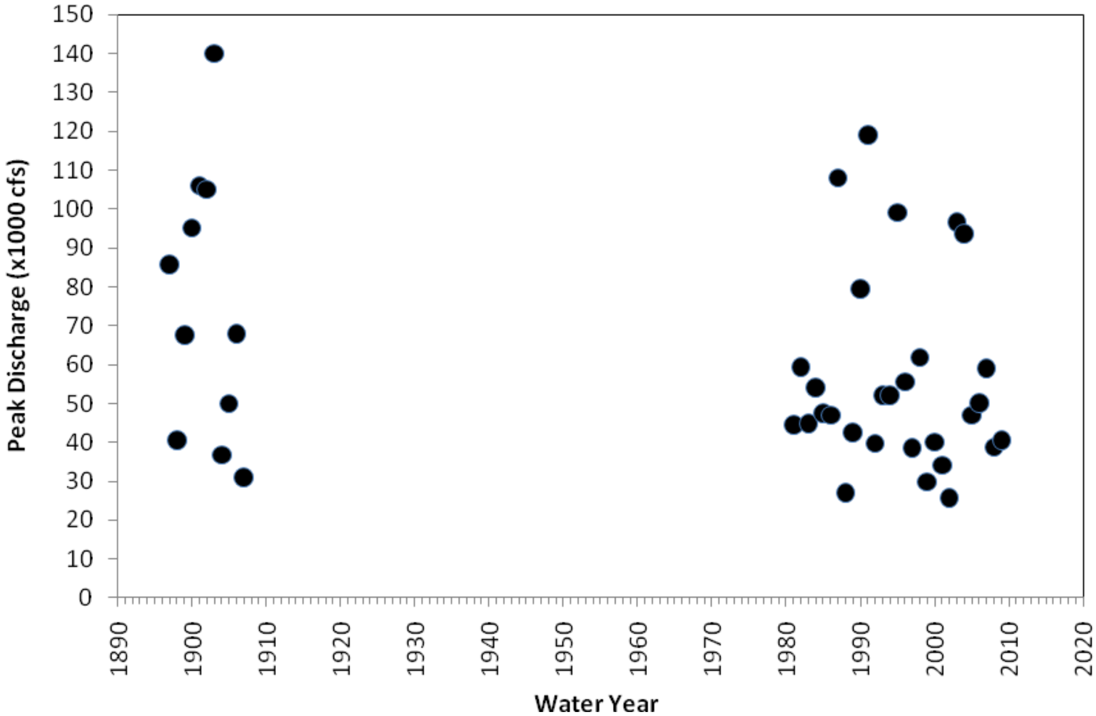

Figure 2.4-1. Peak Discharges Reported for Alston, South Carolina

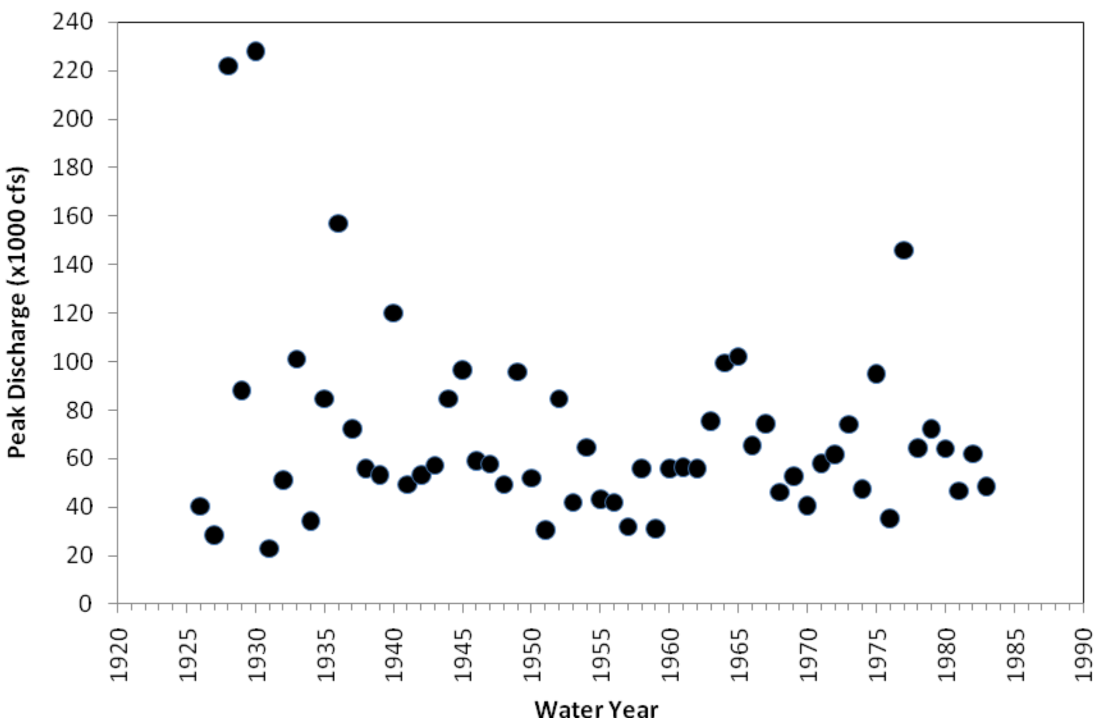

Figure 2.4-2. Peak Discharges Reported for Richtex, South Carolina

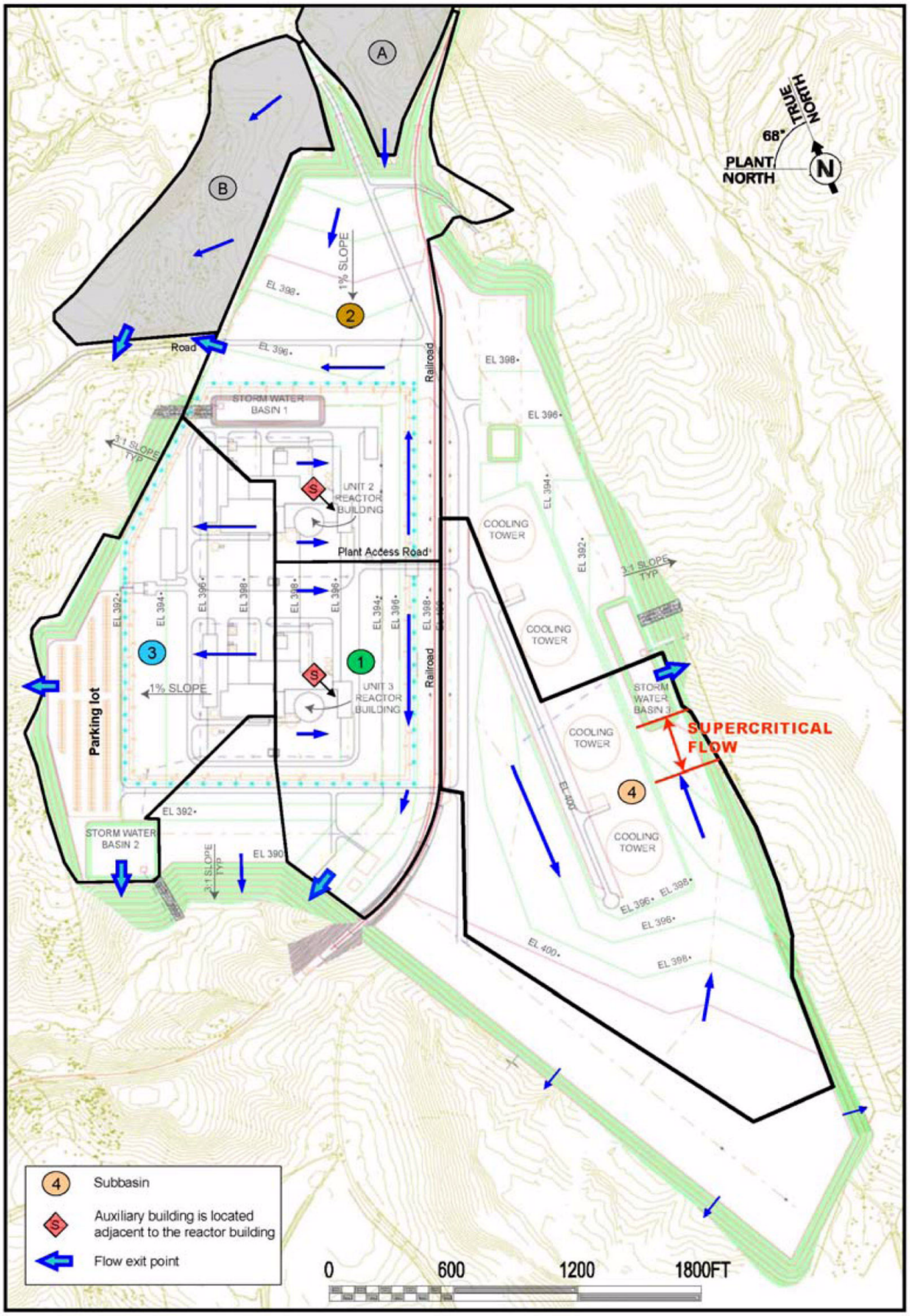

Figure 2.4-3. Plant Site Drainage Basins and Flow Paths (FSAR Figure 2.4.-261)
Subbasin 5 was designated by staff for examination of flow effects at the storm water basin in Subbasin 4

Table 2.4-1. Summary Results Showing the Impact of Sensitivity Tests on Flood Levels

Drainage	Applicant's predicted Water Surface Elevation (ft)	Manning's roughness	Contraction/ expansion Coefficient	Downstream B.C (ft)	
		0.075 (heavy brush)	0.6, 0.8 (abrupt transition)	Dam break (391.85 ft)[(a)]	Critical depth (Flow from Subbasin 4+5)[(b)]
Subbasins1	399.35	399.24	399.36	N/A	N/A
Subbasins2	399.36	399.24	399.24	N/A	N/A
Subbasins3	399.39	399.5	399.39	N/A	N/A
Subbasins4	399.8	400.91	399.88	399.80	399.80

(a) The water surface elevation near the site in Mayo Creek was calculated by assuming extreme dam break condition (Monticello reservoir).
(b) PMP flow from Subbasin 5 was added by Staff to the downstream cross-section (at Storm Water Basin 3) of HEC-RAS for Subbasin 4.

Table 2.4-2. Parameters Used by Applicant for Analysis of Accidental Release to Ground Water

Parameter	Unit 2	Unit 3	Comments
Point of Release to Surface Water	Unnamed creek to north-northwest	Unnamed creek to south-southwest	
Saturated Hydraulic Conductivity (Ks), ft/day	1.7	1.7	75th percentile of slug test data in saprolite/shallow bedrock
Effective Porosity, ne	0.39	0.39	Estimated from particle size data
Distance (L), ft	850	1727	Straight line distance between auxiliary building and point of release
Hydraulic Gradient (grad), ft/ft	-0.0307	-0.0369	Calculated from water level data collected during monitoring program, June 2006 to June 2007
Ground Water Velocity (v), ft/yr	48.9	58.8	Ks x grad / ne
Travel Time (t), yr	17.4	29.4	L x R / v (R is adsorption, which is assumed to be zero in this example)
Ground Water Flow Rate to Unnamed Creek, cfs	1.67 x 10-4	2.01 x 10-4	Square plume, 10 ft thick, effluent filled the effective porosity only
Dilution Factor in Broad River	1.34 x 10-6	1.61 x 10-6	Assumes 100-year daily mean low flow in the Broad River is 125 cfs

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ADAMS Accession No.: ML102140255
Concurrence for DCD Rev. 17/FSAR Rev. 2 **NRO-002**

OFFICE	DNRL/ NWE1: LA	DSER/RHEB:BC	DNRL/NWE1:PM	OGC	DNRL/ NWE1: BC
NAME	KGoldstein*	RRaione	JSebrosky	KRoach	JCruz*
DATE	09/16/2010	09/16/2010	09/16/2010	09/21/2010	09/24/2010

*Via e-mail **OFFICIAL RECORD COPY**