about 1.14 mi downstream from the intake structure. Figure 2.4.1-203 deplicts the location of the intake and discharge structures on Lake Granbury. Emergency safe shutdown of the reactor does not rely on an external source of cooling water.

The individual plant arrangement is comprised of five principal building structures; the reactor building, auxiliary building, emergency power source building, access building, and turbine building. The two unit configuration employs a single radwaste building located between the two units. The reactor building, power source buildings, power source fuel storage vaults, essential service water pipe tunnel and ultimate heat sink related structures are designed to seismic category I requirements and contain safety-related equipment for accident mitigation. The nuclear island consists of the reactor building including pre-stressed concrete containment vessel and containment internal structure, auxiliary building, access building, and power source buildings. The foundation for the nuclear island is an independent base mat which supports each building. Floor elevation of the nuclear island is set 1 ft above the plant grade of 822 ft msl with the embedded depth of the nuclear island base mat at approximately 784 ft msl. The locations of these safety-related components are shown on Figure 2.1-201. The elevation for all facilities and accesses are listed in Table 2.4.1-201.

Flooding at the CPNPP Units 3 and 4 site, of SCR, and on the Brazos River are considered for potential impacts to the site and safety-related facilities. The causal mechanism considered for flooding in the immediate vicinity is local intense precipitation. Temporal distribution of the precipitation is selected to maximize the effects of local intense precipitation. The local intense precipitation is point precipitation and assumed to apply to the entire site. Therefore, spatial distribution of the precipitation is not applicable. The effects of local intense precipitation are discussed in Subsection 2.4.2. Flooding of SCR is considered as discussed in Subsection 2.4.1.2.2. Flooding on the Brazos River is considered as discussed in Subsection 2.4.1.2. RCOL2_02.04.01-6

The majority of the natural surface runoff surrounding the CPNPP Unit 3 and 4 site area flows in a northerly direction into SCR. At the location of the power plant facilities, the surface drainage is directed to the yard holding pond and Probable Maximum Precipitation (PMP) ditch. Runoff collected in the yard holding pond and PMP ditch is expected to drain by overflow weirs or sheet flow into SCR. A small amount of surface runoff on the northwest side of the power plant facilities is anticipated to flow along the natural gap and piping grade towards SCR. A description of the site grading and earthwork is presented in Subsection 2.4.2.3.

A bathymetric survey was conducted in April, 2007 in the vicinity of the intake and discharge structures on Lake Granbury (Reference 2.4-202). Figure 2.4.1-204 shows the locations of waypoints used for temperature measurements, and Table 2.4.1-202 provides measurement data. Figure 2.4.1-205 depicts water depth obtained from the bathymetric survey within the portions of Lake Granbury adjacent to the intake and discharge structures. Water temperatures were taken at the surface then at 10 feet increments to a depth of 50 feet where allowable due to

total depth at that location. The data reveal an approximate 8°F difference in water temperature between surface and bottom measurements.

Soil characteristics are discussed in Subsection 2.5.4. Site vicinity maps are provided in Section 2.1.

2.4.1.2 Hydrosphere

The Brazos River Basin has the largest drainage area of all basins between the Rio Grande and the Red River in Texas. Total basin drainage area is approximately 45,700 sq mi, of which approximately 43,000 sq mi are in Texas, the remainder, in New Mexico. (Reference 2.4-203) The Brazos River Basin crosses through three distinct physiographic provinces: the Great Plains, Central Lowland, and Coastal Plain (Reference 2.4-204). Watershed elevations range from about 4700 ft near the headwaters in eastern New Mexico to sea level near Freeport (Reference 2.4-201).

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Rainfall runoff in the Brazos River watershed generally flows southeast from the upper reaches of Brazos River tributaries in northwest Texas and portions of New Mexico to the Gulf of Mexico. According to the Brazos River Authority (BRA) Clean River Program (Reference 2.4-273), tributaries of the Salt and Double Mountain Forks of the Brazos River are located in the Caprock watershed.

The Caprock watershed is a non-contributing watershed to the Brazos River Basin due to lack of rainfall and high evaporative rates in northwest Texas. Precipitation in this area is either absorbed by area soils or is contained in the hundreds of playa lakes in this part of the state. Playa lakes are shallow, round depressions that fill after storms then rapidly dry due to evaporation. Due to their ephemeral natures, these lakes are not monitored or assessed as part of the BRA Clean River Program. The Caprock watershed contains the ephemeral headwaters of the Brazos River identified in Figure 2.4.1-208, Yellow House Draw (Hydrologic Unit 12050001), Blackwater Draw (Hydrologic Unit 12050002), Running Water Draw (Hydrologic Unit 12050005), and White River (Hydrologic Unit 12050006).

The watershed of the Salt Fork and Double Mountain Fork of the Brazos River begins with the formation of the Double Mountain Fork of the Brazos River near the city of Tahoka in Lynn County. The Salt Fork of the Brazos River is formed in southeastern Crosby County and flows approximately 175 miles before joining with the Double Mountain Fork in Stonewall County to form the main stem of the Brazos River. Both the Double Mountain Fork and Salt Fork are shallow meandering streams. Figure 2.4.1-208 identifies the watershed containing the Salt Fork (Hydrologic Unit 12050007), Double Mountain Fork (Hydrologic Unit 12050003), and North Double Mountain Fork (Hydrologic Unit 12050004). The main stem of the Brazos is also identified as Middle Brazos-Miller(Hydrologic Unit 12060101).

The Clear Fork watershed begins in Fisher County and flows 284 miles east through Jones, Shackelford, Throckmorton, Stephens, and Young Counties, to its

mouth on the Brazos River near South Bend in southern Young County. Figure 2.4.1-208 identifies the watershed containing Paint (Hydrologic Unit 12060103), Upper Clear Fork Brazos (Hydrologic Unit 12060102), Lower Clear Fork Brazos (Hydrologic Unit 12060104), and Hubbard (Hydrologic Unit 12060105). RCOL2_02.04.01-6

The Upper watershed of the Brazos River drains approximately 4725 square miles stretching from the Salt and Double Mountain Fork confluence to the impoundment at the Lake Whitney Dam. The river is generally wide with banks heavily vegetated with elm, willow, oak, and juniper trees. Figure 2.4.1-208 identifies the watershed containing Middle Brazos-Palo Pinto (Hydrologic Unit 12060201) and Middle Brazos-Lake Whitney (Hydrologic Unit 12060202).

The Aquilla Creek watershed covers about 466 square miles, begins in Johnson County flows through Hill County then discharges into the Brazos River in McLennan County. The Aquilla Creek watershed is contained in the Middle Brazos-Lake Whitney (Hydrologic Unit 12060202) and joins the Brazos below Lake Whitney.

The Bosque River begins in Erath County and drains 1652 square miles before emptying into Lake Waco in McLennan County. Figure 2.4.1-208 identifies the watershed containing North Bosque (Hydrologic Unit 12060204) and Bosque (Hydrologic Unit 12060203).

The Leon River watershed drains approximately 3750 square miles through Bell, Hamilton, Coryell, Comanche, and Eastland Counties. Figure 2.4.1-208 identifies the watershed containing Leon (Hydrologic Unit 12070201) and Cowhouse (Hydrologic Unit 12070202).

The Lampasas River watershed drains approximately 1502 square miles through Lampasas and portions of Mills, Burnet, Williamson and Bell Counties. The majority of the Lampasas River watershed drains into Stillhouse Hollow Lake. Salado Creek drains into the Lampasas River below Stillhouse Hollow Lake before the confluence with the Leon River. Much of the Lampasas River has heavily vegetated banks and is characterized by low flow conditions much of the time. Lampasas (Hydrologic Unit 12070203) is identified in Figure 2.4.1-208.

The Little River watershed drains approximately 2349 square miles through Williamson, Bell, Milam and portions of Burnet Counties. This watershed includes Lake Georgetown and Lake Granger. Figure 2.4.1-208 identifies the watershed containing San Gabriel (Hydrologic Unit 12070205) and Little (Hydrologic Unit 12070204).

The Central Brazos River watershed drains approximately 2710 square miles from Lake Brazos Dam in Waco to the mouth of the Navasota River southeast of College Station through Falls, Burleson, Robertson, and portions of McLennan and Brazos Counties. The Central Brazos is identified as Lower Brazos-Little Brazos (Hydrologic Unit 12070101) in Figure 2.4.1-208.

The Navasota River watershed drains approximately 2235 square miles through Limestone, Robertson, Brazos, Grimes and portions of Madison, Leon, and Freestone Counties. The main stem of the river is impounded in three places in Limestone County creating Lake Mexia, Lake Springfield, and Lake Limestone. Navasota (Hydrologic Unit 12070103) is identified in Figure 2.4.1-208. RCOL2_02.04.01-6

The Yegua Creek watershed drains approximately 1316 square miles through Milam, Lee, Burleson, and Washington Counties. Yegua (Hydrologic Unit 12070102) is identified in Figure 2.4.1-208.

The Upper Oyster Creek watershed drains approximately 127 square miles in Fort Bend County. This segment varies from a natural stream course to a highly modified system of canals and dams. The Upper Oyster Creek watershed is a small portion of the area of the Lower Brazos (Hydrologic Unit 12070104) identified in Figure 2.4.1-208.

The Lower Brazos watershed drains approximately 2077 square miles through Washington, Grimes, Waller, Austin, Fort Bend, and Brazoria counties before discharging into the Gulf of Mexico. Lower Brazos (Hydrologic Unit 12070104) is identified in Figure 2.4.1-208.

Within the Brazos River Basin, the CPNPP site is located in the Middle-Brazos Lake Whitney watershed, USGS hydrologic unit code 12060202, and Lake Granbury is located in the Middle-Brazos Palo Pinto watershed, USGS hydrologic unit code 12060201 (Reference 2.4-205). These watersheds incorporate portions of Archer, Young, Jack, Stephens, Palo Pinto, Parker, Eastland, Erath, Hood, Somervell, Johnson, Bosque, Hill, McClennan, Limestone, and Falls counties.

Near the site, the Brazos River Channel is located in incised meanders formed by the river. These meanders may be the result of uplift of the area and sea level fluctuations after a mature meandering drainage pattern is attained. The meanders eroded through and are flanked by rock slopes confining the river within a relatively narrow channel. Immediately adjacent to the channel within the meanders is a narrow flood plain. Although accretion and erosion occur within the channel, as is typical of a meandering river, the well-defined meanders indicate that the channel location is closely confined. The geometry of the banks is governed closely by their location with respect to the meander pattern. The bank on the outside of a bend generally is steep; whereas, the bank on the inside of the bend usually has a gentler slope (Reference 2.5-201-). CTS-01134

Because of the proximity to the site, flooding on the Brazos River is considered for potential impacts to the site and safety-related facilities. The causal mechanisms considered for flooding are precipitation, dam failures, ice effects, and flooding generated from the Gulf of Mexico. Precipitation flooding for the watershed above site is evaluated in Subsection 2.4.4. Dam failure flooding is also considered in the evaluation for existing and future conditions. Dam failures are considered coincident with probable maximum flooding to maximize the effects of precipitation and dam failures combined. In addition, coincident wind wave activity RCOL2_02.04.01-6

is included to maximize resulting flood levels. Flooding from ice effects are considered in Subsection 2.4.7. Ocean surge and tsunami from the Gulf of Mexico are considered in Subsections 2.4.5 and 2.4.6. RCOL2_02.04.01-6

The Texas Water Development Board (TWDB) lists 44 major reservoirs within the watershed of the Brazos River Basin (Reference 2.4-206). These reservoirs and their associated dams (Figure 2.4.1-206) are utilized for water supply, recreation, flood control, cooling, and power generation. For the safety analyses, the most significant portions of the Brazos River basin are those between Possum Kingdom Lake and Lake Whitney, including Lake Granbury, as this area exhibits closely confined basin geometry and includes the highest concentration of major main stem reserviors. As shown on Figure 2.4.1-207 there are seven large manmade impoundments located within 150 stream mi of the DeCordova Bend Dam on Lake Granbury that could affect or be affected by plant operations. These impoundments include:

- Possum Kingdom Lake, on-channel, upstream reservoir located approximately 145 stream mi northwest of DeCordova Bend Dam, in Hydrologic Unit 12060201 (Figure 2.4.1-208).
- Lake Palo Pinto, off-channel, upstream reservoir located approximately 80 stream mi northwest of DeCordova Bend Dam, in Hydrologic Unit 12060201.
- Lake Mineral Wells, off-channel, upstream reservoir located approximately 70 stream mi northwest of DeCordova Bend Dam, in Hydrologic Unit 12060201.
- Lake Granbury, the primary cooling water source for CPNPP Units 3 and 4, on-channel reservoir located approximately 7 mi northeast of the CPNPP site, in Hydrologic Unit 12060201.
- SCR, off-channel reservoir located adjacent north and east of CPNPP Units 3 and 4, in Hydrologic Unit 12060202.
- Wheeler Branch Reservoir, off-channel reservoir located approximately 2 mi south of CPNPP Units 3 and 4, in Hydrologic Unit 12060202.
- Lake Whitney, on-channel, downstream reservoir located approximately 70 stream mi south of DeCordova Bend Dam in Hydrologic Unit 12060202.

Possum Kingdom Lake and Lake Granbury are operated by the Brazos River Authority (BRA), Lake Whitney by the USACE, Lake Palo Pinto by the Palo Pinto Water District No. 1, Lake Mineral Wells by the City of Mineral Wells, SCR by Luminant, and Wheeler Branch Reservoir by the Somervell County Water District. Table 2.4.1-203 provides information on dam and reservoir specifications for these impoundments.

The U.S. Army Corps of Engineers (USACE) maintains water flow rates on its website (Reference 2.4-207) for each day of the year for the major impoundments on the Brazos River, including Possum Kingdom Lake, Lake Granbury, and Lake Whitney.

Reservoir yields for the years 2000 and 2060 were obtained from the 2006 Brazos G Regional Water Plan (Reference 2.4-208). The firm yield is the greatest amount a reservoir could have supplied without shortage during a repeat of historical hydrologic conditions. Safe yield is defined as the amount of water that can be diverted from a reservoir during a repeat of the worst drought of record while still maintaining a reserve capacity equal to a 1-yr supply. Utilization of safe yield versus firm yield is a common practice in west Texas. Safe yield provides additional assurance of supply in an area where water resource alternatives are limited. Reservoir yields were limited to authorized diversions, and the period of record for the firm yield analyses was for the years 1940 through 1997.

For the dam failure analysis discussed in Subsection 2.4.4, the peak flow of the PMF coincident with assumed hydrologic domino-type dam failure of ~~Hubbard Creek Dam~~Fort Phantom Hill Dam, the proposed Cedar Ridge Reservoir Dam, Stamford Dam, Morris Sheppard Dam, and De Cordova Bend Dam at the Brazos River and the Paluxy River confluence were analyzed. ~~These reservoirs were chosen for the dam failure analysis based on storage capacity and distance from the Brazos River and the Paluxy River confluence. Hubbard Creek Dam is located approximately 357 miles upstream of the Brazos River and Paluxy River confluence and was included in the dam failure analysis based on its distance from Morris Sheppard Dam and greater storage capacity (324,983 ac ft), when compared to other upstream reservoirs in the region.~~Using a qualitative analysis approach based on a comparison of distance from the Brazos River and the Paluxy confluence, storage capacity, dam height, and drainage area along with the assumption of transposition of resulting dam failure effects without attenuation, it was determined that the controlling dam failure scenario would include domino-failure of Morris Sheppard Dam and De Cordova Bend Dam. Upstream of Morris Sheppard Dam the significant dams are located on individual tributaries. Using the qualitative approach, Hubbard Creek Dam was determined to be the controlling dam failure scenario upstream of Morris Sheppard Dam. However, considering future conditions, the domino-failure of Fort Phantom Hill Dam and the proposed Cedar Ridge Reservoir Dam along with the simultaneous failure of Lake Stamford Dam was determined to be the controlling dam failure scenario upstream of Morris Sheppard Dam. By quantitative analysis, it was determined that future conditions provide the controlling dam failure scenario. A complete description of the qualitative and quantitative analyses is provided in Subsection 2.4.4. RCOL2_02.04.01-7

According to the 2006 Brazos Region G Water Plan, most of the sites in the state that are readily amenable to reservoir development have already been utilized. Many other sites that are amenable to reservoir development have not been thoroughly developed as potential water supplies, even though they have been studied for many years. These projects have been mentioned in previous state

water plans, but have not been developed due to permitting problems, environmental impacts, water quality, or cost considerations. Over the last 10 to 20 years, the development of major reservoirs has slowed considerably due to stringent permitting requirements and increased environmental awareness. For these reasons, any major reservoir should be considered only as a long-term solution for the development of the project. If the project is taken to fruition, it would most likely take more than 10 years.

Seven potential upstream reservoir sites were evaluated in the 2006 Brazos Region G Water Plan (Reference 2.4-208). For the dam failure analysis, the ~~volume, upstream distance from the Brazos River and Paluxy River confluence, and~~ development potential of each ~~proposed~~potential reservoir site ~~were~~was considered. All but one of these potential ~~reservoirs~~sites, the South Bend Reservoir, were found to contain less storage than Possum Kingdom Lake ~~and were excluded from the dam failure analysis~~. RCOL2_02.04.01-7

The ~~proposed~~site known as South Bend ~~Site~~, located approximately 251 miles upstream of the Brazos River and Paluxy River confluence, ~~would~~could store up to 771,604 ac-ft. This ~~reservoir~~site was not recommended as a water management strategy in the ~~2006~~2011 Region G Water Plan, which indicates ~~implementation of the~~that development of the site known as South Bend Reservoir would encounter difficult permitting constraints and would likely require significant treatment due to water quality concerns. Although ~~the proposed South Bend Reservoir~~this site would be ~~closer~~one of the closest to the Brazos River and Paluxy River confluence and would impound a greater volume of water than ~~the Hubbard Creek Reservoir and Possum Kingdom Lake~~any reservoir upstream of the confluence, the potential site has not been recommended as a water management strategy for Region G, is not a proposed reservoir, and was not included in the dam failure analysis. RCOL2_02.04.01-7 RCOL2_02.04.01-7

Similarly, the two Double Mountain Fork Reservoir alternatives, the Lake Palo Pinto Off-Channel Reservoir and the Throckmorton Reservoir are not identified in the 2011 Region G Water Plan as recommended water management strategies. Therefore, these sites are not proposed reservoirs and are not included in the dam failure analysis. The sites recommend as water management strategies are included for consideration in the dam failure analysis, as described in Subsection 2.4.4. RCOL2_02.04.01-7

~~Potential reservoirs~~Three potential reservoir sites are identified in the ~~2006~~2011 Llano Estacado (Region O) Water Plan (Reference 2.4-269) ~~contain less storage than Possum Kingdom Lake and are at locations greater than 500 miles upstream from the Brazos River and Paluxy River confluence. Based on distance and storage capacity, these potential sites were not included in the dam failure analysis.~~as recommended water management strategies. Therefore, these sites are included for consideration in the dam failure analysis as described in Subsection 2.4.4.

The results of the 1997 TWDB Volumetric Survey indicate SCR has a volume of 151,418 ac-ft, and extends across 3297 surface ac at the conservation pool elevation of 775.0 ft above msl. Within the lake, the survey determined that the Squaw Creek safe shutdown impoundment (SSI) held 701 ac-ft, spread over a surface area of 53 ac. (Reference 2.4-212)

Yield analysis for SCR indicates a firm yield of 8830 ac-ft/yr in 2000 and 8710 ac-ft/yr in 2060 (Reference 2.4-208).

Because SCR is adjacent to the site, flooding of SCR is considered for potential impacts to the site and safety-related facilities. The causal mechanisms considered for flooding are precipitation over the Squaw Creek watershed, backwater analysis due to downstream flooding, wind induced surge, seismic induced surge or seiche, and landslide induced seiche. Precipitation flooding for the Squaw Creek watershed is evaluated in Subsection 2.4.3. Temporal and spatial distributions of the precipitation are examined to determine the maximum runoff and resulting water surface elevation. In addition, coincident wind wave activity is included to maximize resulting flood levels. The backwater analysis considers downstream flooding from adjacent watersheds and the Brazos River including dam failures. Surges are considered in Subsection 2.4.5. Seiches are considered in Subsection 2.4.6. RCOL2_02.04.01-6

2.4.1.2.3 Water Control Structures

2.4.1.2.3.1 New Water Control Structures

Lake Granbury is bounded by two existing dams; DeCordova Bend Dam is located approximately 1.31 mi downstream of the CPNPP intake structures and Morris Sheppard Dam is located approximately 145 river miles upstream from the DeCordova Bend Dam. Both of these dams are owned and operated by the BRA and are primarily used for water supply, with secondary uses that include recreation, flood control, cooling, and power generation. No additional water control structures are planned or required for the facility.

2.4.1.2.3.2 Makeup Water Intake Structure

The Makeup Water Intake Structure is a reinforced concrete box-type structure housing the makeup water pumps, makeup water jockey pump, strainers, valves and associated piping. There is no safety-related equipment in the Circulating Water System, nor does loss of its normal operating capability adversely affect any safety-related components.

The intake structure is located approximately 1.31 mi upstream from the DeCordova Bend Dam. The blowdown water from the Circulating Water System is discharged through a separate pipeline back to Lake Granbury about 1.14 mi downstream from the intake structure

2.4-272 Jones, K.F., J.E. Friddell, S.F. Daly, and C.M. Vuyovich, "Severe Winter Weather in the Continental U.S. and Global Climate Cycles," U.S. Army Corps of Engineers TR-04-19, October 2004.

2.4-273 Brazos River Authority, The Texas Clean Rivers Program 2009 Basin Highlights Report, Website, http://www.brazos.org/crpHistoricalReports.asp, accessed May 26, 2010. RCOL2_02.04.01-6