This version of Section II, “Station Site and Environs,” of Cooper Nuclear Station Safety Analysis Report (SAR) Revision 29 is the licensee’s redacted version, issued in April 2019, with certain additional redactions of sensitive information by the staff of the Nuclear Regulatory Commission (NRC) to allow release to the public. The redactions are made under the provisions of Section 2.390 of Title 10 of the Code of Federal Regulations. The material included within is classified as publicly available information. The redactions were made to meet the NRC’s criteria on sensitive information, as specified in SECY-04-0191, “Withholding Sensitive Unclassified Information Concerning Nuclear Power Reactors from Public Disclosure,” dated October 19, 2004 (ADAMS Accession No. ML042310663), as modified by the NRC Commissioner’s Staff Requirements Memorandum SECY-04-0191, dated November 9, 2004 (ADAMS Accession No. ML043140175). The following SAR pages were redacted by the NRC staff:

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II - STATION SITE AND ENVIRONS

1.0 INTRODUCTION AND SUMMARY DESCRIPTION

Chapter II provides information on the site and environs of Cooper Nuclear Station (CNS), summarizes the analyses and studies which have been conducted pertinent to the site, and sets forth the conclusions which confirm the suitability for operating a nuclear facility at the site.

This USAR section contains historical information as indicated by the italicized text. USAR Section I-3.4 provides a more detailed discussion of historical information. The factual information being presented in this section has been preserved as it was originally submitted to the Atomic Energy Commission in the CNS FSAR in February 1971, as amended.

1.1 Location

The station site is located on the west bank of the Missouri River between the villages of Brownville and Nemaha, Nebraska. The station is located on a section of land bounded by the Missouri River on the east and by privately-owned properties on the north, south, and west. The site area also includes a parcel of land in Atchison County, Missouri, on the east side of the Missouri River.

1.2 Site Ownership

Nebraska Public Power District (NPPD) owns the entire site.

1.3 Activities at the Site

All activities at the station site are under the direct control of NPPD. NPPD has developed the site primarily for the purpose of generating and transmitting electrical energy in support of its normal business activities. Controlled farming is practiced on site land not required for station operation.

1.4 Access to the Site

The immediate area around the station (the Protected Area) is completely enclosed by a security fence with access controlled at a security gate in accordance with 10CFR73.55. A plant security system monitors the Protected Area, as well as the buildings within that comprise the station.

Normal access to the site is by a paved entrance road built across the site from the local Nemaha County road located on the west side of the property. Access was previously available by connection to a railroad spur line of the Burlington-Northern Railroad, but this was abandoned by Burlington-Northern in 1991. A paved bicycle trail now runs along the previous railroad right-of-way.

1.5 Description of the Environs

The site surroundings are predominantly agricultural with zero population within a one-half mile radius of the plant. The nearest residence is approximately 3,500 feet from the reactor. The nearest developed community (Brownville), at a distance of approximately 2 ¼ miles from the site, has a population of 243.

There are no missile sites within a ten mile radius of the CNS plant site. Only one airport, the Auburn Municipal Airport, is located within a ten mile radius of the CNS plant site. The location of this airport and the Cooper Nuclear Station are shown on Figure II-1-1. The Auburn Municipal Airport has two turf runways with lengths of 2,800 feet and 2,200 feet respectively. This limits the use of this airport to light single-engine and partially loaded twin-engine "executive" type aircraft. Flight paths of aircraft using this airport are generally within one-half mile of the airport boundary. Current aircraft traffic averages approximately three hundred operations per month. The traffic volume has shown a slight increase over the last five years; however, it is not expected to increase significantly in the foreseeable future. There are no current plans for airport expansion.[20]

2.0 SITE DESCRIPTION

This USAR section contains historical information as indicated by the italicized text. USAR Section I-3.4 provides a more detailed discussion of historical information. The factual information has been preserved as it was originally submitted to the Atomic Energy Commission in the FSAR, as amended. The purpose of this information was to demonstrate the acceptability of the station relative to the population center siting requirements of 10CFR100. The Chapter XIV offsite dose analyses and the NPPD Emergency Plan for Cooper Nuclear Station provide contemporary assurance that the site remains acceptable relative to changes in the population distribution and site surroundings occurring since initial licensing.

2.1 Location and Area

The station site is located in Nemaha County, Nebraska, on the west bank of the Missouri River, at river mile 532.5. This part of the river is referred to by the Corps of Engineers as the Lower Brownville Bend. Site coordinates are approximately 40° 21' north latitude and 95° 38' west longitude. The site consists of 1,351 acres of land owned by NPPD. About 205 acres of this property is located in Atchison County, Missouri, opposite the Nebraska portion of the station site. The land which the station physically occupies is bounded by the Missouri River on the east and by privately-owned property on the north, south, and west. The overall site and vicinity plan is presented in Burns and Roe Drawing 4003. An historical aerial photograph of the site is presented in Figure II-2-1, and a location plan of the site showing the surrounding area within a 50 mile radius is provided in Figure II-2-2. An historical topographical map delineating the boundaries of the Evacuation Zone, Low Population Zone, Exclusion Area and the Protected Area is provided in Figure II-2-5. Current descriptions of the Low Population Zone and Exclusion Area boundaries are found in Section 4.1 of the Technical Specifications. Current depictions of the Plume Exposure Emergency Planning Zone (Evacuation Zone) are included in the NPPD Emergency Plan for Cooper Nuclear Station. A more detailed plot plan is shown in Burns and Roe Drawing 4003.

The terrain at the station site is fairly level with grade at approximate Elevation 890 feet Mean Sea Level (MSL). An earth levee runs parallel with the Missouri River. The immediate station site area, excluding the switchyard which is west of the levee, was filled to Elevation 903 feet MSL, one foot higher than the top of the levee. This fill extends around the station buildings.

A formal application for a permit for the construction of an intake structure on the Missouri River was made to the Corps of Engineers. Approval for the construction of an intake structure was granted by the Corps of Engineers on November 29, 1967.

2.2 Population Distribution

A presentation of the resident population distribution as a function of distance and direction from the nuclear power plant is shown on Figures II-2-3 and II-2-4 (distribution at time of the 1970 Census). The distribution is presented graphically by insertion of appropriate numbers of persons resident in individual area segments of a selected grid system. This grid system may be cross-referenced to the map included as Figure II-2-2.

The grid system is centered on the reactor vessel of the power plant and extends radially outward a distance of 50 miles. The grid is defined by concentric circles with radii of ½, 1, 2, 3, 4, 5, 10, 20, 30, 40, and 50 miles and is divided by sixteen equally spaced radial lines. Figure II-2-3 includes distances less than 5 miles while Figure II-2-4 is for distances from 5 to 50 miles.

The 1970 census entitled "Number of Inhabitants, Population of Counties, by Minor Civil Divisions 1970", was used as a reference. Enlargements of the census maps of Minor Civil Divisions - Election Precincts and Townships were used as work sheets in deriving Figures II-2-3 and II-2-4.

For the area within a two mile radius of the plant site an actual head count was made. For areas from 2 to 50 miles, population density was determined by taking the number of inhabitants in concentrated locations within this civil division and dividing by the land area to obtain the number of people per square mile. This number was then multiplied by the partial area of each civil division within a segment to determine the contribution of each civil division to the total population within each segment. To this number the concentrated groups of people within the segment have been added. A planimeter was used to determine relative areas.

Table II-2-1 shows present and forecasted future population from 0 to 50 radial miles from the site. Table II-2-2 shows Population Histories and Projections by counties. Table II-2-3 shows Population Histories and Projections of selected cities, towns, and villages.

By actual head count, there are two permanent residents residing within a 1 mile radius and 54 permanent residents in a 2 mile radius of the reactor.

2.3 Character of Site Surroundings

The station is located on land that was previously used for agriculture. There are 755 farms in Nemaha County, averaging approximately 316 acres per farm. The agricultural products are corn, wheat, alfalfa, and soybeans. Cattle and hogs are also raised. The land use is distributed approximately as follows:

Land Use	*% of Total County Acreage*
Agricultural	*99.18*
Residential Suburban	*0.03*
Commercial Suburban	*0.01*
Industrial Suburban	*0.01*
Urban	*0.77*
	Total 100.00

The nearest developed community in the area of the site is Brownville, Nebraska, population 174. The next closest community is Nemaha, Nebraska, population 207. It is approximately 3 miles southwest of the site.

Phelps City, Missouri, with a population of 76, located approximately 4 miles northeast of the site, is the closest city with industry. Missouri Beef Packers employs approximately 400 people and processes approximately 1,150 head of cattle per eight-hour day, 5-1/2 days per week.

Auburn, Nebraska, with a population of 3,650, located approximately 10 miles west of the site, is the closest city with industry. Manufacturing plants in Auburn are:

Company	*Product*
Wood Carve Co.	*Wood Cabinets*
Magnolia Company	*Metal Products*
Auburn Machine Co.	*Trenching Machines*
G&S Manufacturing Co., Inc.	*Children's Clothing*

TABLE II-2-1

POPULATION HISTORIES AND PROJECTIONS AT VARIOUS DISTANCES FROM REACTOR BUILDING

Distance from Reactor Building Miles	Population
	1960
0.0- 0.5	0.0
0.5- 1.0	4.0
1.0- 2.0	47.0
2.0- 3.0	461.0
3.0- 4.0	254.0
4.0- 5.0	252.0
5.0-10.0	3,654.0
10.0-20.0	23,540.0
20.0-30.0	39,760.0
30.0-40.0	37,082.0
40.0-50.0	74,058.0
0.0-50.0	179,112.0
	1970
0.0- 0.5	0.0
0.5- 1.0	2.0
1.0- 2.0	52.0
2.0- 3.0	418.0
3.0- 4.0	214.0
4.0- 5.0	146.0
5.0-10.0	4,498.0
10.0-20.0	22,350.0
20.0-30.0	30,066.0
30.0-40.0	47,453.0
40.0-50.0	66,945.0
0.0-50.0	172,144.0
	1980
0.0- 0.5	0.0
0.5- 1.0	2.0
1.0- 2.0	51.0
2.0- 3.0	418.0
3.0- 4.0	213.0
4.0- 5.0	146.0
5.0-10.0	4,484.0
10.0-20.0	22,283.0
20.0-30.0	29,976.0
30.0-40.0	47,311.0
40.0-50.0	66,744.0
0.0-50.0	171,628.0

TABLE II-2-2

POPULATION HISTORIES AND PROJECTIONS BY SELECTED COUNTIES

State		1940	1950	1960	1970	1980
Iowa*	Mills	15,064	14,064	13,050	11,606	10,905
	Montgomery	15,697	15,685	14,467	12,781	11,458
	Page	24,887	23,921	21,023	18,507	16,663
	Taylor	14,258	12,420	10,288	8,713	7,706
	Fremont	14,645	12,323	10,282	9,282	8,520
Kansas*	Brown	17,395	14,651	13,229	11,685	12,854
	Doniphan	12,936	10,499	9,574	9,107	10,528
	Marshall	20,986	17,926	15,598	13,139	13,342
	Nemaha	16,761	14,341	12,897	11,825	14,154
Missouri*	Andrew	13,015	11,727	11,062	11,913	12,533
	Atchison	12,897	11,127	9,213	9,240	9,204
	Holt	12,476	9,833	7,885	6,654	6,447
	Nodaway	25,556	24,033	22,215	22,467	22,840
Nebraska*	Cass	16,992	16,361	17,821	18,076	18,820
	Gage	29,588	28,052	26,818	25,719	24,250
	Johnson	8,662	7,251	6,281	5,743	5,290
	Lancaster	100,585	119,742	155,272	167,972	184,091
	Richardson	19,178	16,886	13,903	12,277	10,930
	Nemaha	12,781	10,973	9,099	8,976	8,610
	Otoe	18,994	17,056	16,503	15,576	15,367
	Pawnee	8,514	6,744	5,356	4,473	3,850

**Based on office projections by appropriate agencies of the states indicated.*

TABLE II-2-3

POPULATION HISTORIES AND PROJECTIONS OF SELECTED CITIES, TOWNS, AND VILLAGES

State	County	City, Town or Village	1940	1950	1960	1970	1980
Nebraska*	Otoe	Nebraska City	7,339	6,872	7,252	7,441	7,620
	Nemaha	Auburn	3,639	3,422	3,229	3,650	3,870
Missouri**	Atchison	Tarkio	2,114	2,221	2,160	2,517	2,640
	Nodaway	Maryville	5,700	6,834	7,807	9,970	10,140
Kansas**	Brown	Hiawatha	3,238	3,294	3,391	3,365	3,440
Iowa**	Mills	Glenwood	4,501	4,664	4,783	4,195	4,230

*Based on official projections by appropriate agencies of state indicated.

**NPPD estimate based on official projections (by county) by appropriate agencies of state indicated.

Nebraska City, Nebraska, is the closest city with a population over 7,000. It is located approximately 24 miles north-northwest of the site and has a population of 7,441. Plants located in Nebraska City are:

Company	*Product*
Morton House Kitchens	*Canned foods*
American Meter Co.	*Meters*
American Beef Packers	*Beef*
Nebr. Outer Wear	*Clothing*
Nebraska City Iron Works	*Steel Products*
Pendleton Woolen Mills	*Clothing*

Tecumseh (population 2,058) which is 30 miles west of the site, has a Campbells Soup processing plant.

Falls City (population 5,444) in Richardson County, 20 miles south of the site is the location of the "Falls City Meat Packing Co.," and the "Frontier Homes Corporation."

Maryville, Missouri, (population 9,970) is located approximately 45 miles to the east and is the largest city within 50 miles of the site. The land between the site and Maryville is used primarily for agriculture. The industries located in Maryville are:

Company	*Product*
Maryville Meat Packing Co.	*Beef*
Robbins Lightning Protection Co.	*Lightning rods*
Lloyds Chain Corporation	*Industrial chains*
Lloyds Sheet Metal Co.	*Rivets and other metal products*
Center Milk Products	*Raw cheese*
Union Carbide	*Batteries*

North-West Missouri State University is also located in Maryville.

Shenandoah (population 5,968) is the largest city in Iowa within 50 miles of the site and is about 32 miles to the northeast. Shenandoah has the following industries:

Company	*Product*
DeKalb Agricultural Assn.	*Seed growers*
Earl May Seed & Nursery Co.	*Seed growers*
Henry Fields Seed & Nursery Co.	*Bulbs and package seeds*
Imperial Chemical Inc.	*Chemicals*
Gulf Farm Center	*Fertilizer*
Raidt Mfg. Co	*Gloves*
Farm Master, Inc.	*Farm equipment*
Kitchen Klatter Products Co.	*Vanilla extracts*
Vet-A-Mix Co.	*Veterinarian supplies*
Eaton Corp. Transmission Div.	*Heavy Duty Transmissions*

Red Oak, Iowa, (population 6,210) is located approximately 47 miles north-northeast of the site. The area surrounding the city is basically agricultural. There are 984 farms in the county. The average size of the farms was approximately 265 acres as of 1970. The following companies are located within the Red Oak city limits:

Company	*Product*
Union Carbide	*Ever-Ready dry batteries*
Red Oak Mfg. Division	*Agricultural chemical packing and material handling equipment*
Thomas D. Murphy Co.	*Wall and desk calendars*

The cities nearest the site with populations of 25,000 or more are Lincoln, in Lancaster County, Nebraska, (population 149,518) which is 60 miles west-northwest of the site, and St. Joseph, Missouri, (population 86,139) which is 60 miles southeast of the site.

2.4 Conclusions

There are no residences within 3,500 feet of the reactor. By actual head count, there are only two residents within a 1 mile radius and only 54 residents within a 2 mile radius of the reactor. The population density is very light for a distance of over 50 miles from the site since cities with populations over 25,000 are at least 60 miles from the site.

The area in the vicinity of the site is predominantly agricultural, and the location of the station at this site will not affect the land usage.

Therefore, from the viewpoints of population density, population distribution, and land usage, the site is well suited for the nuclear station.

3.0 METEOROLOGY

This USAR Section contains historical information as indicated by the italicized text. USAR Section I-3.4 provides a more detailed discussion of historical information. The factual information being presented in this section on site meteorology has been preserved as it was originally submitted to the Atomic Energy Commission in the CNS FSAR in February 1971, as amended. Supplemental information from the CNS PSAR has also been included where it contributes to understanding the CNS design bases for meteorological conditions.

3.1 General

The following information on site weather data (i.e., fog, snow depth, etc.) was obtained from the National Climate Center located in Asheville, North Carolina. The two closest locations to CNS where meteorological data is monitored are Lincoln and Omaha, Nebraska.

Lincoln is near the center of Lancaster County in southeastern Nebraska. The surrounding area is gently rolling prairie. The western edge of the city is in the flat valley of Salt Creek, which receives a number of tributaries in or near the city and flows northeastward to the lower Platte River. The terrain slopes upward to the west and is sufficient to cause instability in moist easterly winds in the Lincoln area. Precipitation with westerly winds is infrequent since they are downslope. The upward slope to the west is a part of the general rise in elevation that begins at the Missouri River 45 miles east of Lincoln and culminates in the Continental Divide about 575 miles to the west. The Chinook (or Foehn) effect often produces rapid rises in temperature here during the winter with a shift of the wind to westerly.

Omaha is situated on the west bank of the Missouri River. The river level at Omaha is normally about 965 feet above sea level and the rolling hills in and around Omaha rise to about 1,300 feet above sea level. The climate is typical continental with relatively warm summers and cold, dry winters. It is situated midway between two distinctive climatic zones, the humid east and the dry west. Fluctuations between these two zones produce weather conditions for periods that are characteristic of either zone, or combinations of both. Omaha is also affected by most storms or "lows" that cross the country. This causes periodic and rapid changes in weather, especially during the winter months.[23]

3.1.1 Temperature

Sunshine is fairly abundant, ranging around 50 percent of the possible in the winter to 75 percent of the possible in the summer.

The temperature has exceeded 110°F on five occasions since the beginning of the record in 1888. However, all five cases occurred in the period 1934-1939, which was a period of remarkable droughts. Hot winds, combining unusual wind force and high temperatures, occasionally cause serious injury to crops.

The majority of winter outbreaks of severely cold air from northwestern Canada move over the Lincoln area. However, the center of some of the cold air masses move southward far enough to the east that their full effect is not felt here.

The average date for the last occurrence in the spring of temperatures as low as 32°F is April 14, and for the first occurrence of 32°F or lower in autumn is October 20. The longest freeze free period on record is 219 days in 1924, and the shortest period is 152 days in 1885. The average length of the freeze free period is 188 days.

General information on temperature inversions in the central plains obtained from the U.S. Weather Bureau indicates that the mid-section of the country has a pronounced continental type climate, and as such, has inversion frequencies closely related to the diurnal cycle; that is, there is a definite tendency for

nocturnal stabilization and daytime instability in the lower levels. In general, inversions occur 20 to 30 percent of the time during the spring and summer, while during the fall and winter months inversions may be expected about 30 to 45 percent of the time.

3.1.2 Wind

Most of the higher winds are caused by deep low pressure systems of great intensity but rare occurrence. In the summer the higher winds are associated with thunderstorms. Lincoln has been relatively free from tornadoes in the past, and significant hail damage has seldom occurred there. There is much sunshine, averaging 64 percent of the possible duration. Moderate to low humidity prevails except for short periods during the summer when warm, moist, tropical air occasionally reaches this area.

Tornadoes, defined as violent local storms with swirling winds of tremendous speed, have occurred in Nebraska and neighboring states. A tornado is usually recognized as a rotating funnel shaped cloud which extends toward the ground from the base of a thundercloud. The color varies from gray to black.

Based on a study of the contiguous United States obtained from the U.S. Weather Bureau, the average path of a tornado is 750 feet wide but may vary up to one mile. Tornados have an average destructive length of 13 miles, but have been reported to have had destructive lengths in excess of 300 miles.

Tornadoes are most prevalent during May and June. About 87% of all tornados come from a westerly direction. Nearly 60% approach from the southwest, and 82% of all tornadoes are recorded as having occurred between noon and midnight. Almost 42% occur between 3 and 7 pm. More tornadoes occur between 4 and 6 pm than during any other hours.

Some observations of interest obtained from the U.S. Weather Bureau and based on information from the American Institute of Architects (AIA) are as follows:

a. No structural damage is known to have resulted to a reinforced concrete building in a tornado.

b. Steel frame buildings built according to AISC standards have withstood tornadoes without structural damage.

c. Curtain walls must be well braced to withstand full tornado forces.

d. Monolithic roofs will probably be undamaged in tornadoes while deck material may be severely damaged unless securely attached to the frame.

e. Fire protection and freedom from water damage can be achieved if sprinkler piping is supported by building frame.

f. Roof and top story of buildings with load bearing masonry walls, and roofs of plank and timber or light deck material on joists will be severely damaged by the full force of a tornado.

3.1.3 Precipitation

Normally the crop season, April through September, receives over three-fourths of the annual precipitation. Nighttime thundershowers are predominant in the summer months, so that the needed moisture is received during much of the growing season at a time of least interference with outdoor work. Since 1884 the annual precipitation has exceeded 40 inches on five occasions and dropped below 20 inches ten times. The largest annual amount was 41.33 inches in 1965, the least 14.09 inches in 1936.

Snowfall is about 25 inches in the average season. The largest recorded amount is the 59.4 inches that fell during the 1914-15 season. Much of the snow is light and melts rapidly. However, at times a considerable amount accumulates on the ground, the greatest recorded depth being 21 inches in February, 1965.

Most of the precipitation in Omaha falls during showers or thunderstorms. Of the total precipitation, about 75 percent falls during the six-month period, April to September, mostly as evening or nighttime showers and thunderstorms. Although winters are relatively cold, precipitation is light, with only 10 percent of the total annual precipitation falling during the winter months.

The Lincoln and Omaha annual climatological data (Tables II-3-1 and II-3-2) give the total number of days of heavy fog/year plus the three months during which the most snow fell, the day on which the most snow fell and the total amount of snow for that year for the years 1952-1971.

The Auburn Department of Roads has informed the District that the Auburn-Brownville Highway 136 has never been snow blocked for more than two days, and that specific incident has only happened once since 1974. Site accessibility from Brownville is by means of a county road and according to the County Commissioner, this road has never been blocked by snow for more than 1/2 day.

With regards to rainfall within the site vicinity, data from the U.S. Department of Commerce - Weather Bureau, climatological summary from 1931 to 1960 for the Falls City, Nebraska, area indicates a maximum 24-hour rainfall total of 6.00 inches. Values obtained from similar reports for the Omaha and Lincoln, Nebraska, areas substantiate this value. Omaha and Lincoln are north and west of the plant site respectively.

From the aforementioned reports, which are summaries of recorded rainfall rates, a rainfall intensity of three inches per hour is indicated as being appropriate for this area. The following documents were also reviewed to determine the rainfall rate[26]:

1. National Standard Plumbing Code as suggested by National Association of Plumbing - Heating - Cooling Contractors (PHCC) 1971 edition, Table A which suggests as the maximum rate of rainfall for the Lincoln, Omaha, Nebraska, area as 7.0 inches/hour for a five minute duration for a ten year return period. Converting this value to a rate equivalent to that used in the design of drainage facilities yields 3.1 inches per hour for a 60-minute duration and a 10-year return period.

2. U.S. Department of Commerce - Weather Bureau and U.S. Department of Army Corps of Engineers, Hydrometeorological Report No. 33 dated April, 1956, from which it was determined that the "probable maximum precipitation" for the site area, 23.5 inches total rainfall for a 24-hour period. This value has been determined from Figure 17 (August) of the aforementioned report. Converting this value to a rate equivalent to a one-hour rainfall, by using the Civil Engineering Bulletin No. 52-8, revised March, 1965, published by the Department of the Army, office of the Chief of Engineers which determines a rainfall rate per hour from a 24-hour period, the "probable maximum precipitation" for the site area was conservatively determined to be 3.56 inches per hour for a ten year return period.

3.2 Meteorological Design Bases

3.2.1 Temperature

The CNS design high outside temperature is 97°F dry bulb (79°F wet bulb). Based on historical records, this temperature is only expected to be exceeded 1% of the time during the summer. Similarly, the design low outside temperature is -5°F dry bulb which will only be exceeded 1% of the time during the winter (see USAR Section X-10.1).

TABLE II-3-1

Annual Climatalogical Data – Lincoln, Nebraska

Year	*3 Months With Most Snow **	*Most Snow On 1 Day **	*Total Yearly Snowfall **	*Total Number of days of Heavy Fog ***
1952	*Mar. - 12.5"* *Dec. - 9.7"* *Nov. - 6.0"*	*Dec. 21-22: 7.1"*	*39.9"*	*6*
1953	*Jan. - 6.1"* *Mar. - 5.1"* *Nov. - 5.0"*	*Mar. 1: 3.8"*	*19.3"*	*4*
1954	*Jan. - 1.8"* *Feb. - 1.5"* *Mar. - 1.2"*	*Feb. 20: 1.5"*	*5.3"*	*7*
1955	*Jan. - 13.9"* *Feb. - 5.4"* *Mar. - 3.5"*	*Jan. 17-18: 5.7"*	*28.7"*	*1*
1956	*Jan. - 11.3"* *Nov. - 5.1"* *Feb. - 3.6"*	*Nov. 20: 4.6"*	*24.2"*	*3*
1957	*Mar. - 13.6"* *Nov. - 12.6"* *Dec. - 5.6"*	*Nov. 17-18: 10.4"*	*44.8"*	*5*
1958	*Mar. - 10.0"* *Jan. - 7.4"* *Feb. - 3.2"*	*Mar. 7: 5.1"*	*21.9"*	*3*
1959	*Jan. - 12.2"* *Mar. - 12.1"* *Feb. - 5.3"*	*Mar. 4-5: 8.6"*	*35.3"*	*4*
1960	*Feb. - 19.2"* *Mar. - 17.8"* *Jan. - 11.1"*	*Feb. 9-10: 5.8"*	*49.3"*	*13*
1961	*Dec. - 12.2"* *Nov. - 6.8"* *Mar. - 5.1"*	*Dec. 10-11: 8.7"*	*31.4"*	*12*
1962	*Dec. - 4.6"* *Feb. - 4.3"* *Jan. - 3.3"*	*Feb. 20-21: 2.9"*	*15.1"*	*8*

** Snow, sleet, hail.*
*** The upper visibility limit for fog is 1/4 mile.*

TABLE II-3-1 (Cont'd)

Year	3 Months With Most Snow *	Most Snow On 1 Day *	Total Yearly Snowfall *	Total Number of days of Heavy Fog **
1963	Mar. - 11.0" Jan. - 6.5" Dec. - 4.2"	Mar. 4-5: 7.4"	23.9"	7
1964	Mar. - 4.1" Jan. - 2.5" Feb. - 2.2"	Jan. 11-12: 2.2"	10.8"	12
1965	Feb. - 26.1" Mar. - 10.3" Jan. - 3.7"	Feb. 11: 19.0"	42.1"	0 or data incomplete
1966	Dec. - 9.9" Mar. - 3.6" Jan. - 1.9"	Dec. 27-28: 7.4"	17.1"	0 or data incomplete
1967	Jan. - 5.5" Apr. - 3.7" May - 3.0"	Apr. 23: 3.7"	14.6"	0 or data incomplete
1968	Dec. - 11.7" Jan. - 4.3" Nov. - 1.7"	Dec. 18-19: 9.0"	18.7"	0 or data incomplete
1969	Dec. - 15.8" Feb. - 13.6" Jan. - 7.8"	Feb. 14: 8.2"	42.4"	0 or data incomplete
1970	Oct. - 6.6" Mar. - 4.7" Feb. - 3.2"	Oct. 9: 6.6"	17.8"	0 or data incomplete
1971	Feb. - 17.6" Jan. - 15.1" Nov. - 10.0"	Jan. 2-3: 12.4"	53.7"	0 or data incomplete

** Snow, sleet, hail.*
*** The upper visibility limit for fog is 1/4 mile.*

TABLE II-3-2

Annual Climatalogical Data – Omaha, Nebraska

Year	*3 Months With Most Snow **	*Most Snow On 1 Day **	*Total Yearly Snowfall **	*Total Number of days of Heavy Fog ***
1952	*Mar. - 13.8"* *Dec. - 8.6"* *Nov. - 8.3"*	*Nov. 25-26: 6.9"*	*38.6"*	*15*
1953	*Jan. - 7.3"* *Feb. - 6.7"* *Mar. - 2.7"*	*Feb. 15-16: 4.0"*	*17.6"*	*9*
1954	*Mar. - 2.9"* *Jan. - 2.8"* *Feb. - 1.9"*	*Mar. 12-13: 2.3"*	*8.3"*	*12*
1955	*Feb. - 5.7"* *Mar. - 4.8"* *Jan. - 3.8"*	*Feb. 3-4: 5.7"*	*23.7"*	*7*
1956	*Jan. - 8.5"* *Nov. - 5.2"* *Feb. - 3.2"*	*Nov. 20: 5.1"*	*20.0"*	*14*
1957	*Nov. - 12.0"* *Feb. - 11.6"* *Jan. - 6.8"*	*Mar. 24-25: 10.8"*	*40.5"*	*18*
1958	*Jan. - 8.8"* *Mar. - 7.8"* *Feb. - 3.7"*	*Jan. 19: 4.4"*	*22.8"*	*18*
1959	*Mar. - 13.2"* *Jan. - 6.0"* *Feb. - 5.3"*	*Mar. 4-5: 7.8"*	*31.8"*	*21*
1960	*Mar. - 22.7"* *Jan. - 14.0"* *Feb. - 13.4"*	*Jan. 14-15: 7.3"*	*51.2"*	*22*
1961	*Dec. - 19.6"* *Mar. - 6.4"* *Feb. - 6.3"*	*Dec. 11: 8.9"*	*42.3"*	*20*
1962	*Feb. - 13.2"* *Mar. - 8.9"* *Dec. - 8.1"*	*Feb. 20-21: 9.5"*	*36.9"*	*16*

** Snow, sleet, hail.*
*** The upper visibility limit for fog is 1/4 mile.*

TABLE II-3-2 (Cont'd)

Year	3 Months With Most Snow *	Most Snow On 1 Day *	Total Yearly Snowfall *	Total Number of days of Heavy Fog **
1963	Jan. - 14.5" Mar. - 13.0" Dec. - 6.6"	Mar. 4-5: 11.0"	37.3"	13
1964	Mar. - 10.5" Dec. - 5.4" Jan. - 4.9"	Jan. 11-12: 4.4"	26.9"	12
1965	Feb. - 25.4" Mar. - 16.1" Jan. - 6.8"	Feb. 11: 18.3"	50.1"	16
1966	Mar. - 8.3" Dec. - 6.8" Jan. - 2.8"	Mar. 22-23: 7.2"	19.3"	18
1967	Jan. - 7.2" Dec. - 5.7" Oct. - 1.5"	Dec. 26-27: 4.5"	17.2"	10
1968	Dec. - 8.6" Nov. - 4.7" Jan. - 4.6"	Nov. 9-10: 4.0"	19.0"	10
1969	Dec. - 19.9" Feb. - 14.0" Jan. - 8.3"	Dec. 5-6: 10.2"	45.9"	23
1970	Mar. - 5.8" Oct. - 3.5" Jan. - 3.2"	Mar. 18-19: 4.5"	14.1"	10
1971	Feb. - 17.4" Jan. - 13.1" Nov. - 9.0"	Feb. 21-22: 10.8"	48.7"	18

* Snow, sleet, hail.
** The upper visibility limit for fog is 1/4 mile.

3.2.2 Wind

The design wind pressures for the station and structures is 30 lbs. per square foot which is the equivalent of sustained winds up to 100 mph. Station structures have been designed to withstand this wind velocity in accordance with ASCE Paper 3269 (see USAR Section XII-2.3.3.1).

Since in the area tornadoes may occur, the station is designed for safe shutdown under tornado conditions (300 mph wind speed). Structures whose failure could affect the operations, function, and integrity of the Primary Containment System have been designed to assure that safe shutdown of the reactor can be achieved when these structures are subjected to the effects of a tornado (300 mph tangential wind velocity and 60 mph transverse velocity with a 3 psi pressure drop occurring over a three second time interval) (see USAR Section XII-2.3.3.2).

3.2.3 Precipitation

Class I and Class II buildings are protected from the effects of precipitation through the use of roof drains and overflow scuppers. The Reactor Building, Diesel Generator Building, and Control Building use 4 inch roof drains and 6 inch scuppers. Using the discharge rates in drains provided in the 1971 issue of the National Standard Plumbing Code, with full flow from the vented systems, the roof drainage and overflow capacity from these buildings can sustain a rainfall rate of over 10 inches of water per hour. The roof drains are designed to eventually be carried through underground piping into the Missouri River. The remaining local site drainage is designed such that any excess rainfall not immediately absorbed into the ground will flow away from the buildings to be discharged into drywells or low lying areas adjacent to the plant site. Accordingly, these designs can safely remove the accumulated water from the probable maximum precipitation rate described in Section II-3.1.3, and can also accommodate the AEC’s estimated 9.7 in./hr in one hour rainfall rate without adverse effects on the safety-related systems necessary for safe shutdown.[26]

3.3 Meteorological Monitoring[7]

Preliminary data concerning the Meteorology of the region in which the Cooper Nuclear Station is located was previously submitted (CNS PSAR, Vol. I, Section II-3) and was based on U.S. Weather Bureau data from Lincoln, Omaha, and Falls City, Nebraska; Kansas City, Missouri; and Des Moines, Iowa. On January 8, 1970, Field Data Collection was initiated at the CNS plant site using installed meteorological instrumentation.

The meteorological monitoring system is described in the NPPD Emergency Plan for Cooper Nuclear Station and is used in predicting offsite dose consequences during plant events. The system is also used as described in the Cooper Nuclear Station Offsite Dose Assessment Manual for Gaseous and Liquid Effluents (ODAM) for estimating the maximum potential annual radiation doses resulting from radioactive materials released in gaseous effluents per 10CFR50.36a(a)(2). Finally, the system is used in applicable Chapter XIV accident analyses to demonstrate that the Control Room Operator dose consequences from postulated design basis accidents are within GDC-19 limits. The meteorological monitoring system is in conformance with Revision 1 to U.S. NRC Regulatory Guide 1.23.

4.0 HYDROLOGY

This USAR section contains historical information as indicated by the italicized text. USAR Section I-3.4 provides a more detailed discussion of historical information. The factual information has been preserved as it was originally submitted to the Atomic Energy Commission in the FSAR, as amended. Additional historical information has been provided on ice flooding as derived from the CNS SER, and on the 1993 Missouri River flood. The most recent hydrogeological investigative report is discussed in USAR Section II-4.4.2.

4.1 General

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4.2 Stream Flow

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TABLE II-4-2

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4.2.3 Low River Levels

4.2.3.1 Design Low River Level

The records described below indicate that a minimum river stage of approximately 870.00 MSL occurred at the site in winter 1946.

At Nebraska City, Nebraska (River Mile 562.6)

Date Records Began	*August, 1929*
Minimum Stage and Date	*905.1' MSL - December, 1960 (ice affected)*
Minimum Discharge and Date	*1,600 cfs - December, 1946 (ice affected)*

<u>At Rulo, Nebraska (River Mile 498.0)</u>

Date Records Began	*October, 1949*
Minimum Stage and Date	*832.2' MSL - December, 1962 (ice affected)*
Minimum Discharge and Date	*4,420 cfs - January, 1957 (ice affected)*

A straight line interpolation between minimum stages at Nebraska City and Rulo indicates an elevation of approximately 870 feet, MSL at the CNS site. This occurred under open river conditions and it is considered improbable that lower elevations will be attained under present day conditions due to controlled low water releases from the upstream dams. Such controls serve the dual purpose of low flow implementation, per se, as well as the breaking up of potential ice jams which tend to occur in the river under certain critical conditions. Minimum discharges that may be expected in the future are obviously a function of releases from the main stream reservoir system, particularly Gavins Point. It is estimated that in severe drought periods the release from Gavins Point may be as low as 3,000 cfs. Contribution from the area located downstream from the dam would add a nominal increment to this release at the CNS site. The open water stage that could be expected at the CNS site from a 3,000 cfs discharge resulting from a prolonged drought could be as low as 865 feet MSL.[15]

Winter icing conditions provide more likely circumstances where a minimum river stage may be experienced at CNS. The historical experience furnished above for Nebraska City and Rulo provides a basis for guidance. Based on the minimum river stages, which were ice affected, it is not considered credible that the river level will ever drop to 865 feet MSL.[15]

Changes in river alignment have occurred in the past as a result of meteorological events (see Figure II-5-5). The river channel line is presently stabilized as a result of permanent revetments constructed under the supervision of the Corps of Engineers over a number of years; thereby, making it extremely unlikely that the river would be diverted at Brownville Bend. If, however, in spite of these controls, the river should be diverted, it would most likely occur with the failure of a major flood control dam - either Oahe or Fort Randall. While the river is at peak flood stage at the site, the postulated diversion of the Missouri River might occur upstream. With the river now diverted and the flood waters fully receded what might remain in front of the Intake Structure would be a large body of still water cut off from the upstream flow and possibly cut off somewhere downstream[16].

4.2.3.2 <u>Site Low River Level Protection</u>

During normal spring to fall barge season, river stages below 880 feet MSL are not expected. Nevertheless, river stages to elevation 865 feet have been reviewed to determine both the effect of such river stages on plant operation and the potential frequency and duration of occurrence. The plant is designed for a safe shutdown under the most critical low water elevation of 865 feet.[9]

An Intake Structure guide wall was constructed (see Chapter XII) to provide a means of limiting and controlling the volume of sediment transported by the Missouri River from entering the Intake Structure and continuing into several plant systems dependent on river water. For the low river conditions described in Section II-4.2.3.1, a gate is installed in the north end of the guide wall which can provide the flowpath between the Missouri River and the forebay that will ensure functionality of a minimum of one Service Water pump. Procedures are in place to ensure the gate is removed prior to reaching a river level of 872 feet MSL. With the gate removed, no credit is taken for water flow over and around the south end of the guide wall during low river level conditions.

In the event of low flow combined with icing conditions, the mouth of the Intake Structure where the water enters is protected by a debris barricade constructed of steel rods spaced at 3'-0" on center which will prevent large blocks of ice from entering the tunnels and hitting the trash racks. In addition, the river water is tempered by recirculation of 25 to 33% of the warm Circulating Water discharge which enters the ice tunnel located on the riverward face of the

structure. Distribution of the tempering water is accomplished through multiple sluice gates. This tempering action will prevent the building up of ice on the debris barricade and racks. The water level within the Intake Structure will therefore reflect the forebay water level (area between the east Intake Structure wall and the guide wall) with only minor differences caused by friction losses from passage through the several screening devices.[15]

As discussed in Subsection II-4.2.3.1, a failure of the Oahe or Ft. Randall flood control dams is the most likely initiator of a river diversion.[16] The closer of the two, Fort Randall, is almost 350 miles upstream from the plant site and there would be a three day warning before the river reaches a peak flood stage at CNS. During this peak flood stage, shutdown procedures to the reactor could begin and continue as the flood waters slowly recede. After the river diversion occurs, the resulting isolated body of water in the vicinity of the site, fed by ground water inflow, would retain essentially the same stage characteristics that apply to the present open river as long as the main channel was retained in the existing valley. Minor variations resulting from elimination of some bends would be of no consequence to the safe operation of the plant. Extreme low water stages which might be attained in the natural channel would not occur under these circumstances because of the lag in response of groundwater to short term changes in the river channel. It is concluded, therefore, that there would be an adequate supply of water to effect a safe shutdown of the plant.[16]

4.3 River Usage

Commercial fishing from Yankton, South Dakota, to the Nebraska-Kansas border is extremely limited. There are over 25 different species of fish in this portion of the river. Carp is the primary commercial catch; other commercially important fish are the channel and flathead catfish. The river carpsucker is very common in this section of the river, however, it is not economically important.[22]

Because the Missouri is a fast flowing, muddy stream, its use for recreation purposes is limited.

The nearest downstream municipality using the river as its source of water supply is St. Joseph, Missouri, which is approximately 84 river miles from the site. River velocities range from 3 to 9 mph so that any discharge at the site would require a minimum of nine hours to reach St. Joseph.

The Missouri River supports barge traffic from its mouth to Sioux City, Iowa, for approximately eight months out of the year.

The transportation of petroleum products by barge, on this section of the Missouri River is relatively limited, thus a possibility that an oil barge could fail is remote. However, in the event of such a failure and considering that it would occur at minimum elevation 880'-0" at the site which coincides with lowest river elevation that is required to support navigation, the top of the opening to the Intake Structure at elevation 867'-6" is 12'-6" below the river surface. The difference in elevations makes it extremely improbable that oil would be drawn into the Intake Structure. However, should this occur in spite of the physical obstruction described above, the Circulating Water and Service Water pump suctions which are placed at elevations 856'-0" and 858'-4" respectively (24'-0" and 21'-8" below minimum navigation river level) have adequate cover to prevent the oil from being drawn into the system. Any oil which might have found its way into the Intake Structure under the postulated conditions would be removed prior to non-navigational, low river water conditions.[19]

The possibility that a runaway barge may strike the Intake Structure is addressed in USAR Section XII-2. In summary, the Intake Structure and Class I equipment located inside are qualified to withstand a barge impact. Additionally, a barge that impacts the Intake Structure guide wall will not significantly

impact the Intake Structure and, therefore, will have little if any effect on plant operations.

The consequences of a barge sinking in the vicinity of the Service Water and Circulating Water intake bays have been assessed. The largest barges operating on the Missouri River in the vicinity of CNS are 295 feet long, 50 feet wide, and 14 feet high. The postulated probability does exist, that a barge of this size could sink in front of the Intake Structure. However, a sunken barge, no matter what size, can not make a watertight closure against the mouth of the Intake Structure due to the protection provided by the Intake Structure guide wall and the configuration of the Intake Structure relative to the guide wall. Even if the guide wall were breached, the resulting plastic deformation of the guide wall would create a bridging effect that would prevent full blockage of an Intake Structure bay (or multiple bays) by the barge. Moreover, the continued contact with the guide wall and river currents would prevent counterclockwise barge movement that could block multiple Intake Structure bays. Similarly, a sunken barge in front of the guide wall could not create a watertight blockage of flow over and around the guide wall. In summary, a sunken barge may reduce the amount of flow into the Intake Structure, but will not affect safe operation of the plant. Should the flow be reduced below the normal requirements of the plant, the Circulating Water System requirements could be reduced temporarily, and if necessary, shutdown procedures could be initiated. Furthermore, should the Service Water intake bay be blocked, means have been provided to permit inflow from the adjacent Circulating Water intake water bay.

No munitions, explosive chemicals, or chlorine traffic by river barge currently exists on the Missouri River in the vicinity of CNS.

Section X-10.4.6.3 provides information on the Control Room toxic hazards associated with barge cargo. Contact is maintained with the Corps of Engineers to determine if and when additional analyses are required due to changes in hazardous cargo barge size or types of hazardous cargo being barged past CNS.

4.4 Ground Water

4.4.1 General

The average rainfall in the area is about 30 inches per year. Essentially all of the precipitation falling on the flood plain is infiltrated into the subsurface, where it is consumed in support of crops. The excess over transpiration and pellicular requirements filters down to the water table (879 feet MSL) about 10 feet below the original surface at the plant site. A higher percentage of water falling on the uplands west of the bluff line goes into run-off. Most of this is collected in drainage ditches located between the site and the bluff line.

As noted, the unconsolidated sediments are mostly sand. Some silt and clay seams, probably discontinuous, are found in the upper 15 feet of the deposit and in discontinuous lenses at a depth of about 40 feet. Over 90% of the deposit is loose to medium dense, fine to coarse, sand. From the hydrologic point of view, the sand deposits constitute an open hydraulic system with the Missouri River. This means that, with respect to the river, ground water in the sand will be either influent or effluent depending on the river stage.

4.4.2 Ground Water Usage

The characteristics of the public water supply wells in the area of influence (of the plant) have been reviewed. The data reviewed includes well logs, pump tests results, and quality analyses obtained from the Layne Western Company of Omaha, Nebraska, and the State Department of Health. All information indicates that the primary source of water along the river is ground water taken from the sand and gravels in the alluvium over the bedrock.

Ground water flow in the general area of the site has a component parallel to and a component perpendicular to the river. On the Nebraska side of the river, flow is therefore toward the river from the northwest; and on the Missouri side, flow is toward the river from the northeast. Subsurface flow parallel to the river is estimated to be at a maximum rate of about 3.5 feet per day. Flow perpendicular to the river varies with the stage of the river.

Because of the direction of ground water flow, the only wells that could be affected would be those downstream of the plant site. Due to the dilution that would occur, the effects of any discharge would be less on the east side of the river than on the west side where the plant is located.

There are six wells within one mile of the plant site, two of which are site wells to supply plant needs. The remaining four are listed as follows:[18]

1. *Farm well approximately 0.7 miles south-southwest from the reactor building, for domestic use, 1 ¼" casing size, pump less than 10 gpm, static water level approximately 15 feet. Driven sand point installation will not permit drawdown measurements.*

2. *Farm well approximately 0.7 miles south-southwest from reactor building, for livestock use, seven inch casing size, pump less than 10 gpm, static water approximately 15 feet. The domestic type installation does not include the means for drawdown measurements.*

3. *Farm well approximately 0.8 miles west from the reactor building, for domestic and livestock use. The well is hand dug, approximately 3 ½ feet in diameter with a rock lined wall. Well capacity is less than 10 gpm; static water level is approximately 15 feet. Drawdown data is not available.*

4. *Farm well approximately 1.0 miles west-northwest from the reactor building. This is an abandoned, hand dug, rock lined well on an abandoned farmstead.*

All of the wells within one mile of the CNS site are small farm wells which were installed to supply domestic and livestock water needs for the individual farmsteads. These wells fall into three classes; drilled and cased wells, hand driven sand points and hand dug, rock or brick lined wells. The wells are shallow and draw their water from the same general aquifer which yields very high solids water with high iron and manganese concentrations. Because of the private nature of these domestic wells and absence of test connections, data is not available for maximum pumping rates and water levels. Therefore, water level is estimated from engineering data from the site wells which were installed in the same, flat, Missouri River bottom land. A pumping rate of less than 10 gpm is consistent with these types of wells.

In between the site and St. Joseph, the area within five miles either side of the river is rural with scattered homes and villages. For protection from flood waters, the majority of the villages are located a mile or more back from the river. For the same reason most farmsteads are at least half a mile back from the river.

The nearest downstream Nebraska village is Nemaha, about two miles downstream and 2 ½ miles west of the river. Present water supply is from about 80 low capacity private wells ranging in depth from 16 to 18 feet and a newly-installed municipal water system which is supplied by two wells having a total capacity in excess of 250 gpm.

The pumping system for Nemaha County Rural Water District No. 1 draws water from wells located 5.2 miles north-northwest of the CNS site. The wells are located one mile from the Missouri River approximately five miles up river from the CNS site. The Nemaha County Rural Water District No. 1 began distributing water to rural areas in 1971 and is replacing many of the farm wells as principal water supply.

The community of Nemaha has two municipal wells located at 7th and Ottoe Streets and 4th and Ottoe Streets respectively. They are eight inch cased wells drilled to approximately 80 feet in depth. Normal static water level is approximately 30 feet. They are equipped with submersible pumps rated at 60 gpm capacity at normal system head. Drawdown is minimal, estimated to be less than six feet. The aquifier receives recharge from the Nemaha River.

Specific engineering information was not catalogued at installation. The above information was retrieved from existing city water system records.

Rulo, population 412, is located on high ground near the river and after Nemaha, is the next downstream Nebraska village situated within three miles of the river. This village which is approximately 35 miles downstream of the site has private wells for its water supply. There are, however, wells at Rulo which supply the town of Falls City, population 5,598, about ten miles west from the river.

There are also several small villages east of the river in Missouri between the site and Rulo. The village of Langdon, population 25, is the closest and is about a mile downstream and 2 ½ miles east of the river.

There are only two occupied farmsteads within a one-mile radius of the plant. For a distance of five river miles downstream there are six Nebraska farmsteads within a mile of the river. Shallow, low capacity, hand dug, or sandpoint wells are the normal sources of water supply for these farmsteads.

Due to subirrigation and ample rainfall, irrigation is virtually nonexistent in the area. There are five registered irrigation wells in Nemaha County and only one in Richardson County. These wells would not be located along the river since subirrigation takes care of water needs. The same situation would be expected on the east side of the river.

There are two site wells that are used for supplying potable water to the site. They are approximately 100 feet apart, located on a north-south line approximately 1250 feet west and 500 feet north of the Reactor Building. Each well is approximately 63 feet deep and designed for 250 gpm pumping capacity. The normal pumping rate is anticipated to be 125 gpm with one well in service. Maximum short term plant demand is approximately 250 gpm which is the capacity of the plant Makeup Water Treatment System.

In the design of the plant, all areas in which contaminated wastes are handled are sealed by suitable non-permeable materials to prevent such wastes from entering the ground water.

The most recent CNS hydrogeologic investigation report was issued in December 2009. The hydrogeologic investigation characterized the geologic and hydrogeologic conditions at CNS. In addition, potential human, ecological, or environmental receptors for any tritium and/or radionuclides that might have been released to the groundwater and/or surface water were evaluated.

An environmental surveillance program has been established to periodically sample and analyze water from wells in close proximity to the plant.

4.5 Chemical and Bacteriological Quality of Water

Tables II-4-3and II-4-4 list the chemical and bacteriological quality of the Missouri River water.

4.6 Conclusions

The immediate station area grade is at elevation 903 feet MSL. This is four feet above the flood of record, one foot above the existing levee and equal to the highest projected level of the maximum probable natural flood. Over topping of the levee would occur before flooding of the station would occur.

Failure of an upstream dam is considered improbable. However, in the unlikely event that such a failure would occur, it would be approximately three days before the water would reach the site, which is sufficient time to provide protection or to conduct a safe and orderly shutdown of the plant. High water resulting from failure of an upstream dam would overtop the levee before flooding the station.

Because of the flow regulation possible with the upstream dams, minimum flow will not be less than 3,000 cfs.

TABLE II-4-3

CHEMICAL CHARACTERISTICS OF MISSOURI RIVER WATER[1]

Item	*Extreme Maximum*	*Normal Maximum*	*Minimum*	*Average*
(Values in ppm unless otherwise noted)				
Calcium (Ca)	*78*	*69*	*30*	*60*
Magnesium (Mg)	*23*	*20*	*8.8*	*17*
Silica ($Si0_2$)	*26*	*21*	*5.5*	*16*
Iron (Fe)	*0.53*	*0.14*	*0*	*0.04*
Bicarbonate (HCO_3)	*310*	*275*	*134*	*195*
Carbonate (CO_3)	*0*	*0*	*0*	*0*
Sulfate (SO_4)	*218*	*196*	*47*	*147*
Chloride (Cl)	*34*	*26*	*6.7*	*19*
Fluoride (F)	*0.6*	*0.56*	*0.2*	*0.46*
Nitrate (NO_3)	*7.5*	*5.5*	*0.7*	*3.8*
Boron (B)	*0.22*	*0.16*	*0.01*	*0.11*
Dissolved Solids	*617*	*548*	*217*	*446*
Hardness, as $CaCO_3$				
Calcium, Mag.	*344*	*275*	*111*	*228*
Non-carbonate	*101*	*86*	*21*	*69*
Specific Conductance (micromhos at 25°C)	*994*	*823*	*273*	*672*
pH	*9.0*	*8.2*	*6.7*	*7.5*
Color	*30*	*13.6*	*2*	*8*
Temperature, °F	*85*[2]		*32*	

[1]*Data from U.S. Geological Survey Station at Nebraska City, Nebraska.*

[2] 95°F is the upper limit assumed for the Service Water temperature in the transient and accident analysis.

TABLE II-4-4

BACTERIOLOGICAL CHARACTERISTICS OF MISSOURI RIVER WATER

BOD mg/1	*Range:*	*6.5 - 1.0*
COD mg/1		*23 (single reading)*
Chlorine Demand 1 - hr, mg/1	*Range:*	*5.4 - 2.0*
24 - hr, mg/1	*Range:*	*6.5 - 3.0*
Turbidity (scale units)	*Range:*	*6,970 - 50*
Coliforms (per 100 ml)	*Range:*	*69,000 - 100*

(Data from October, 1959 - September, 1960, U.S. Department of Health, Education and Welfare, Public Health Service Publication "National Water Quality Network" Station: Missouri River at St. Joseph, Missouri)

St. Joseph, Missouri, 84 miles downstream, is the closest downstream municipality using the Missouri for its water supply. In between the site and St. Joseph, there are few wells along the river and they are primarily shallow, low capacity, hand dug, or sand point wells.

5.0 GEOLOGY AND SEISMOLOGY

This USAR Section contains historical information as indicated by the italicized text. USAR Section I-3.4 provides a more detailed discussion of historical information. The factual information being presented in this section on geology and seismology has been preserved as it was originally submitted to the Atomic Energy Commission in the CNS FSAR in February 1971, as amended.

5.1 Geology

5.1.1 General

The site of the nuclear power station is in Nemaha County, southeastern Nebraska, on the west bank of the Missouri River. It is situated on the first bottomland of the broad, nearly level, flood plain which is approximately six miles wide at the site. The natural relief is about ten feet. The site is shown in a regional map, Figure II-2-2; an aerial view is shown in Figure II-2-1.

5.1.2 Geologic Investigation Program

A geologic investigation program of the site and its environs was conducted by means of a review of geologic literature, study of old and current topographic and geologic maps, interpretation of air photos, interviews with geologists associated with public agencies and universities, and a field geologic survey.

5.1.3 Regional Geology

The principal geologic strata in the region in order of increasing depth are soil deposits, sedimentary rocks, and deep basement igneous rocks. The soil deposits consist of loess and till in the uplands, and either stratified or heterogeneous alluvium in the flood plains. Thickness of deposits varies from a few feet to about 100 feet for loess, none to several feet for till, and less than 10 feet to more than 100 feet for alluvium. The rock strata are gently dipping sedimentary rocks mainly Paleozoic in age. Alternating beds of shale, limestone, sandstone, and occasional thin beds of coal are present. The total thickness varies from over 3,500 feet near the site to about 500 feet, 30 miles west. The deep basement igneous rocks are Precambrian in origin, chiefly primary granite or granitoid rocks. The regional bedrock geology and cross section are shown in Figure II-5-1, the Precambrian surface configuration is shown in Figure II-5-2.

The major geologic structures in the region are the Nemaha Anticline, Forest City Basin, Humboldt Fault, and Thurman-Wilson Fault. Except for the Forest City Basin, none of these structures is in the immediate vicinity of the site. The closest one, 20 miles to the west, is the Nemaha Anticline and its associated Humboldt Fault. The principal structural features of the region are shown in Figure II-5-2.

The Nemaha Anticline is a major structural feature of the midcontinent which separates two depositional basins, the Forest City Basin on its east flank and the northern extension of the Salina Basin on the west. It is a sharp uplift of Precambrian granite. The anticline is believed to have first come into existence by folding and faulting at the close of the Proterozoic. Its development of near orogenic proportions occurred near the end of the Mississippian and continued through Pennsylvanian into early Permian. By early Permian, major tectonic movements appear to have ceased. The anticline trends southward from Omaha, through Nebraska, across Kansas, and into northern Oklahoma. The crest of the buried mountain range is irregular; its depth below ground surface varies from 400 feet at the Nebraska-Kansas line to 3,000 feet at the Kansas-Oklahoma line. The anticline has a very steep eastern front which is faulted in several areas. The most notable fault is the Humboldt Fault, principally a normal fault striking in a general north-south direction. Vertical displacement of 1,000 to 1,500 feet in Nebraska and in the vicinity of Nebraska City, Nebraska, are reported. The Humboldt and Thurman-Wilson Faults are shown in Figure II-5-3.

The Forest City Basin underlies the site. Its basinal axis in Nebraska lies close to and roughly parallels the Nemaha Anticline on the east. Its west flank shares a common front with the steep eastern flank of the Nemaha Anticline.

The Thurman-Wilson Fault is associated with the Redfield Anticline which strikes southwest from approximately Des Moines, Iowa, toward Lincoln, Nebraska. The fault is about 40 miles north of the site and is located south of the crest of the anticlinal axis. The fault has a southward displacement of about ten feet.

5.1.4 Site Geology

Locally, the stratigraphy is best represented by a section through the bluffs along the western boundary of the site. It shows Peorian loess, Kansas till, limestone and shale of the Permian system, and limestone, shale, sandstone, and occasional thin beds of coal of the Pennsylvanian system. The contact between the two systems is unconformable and occurs in the bluff at approximately elevation 930 feet MSL. A generalized columnar section is shown in Figure II-5-3 and a stratigraphic chart is shown in Figure II-5-4.

Detailed classification of rock cores obtained in borings at the site show excellent correlation with published regional stratigraphic columns in both sequence and thickness.

The geologic structures occurring within the rocks at the site are minor. Field observations suggest the possibility of minor plains-type folding resulting from differential compaction of underlying sediments. No faults have been found at the site or in the local area, nor are any known of or suspected.

Locally, three principal types of soils are found, each of different geologic origin; loess and till in the bluffs and alluvial and glacial deposits in the flood plains.

The loess are wind-blown silts. The topography of the loess reflects the surface configuration of the underlying till or rock. Its ability to maintain steep faces is responsible for the near vertical slopes in the upper portion of the bluffs.

The Kansan till underlies the loess. It is a heterogeneous mixture of clay, silt, sand, gravel, cobble, and boulder, and is five to ten feet thick. In an unleached and unoxidized condition, it is commonly a dark gray silty clay which contains erratics and locally derived cobbles and boulders. Sand lenses are distributed throughout the deposit. Complete removal of calcareous minerals in the upper limits of the till produces the highly tenacious gumbotil.

The alluvial deposits in the flood plain at the site vary in thickness from 62 to 71 feet. Two major subtypes of different geologic origin are present; the surficial fine-grained soils and the underlying sands.

The surficial fine-grained soils are recent alluvial deposits derived from the meandering Missouri River. Evidences of the meander were analyzed by a stereoscopic study of aerial photographs. Figure II-5-5 shows the interpreted location of former natural levees. The surficial soils consist of meander-belt and back-swamp deposits, ranging in thickness from 10 to 25 feet. For the most part, these deposits are silty sand, sandy silt, silty clay, and clay, and may be encountered in localized pockets or in complex combinations.

The underlying sands appear to be either fluvial or glacial outwash deposits or both. The amount of silt and clay size particles is generally small. They grade from fine to coarse with increasing depth. Lenses of clay, coarse sand, and fine gravel are distributed irregularly throughout the deposit.

5.2 Seismology and Design Response Criteria

5.2.1 General

The seismic-probability map of the United States compiled by the USC&GS indicates that the site is located within Zone 1. It corresponds to an earthquake intensity of Modified-Mercalli (MM) V or VI.

Between 1811 and 1964, 27 recorded earthquakes of epicentral intensity greater than MM IV have or may have been felt at the site. Among these 27 earthquakes, the three 1811-1812 New Madrid earthquakes were of intensities MM XII and had epicenters approximately 430 miles from the site. A maximum of six earthquakes were of intensities MM VII. Four of these had epicenters between 28 and 80 miles from the site; the last two had epicenters

approximately 350 miles from the site. The earthquake epicenter map (Figure II-5-6) shows the epicenters of earthquakes of epicentral intensity greater than MM IV which have or may have been felt at the site.

5.2.2 Seismicity of the Site

The earthquakes most significant for the evaluation of the seismicity of the site are the New Madrid earthquakes of 1811 and 1812; the Lincoln, Nebraska, earthquake of 1877; the Tecumseh, Nebraska, earthquake of 1935; and the El Reno, Oklahoma, earthquake of 1952. On the basis of the historical earthquake records, it is concluded that:

1. *There is a reasonable chance that during the life of the nuclear power station, earthquakes would affect the site with an intensity MM VII.*

2. *The hypothetical maximum possible intensity of ground motion at the site would result from a local earthquake smaller than the New Madrid earthquakes of 1811 and 1812.*

Small slips appear to occur along the Humboldt Fault and many of the regional earthquakes had epicenters in the vicinity of the Nemaha Anticline and Humboldt Fault. However, important displacements of the Humboldt Fault have not occurred for 200 million years and it is improbable that future earthquakes with epicenters located in the vicinity of the Humboldt Fault will have epicentral intensities greater than MM VII.

There is no evidence at the site of either a fault or other bedrock discontinuity which would tend to increase the seismicity of the site as compared to nearby sites.

5.2.3 Selection of Design Earthquakes

The selection of the design earthquakes is based on the USC&GS Seismic-Probability Map, the records of historical earthquakes, and the regional and local geologic structural features.

A maximum probable design earthquake was selected for structural analysis of the major structures under an elastic response requirement. The maximum value of 0.10 gravity was selected for the horizontal component of the acceleration at both the rock surface, approximate elevation 820 feet MSL, and the base of the structures, approximate elevation 850 to 860 feet MSL. The selection was based on the assumption that the structures will be built on mat foundations supported by a dense structural fill, extending from the bedrock surface to the mat foundations. The accelerogram of the N69W component of the July 21, 1952, earthquake as recorded at Taft was used for the development of the response spectra. The design values of the vertical component of the accelerations are one-half those of the horizontal component.

A hypothetical maximum possible design earthquake was selected for structural analysis under the requirement of safe and orderly shutdown of the nuclear reactor and functional integrity of the major structures. The maximum value of 0.20 gravity was selected for the horizontal component of the acceleration at both the rock surface and the base of the structures. This selection is based on the assumption, as above, that the structures will be founded on a dense structural fill. The response spectra were obtained by multiplying by two the values of the displacements, velocities, and accelerations of the response spectra selected for the maximum probable design earthquake. The values of the vertical component of the accelerations are one-half those of the horizontal component.

A hypothetical maximum possible design earthquake was selected for liquefaction analysis. The maximum value of 0.25 gravity was selected for the horizontal component of the acceleration at the bedrock surface. The accelerogram was developed from the N69W component of the 1952 Taft earthquake as reported by USC&GS by repeating the 4 to 14 second portion of the reported accelerogram at the end of the 0 to 16 second portion and adding the remaining 14 seconds of the reported accelerogram.

5.2.3.1 Response Spectra for Structural Analyses

Response spectra are recommended for both the maximum probable design earthquake and the hypothetical maximum possible design earthquake.

The response spectra presented in Figures II-5-7, II-5-8, II-5-9, and II-5-10 were developed after the accelerogram of the N69W component of the July 21, 1952, Kern County earthquake recorded at Taft, California, as reported by the USC&GS (page 100, Murphy and Cloud, 1954). This accelerogram was selected in preference to any other, e.g., one of the 1940 El Centro accelerograms, for reasons of geology, geometry, seismology, and comparison with other response spectra.

The July 21, 1952, Kern County earthquake had a Richter magnitude of 7.7 and an epicentral intensity of MM XI. It was caused by a dip slip (vertical motion) along the White Wolf Fault. The depth of focus was estimated at 10 miles, plus 4 miles. The accelerogram used was recorded at Taft, at a distance of 30 miles plus 2 miles from the epicenter. The intensity at Taft was MM VII. The strong-motion seismograph was located in a tunnel between two buildings. The subsurface conditions consist of 50 feet of recent alluvium (clayey silty sands) overlying soft sedimentary rocks.

The May 18, 1940, El Centro earthquake had a Richter magnitude of 7.1 and an epicentral intensity of MM X. It was caused by a strike slip (horizontal motion) along a fault. The depth of focus was estimated at 6 to 10 miles. The accelerograms were recorded at a distance of approximately 27 miles from the epicenter, but only 4 miles from the causative fault. The strong-motion seismograph was located in a heavy concrete basement. The subsurface conditions consist of alluvium to a depth of at least a thousand feet.

The earthquakes affecting the site of the Cooper Station are expected to be caused by a slight slip along the Humboldt Fault which, at its closest point, is located 20 miles west of the site. The depths of focus of such earthquakes are estimated to range from approximately 16 to 38 miles (Merriam, 1963). The selected maximum probable design earthquake has an intensity of MM VII at the site, with a maximum ground acceleration of 0.10 gravity. The subsurface conditions consist of approximately 70 feet of alluvium overlying soft sedimentary rocks.

It is seen that in two important aspects, namely the distance of the affected point from the fault causing the earthquake and the subsurface conditions, the Taft records appear to be more pertinent for the site than the El Centro records.

The seismologic reason for preferring the Taft record over the El Centro record is related to the distance of the affected point from the causative fault, and to the Midwestern location of the site. The earthquakes affecting the site are expected to be of intermediate magnitude with an epicenter located at least 20 miles from the site. The selected Taft accelerogram scaled down or up, respectively for the maximum possible design earthquakes, seems to be most closely related to these conditions. On the contrary, the El Centro accelerograms, recorded very close to the causative fault, appear much less representative and would, moreover, have to be scaled down considerably for both the maximum probable and hypothetical maximum possible design earthquakes.

Figure II-5-11 shows that the recommended smoothed response spectra developed from the selected Taft accelerogram agree well with the average spectra proposed in Figure 1.21 of Nuclear Reactors and Earthquakes (TID 7024, 1963) scaled according to the spectral intensity. El Centro acceleration response spectra which were available only in unsmoothed form (Alford, et al., 1951), were scaled down according to the maximum ground acceleration and plotted on a common plot with the unsmoothed Taft acceleration response spectra obtained from two sources; Figures II-5-12 and II-5-13. Except for periods around 0.5 seconds where El Centro spectra are somewhat higher, the differences between the two spectra are small.

In conclusion, the N69W component of the July 21, 1952, Taft accelerogram is recommended for use in the calculation of structural response at Cooper Nuclear Station for reasons of geology, geometry, seismology, and comparison with other response spectra.

5.2.4 Application of the Design Earthquake Criteria

The characteristics of the selected design earthquakes are given in Table II-5-1. The Maximum Possible Design Earthquake previously referred to is now termed the Safe Shutdown Earthquake (SSE). The Maximum Probable Design Earthquake is the Operating Basis Earthquake (OBE). The seismic design for

Class I structures and equipment is based on dynamic analyses using acceleration response spectrum curves which are based on a ground motion of 0.1g. This OBE ground acceleration corresponds to an intensity of MM VI. The combined stresses resulting from dead, live, pressure, thermal and earthquake having a ground acceleration of 0.2g are applied to Structures, Systems, and Components (SSCs) that are necessary to achieve safe shutdown. This SSE ground acceleration corresponds to an intensity of MM VII.

For the design of Class I structures and equipment, the maximum horizontal and vertical accelerations were considered to occur simultaneously. Where applicable, stresses were added directly.

5.2.4.1 Application of Response Spectra for Strutural Analysis

A dynamic analysis has been made for the Class I structures. The Class I structures are designed to respond elastically, using normal allowable stresses without one-third increase and the response spectra as shown in Figure II-5-7 and II-5-8, which have been developed from the selected Operating Basis Earthquake.

The Class I structures have been designed using an ACI ultimate strength design and the response spectra as shown in Figures II-5-9 and II-5-10, which have been developed from the selected hypothetical Safe Shutdown Earthquake.

5.2.5 Seismic Instrumentation

5.2.5.1 System Components

Three peak accelerographs are located in the following areas selected per the criteria of NRC Regulatory Guide 1.12, Revision 1[8]:

1. One peak accelerograph mounted on the support skirt for the reactor vessel (elevation 915).

2. One peak accelerograph is located on the Core Spray 1A Line entering the drywell at elevation 946.

3. One peak accelerograph is located on the Seismic Category I Isolation Relay Panel "C" in the Cable Spreading Room.

Data provided by these peak accelerographs may contain recordings of non-seismic loadings, such as vibratory or shock loadings, which will be considered during evaluations of the data.

In addition to the peak accelerographs, three recorder/triaxial sensors are rigidly mounted on concrete slabs at key locations at CNS. The instruments measuring range is +4g to -4g and all recorder/triaxial sensors are oriented such that each major axis of each sensor is parallel to its counterpart in the other sensor.

The recorder/triaxial sensors are located as follows[24]:

1. In the Reactor Building northwest quad; 4 feet south of column line 12.7 and 4 feet east of column line Q.

TABLE II-5-1

SELECTED DESIGN EARTHQUAKES

OPERATING BASIS EARTHQUAKE (OBE)

Maximum Ground Acceleration at Site

Horizontal component at rock surface, elevation 820 approximately, or at base of structures, elevation 850 to 860 approximately, if founded on structural fill: 0.10 gravity.

Vertical component: two-thirds of horizontal component.

Accelerograms for Development of Response Spectra

Horizontal component. For basic data, use N69W accelerogram recorded at Taft on July 21, 1952, between times 0 and 30 sec (page 100, Murphy and Cloud, 1954). To obtain accelerogram, multiply these accelerations by 10/18.

Vertical component: two-thirds of horizontal component.

SAFE SHUTDOWN EARTHQUAKE (SSE)

Maximum Ground Acceleration at Site

1. Structural Design - Horizontal component at rock surface, elevation 820 approximately, or at base of structures, elevation 850 to 860 approximately, if founded on structural fill: 0.20g. Vertical component: two-thirds of horizontal component.

2. Liquefaction Analysis - Horizontal component at rock surface, elevation 820 approximately: 0.25g. No vertical component.

Accelerogram for Development of Response Spectra

1. Structural Design - Horizontal component: multiply accelerations of accelerogram recommended for the SSE by two. Vertical component: use two-thirds of horizontal component.

2. Liquefaction Analysis – Horizontal component: multiply accelerations of accelerogram recommended for maximum probable design earthquake by two and one-half. Repeat 4 - 14 sec portion of this accelerogram at end of 0 - 16 sec portion and add remaining 14 sec of this accelerogram. Duration of accelerogram used for liquefaction analysis is: 16 + 10 + 14 = 40 sec. No vertical component.

2. Reactor Building refueling floor elevation 1,001'; exactly on column line 12.7 and 4 feet east of column line Q.

3. In the zone of compacted backfill 140 feet north and 80 feet east of the Diesel Generator Building northeast corner.[5]

In addition to the above, events are recorded at each recorder/triaxial sensor on an SD card.

The events are retrievable from a computer in the control room that is connected to the system.

5.2.5.2 System Operation

Activation of the seismic system occurs at 0.01g and will be alarmed in the main control room. The value of 0.01g was selected as it is at the lower end of the equipment and structural damage threshold, and above the levels anticipated for ambient disturbances (i.e., truck, cranes, etc.).

The data generated by the aforementioned instruments is reduced and evaluated as follows:

1. The data from the recorder/triaxial sensors is retrieved as soon as possible. The acceleration time history and response spectra graphs are plotted into a PDF file using the EAW software installed on the computer. The data should be saved as soon as possible to a CD or DVD. The resulting response spectra is then analyzed for each recorder/triaxial sensor.

2. The scratch plates from the peak recording accelerographs are retrieved as soon as practicable. The scratch plates from the peak accelerograph mounted on the reactor vessel support skid are retrieved following the next reactor shutdown when the drywell is deinerted.

3. The data for the actual time history acceleration at the reactor building mat (obtained from the recorder/triaxial sensor located in the Reactor Building northwest quad) is compared with the input time history of the motion assumed for the dynamic analysis for the original plant as soon as possible. The analytical output is compared with the measured accelerations of the peak recording accelerograph and recorder/triaxial sensor located on the Reactor Building operating floor to evaluate the validity of the mathematical model and to determine the effects of the earthquake on the plant. The seismic accelerations from the earthquake determined from this evaluation will then be compared to the design requirements in order to determine whether the operational capability of the plant has been impaired.

4. A report is prepared for each seismic event analyzed and is available for inspection.

6.0 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

The Cooper Nuclear Station Radiological Environmental Monitoring Program[6] (formerly known as the CNS Environmental Radiation Surveillance Program) was started during October, 1970, and has been continued through station start-up and operation. The preoperational phase of the program was designed to determine background levels of radioactivity in the various environmental media at the plant site and at suitable off-site locations in areas surrounding the plant site, and to provide a baseline upon which subsequent operational environmental radiation surveillance data can be evaluated. Continuation of the environmental monitoring program during subsequent plant operation is for the purpose of detecting and evaluating significant influences, if any, on the environmental radiation which may result from operation of the plant. The program is conducted to satisfy the requirements of 10CFR50, Appendix I, Sections IV.B.2 and 3.

The Cooper Nuclear Station Offsite Dose Assessment Manual for Gaseous and Liquid Effluents (ODAM) describes in detail the actual monitoring program and is controlled by the CNS Technical Specifications. The program monitors radiation levels in the air, terrestrial, and aquatic environments. Samples are collected and are shipped for analysis to a contractor's laboratory. The program also conducts a periodic land use census. The program results are submitted in the Annual Radiological Environmental Operating Report.

7.0 REFERENCES FOR CHAPTER II

1. Deleted.

2. Army Corps of Engineers letter dated January 26, 1972, to Mr. M. J. Hroncich (Burns and Roe) from Mr. R. G. Burnett, Chief, Engineering Division of the Omaha District, Corps of Engineers.

3. Army Corps of Engineers letter dated January 17, 1968, to Mr. M. J. Hroncich (Burns and Roe) from Mr. C. L. Hipp, Chief, Engineering Division of the Omaha District, Corps of Engineers.

4. Deleted.

5. MDC 84-002.

6. Amendment 89 to the Technical Specifications dated December 24, 1984.

7. MDCs 81-118, 81-119, 84-015, and 84-025.

8. MDC 77-108.

9. NEDC 94-271.

10. Deleted.

11. FSAR Amendment 9, Q/A 2.1

12. FSAR Amendment 9, Q/A 2.2

13. FSAR Amendment 9, Q/A 2.3

14. FSAR Amendment 11, Q/A 2.4

15. FSAR Amendment 9, Q/A 2.5

16. FSAR Amendment 9, Q/A 2.6

17. FSAR Amendment 9, Q/A 2.7

18. FSAR Amendment 9, Q/A 2.8

19. FSAR Amendment 9, Q/A 2.10

20. FSAR Amendment 9, Q/A 2.12

21. FSAR Amendment 9, Q/A 2.16

22. FSAR Amendment 9, Q/A 2.23

23. FSAR Amendment 13, Q/A 2.28 and 2.29

24. FSAR Amendment 18, Q/A 2.32

25. FSAR Amendment 17, Q/A 2.34

26. FSAR Amendment 16, Q/A 2.35