OMAHA PUBLIC POWER DISTRICT

FORT CALHOUN STATION STRETCH POWER

ENVIRONMENTAL ASSESSMENT

POWER

OMAHA PUBLIC POWER DISTRICT

HEAT LIGHT

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ATTACHMENT A

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SECTION 1 - INTRODUCTION

This analysis assesses the environmental consequences of increasing (stretching) the thermal power level of the Omaha Public Power District's (OPPD) Fort Calhoun Station Unit No. 1 from 1420 MWt to 1500 MWt. The stretch rating is approximately 5.6% greater than the power level currently authorized by Operating License No. DPR-40, dated May 24, 1973.

Various documents, previously reviewed by the Nuclear Regulatory Commission, have been used, as appropriate, to prepare this report. These include the following:

1. Fort Calhoun Station Unit No. 1 Revised Environmental Report (U1 ER).

2. Fort Calhoun Station Unit No. 1 Final Safety Analysis Report (U1 FSAR).

3. Safety Evaluation of the Omaha Public Power District Fort Calhoun Station Unit No. 1, August 9, 1972 (U1 SER).

4. Fort Calhoun Station Unit No. 1 Five Year Report, A Summary of Environmental Study Programs Conducted in Compliance With Appendix B to Operating License No. DPR-40.

5. Fort Calhoun Station Unit No. 2 Environmental Report (U2 ER).

6. NUREG-0434, Final Environmental Statement, Fort Calhoun Station Unit No. 2 (U2 FES).

Items 1. through 4. may be found on Docket No. 50-285 and items 5. and 6. on Docket No. 50-548. Since the U1 ER was written prior to 1973, the U2 ER was used as a format for addressing current environmental issues in this report and for updating information provided in the U1 ER.

The importance of attaining additional generating capacity through stretching of the Fort Calhoun Station, as opposed to utilizing other non-nuclear forms of generation, is best illustrated by differential fuel costs for coal and oil. Differential fuel costs, expressed in terms of mills/KwHr, show the additional cost associated with producing a kilowatt-hour of generation with coal or oil, rather than nuclear fuel, for OPPD generating stations. Differential fuel costs for 1979 are predicted to be approximately 12.4 mills/KwHr for coal and 40.0 mills/KwHr for oil. Assuming an annual capacity factor for Fort Calhoun Station of 75%, a savings of approximately 2 million dollars per year (based on 1979 data) could be realized by generating additional power through stretching the nuclear unit, rather than using coal generation. The savings of using nuclear generation instead of oil would be approximately 7 million dollars.

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SECTION 1 - INTRODUCTION (Continued)

The need for the additional power, achieved by stretching the Fort Calhoun Station, is evidenced by the forecasted annual growth rate of electricity use in Nebraska, over the next 5 years, ranging from 5.3% to 6.9%, as predicted in the Commission staff's electrical energy forecast in the U2 FES. In addition, producing as much electricity with nuclear generation as possible is in keeping with national policy aimed at reducing the consumption of natural gas and oil. Finally, the staff's conclusion in the U2 FES was that additional generating capacity will be needed by OPPD to satisfy customer demands within the next few years.

The following sections of this report will demonstrate that stretching the Fort Calhoun Station will have no adverse impact upon the environment. Additional power can be attained, cost effectively, without damage to the environment or health and safety of the public.

SECTION 2 - SITE AND ENVIRONMENTAL INTERFACES

2.1 Site Description and Location

The Fort Calhoun Station is located in Washington County, Nebraska, approximately 21 miles north of downtown Omaha. The plant is situated on the flood plain immediately adjacent to the southwest bank of the Missouri River. The town of Fort Calhoun, Nebraska, is approximately 5 miles southeast of the site. U. S. Highway 73, on the bluff west of the Missouri River, is less than 1 mile southwest of the plant. Figure 2.1-1 shows the area within a 50 mile radius of the site.

The site area is the area of land for which OPPD has the legal right to control access by individuals and to restrict land use for the purpose of limiting potential exposure to radiation during normal facility operation. The site boundary is synonymous with the exclusion area boundary which has been evaluated in accordance with 10 CFR 100 such that an individual located at any point on the boundary for 2 hours, following an accident, would receive a total radiation dose to the whole body of less than 25 rem and a thyroid dose of less than 300 rem. The exclusion radius lies entirely within the exclusion boundary. The exclusion area boundary consists of approximately 1242 acres, including approximately 660 acres in Washington County, Nebraska, owned by OPPD and 582 acres in Harrison County, Iowa, on the east bank of the river directly opposite the facility, on which OPPD retains perpetual easement rights. The minimum exclusion area boundary point is located approximately at the 187.0 degree radial from the outer wall of the containment building and at a distance of 910 meters. U. S. Highway 73 traverses the extreme south-southwest corner of the site boundary, and a railway line follows a similar path. Figure 2.1-2 shows the site. The only activity, not related to plant operations, occurring on the site is farming.

2.2 Population

The information contained within this section is based on 1970 census data. This data was primarily taken by the U. S. Bureau of the Census, with additional information being supplied by master plans of local jurisdictions, aerial photographs from the Agricultural Stabilization and Conservation Service, Washington and Harrison County highway maps, and field reconnaissance.

The total population within a 10-mile radius circle of the plant was approximately 13,900 in 1970 and is projected to increase to 15,859 in 1983 and 21,612 in 2020. Average densities for these population figures are 44.2, 50.5, and 68.8 persons per square mile, respectively, but most of the people are concentrated in small communities. The closest community is Blair, Nebraska, located 3.5 miles north-northwest of the site, with a 1970 population of 6106.

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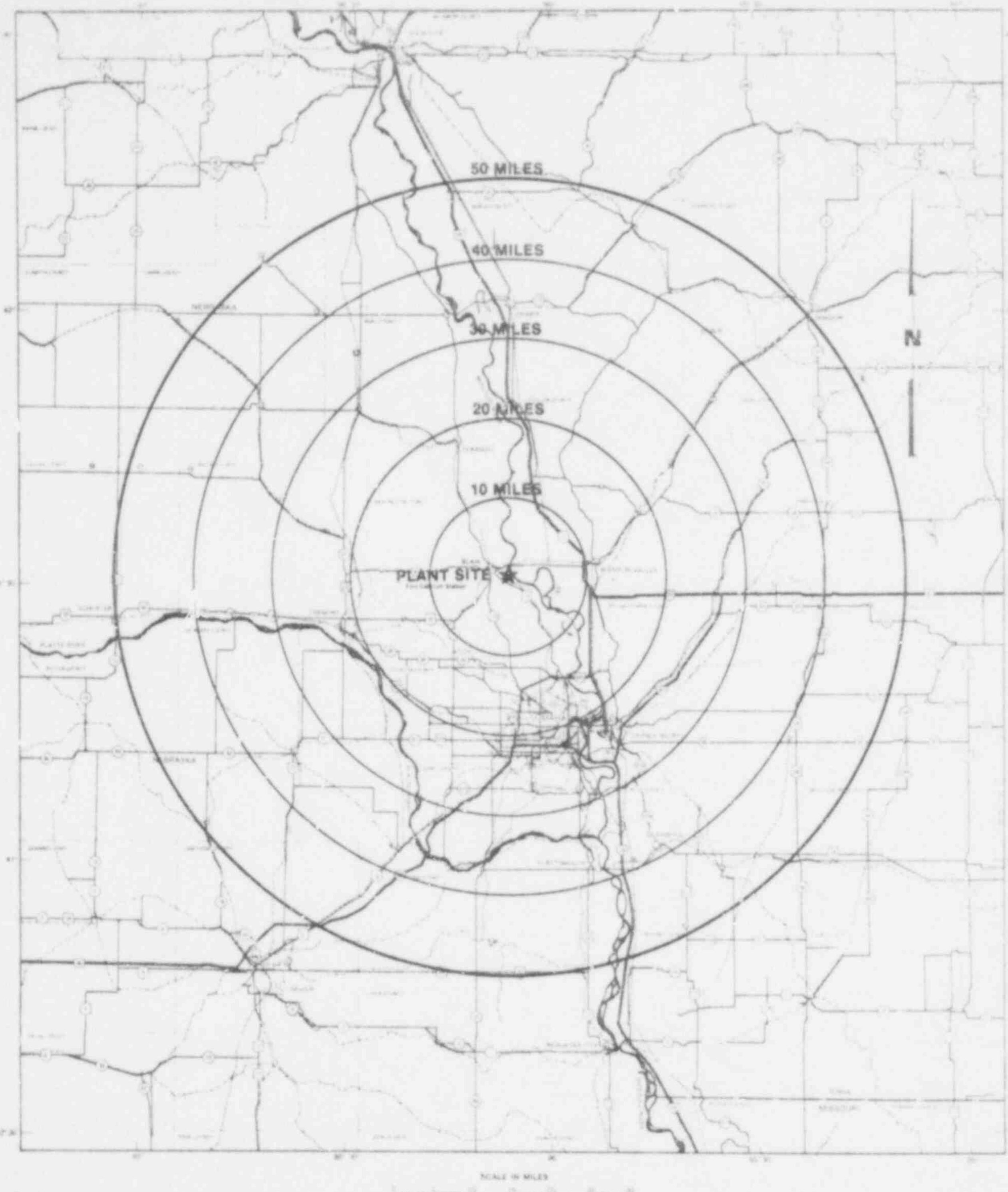

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OMAHA PUBLIC POWER DISTRICT FORT CALHOUN STATION UNIT NO. 1	Figure 2.1-1 Site Location Map

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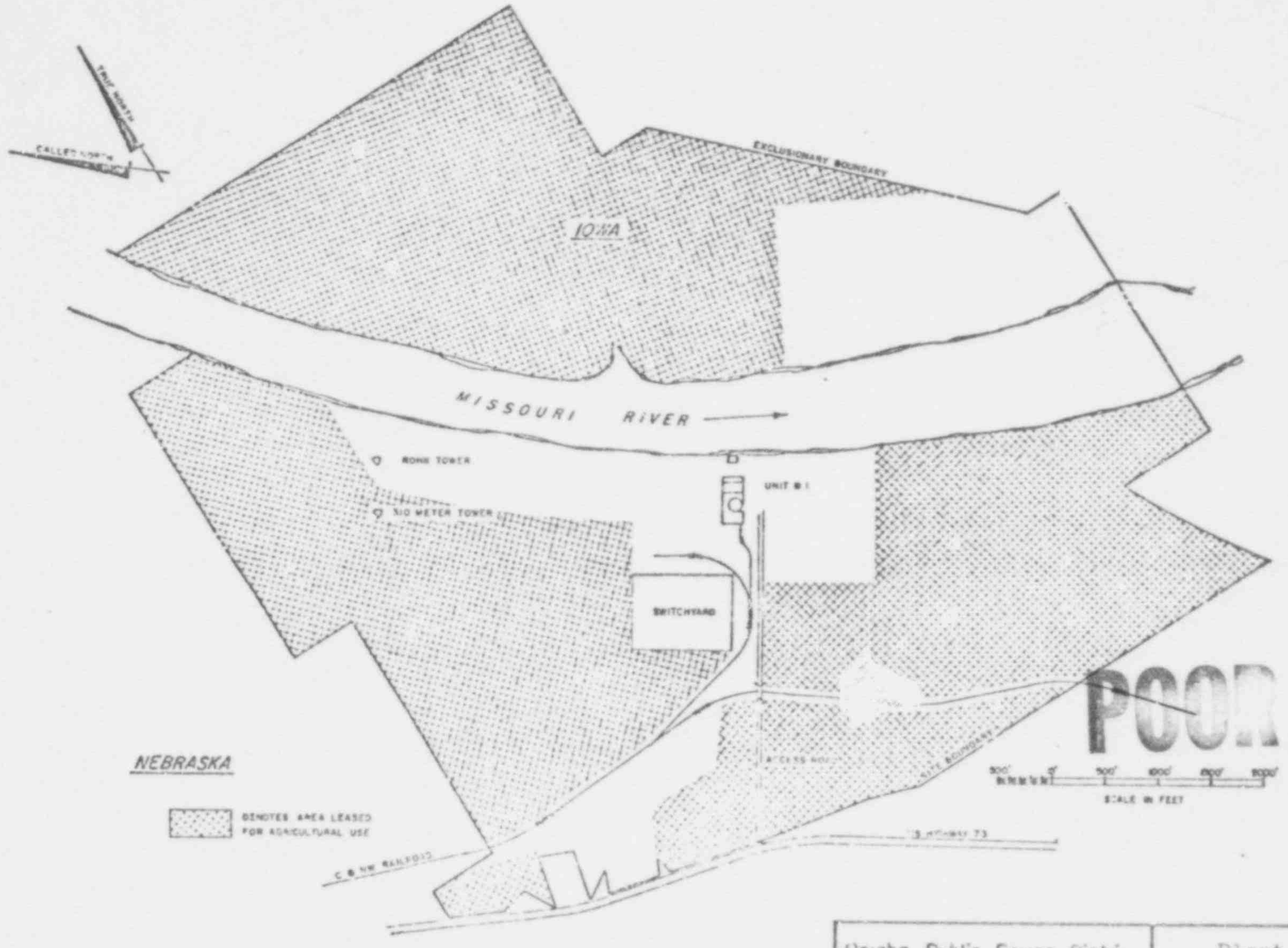

Omaha Public Power District Fort Calhoun Station Unit No. 1	Plant Site	Figure 2.1-2

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2.2 Population (Continued)

Other communities within approximately 10 miles of the site include California Junction, Fort Calhoun, Kennard, Modale. Nashville, Loveland, Missouri Valley, Findley, and Washington. Table 2.2-1 shows locations of population centers in the vicinity of the Fort Calhoun Station. Tables 2.2-2, 2.2-3, and 2.2-4 show the 1970, 1983, and 2020 population by compass sectors and by concentric rings from the site center, 0 to 10 miles. Figure 2.2-1 provides a site vicinity map showing present and future population for the same years, 0 to 10 miles. The majority of the increase in population projected for the 10-mile radius area for 2020 will be concentrated near Blair and on the outskirts of Omaha.

Total population within 50 miles of the Fort Calhoun site was 728,527 in 1970 and is expected to increase to 1,218,424 in 2020. Of these totals, the population between 10 and 50 miles of the site was 714,627 (average of 94.8 persons per square mile) in 1970 and is anticipated to be 1,196,812 in 2020 (average of 158.7 persons per square mile).

The major population center within the 50-mil radius is Omaha, Nebraska. The metropolitan area lies between 10 and 30 miles from the site in the south and south-southeast sectors. Omaha had a 1970 population of 389,455 and a projected 2020 population of 542,819. In 1970, approximately 30 percent of Nebraska's population resided in the Omaha metropolitan area. About 8 percent of Iowa's 1970 population resided within the 50-mile radius of Fort Calhoun, and this percentage includes a major population concentration of 60,348 in Council Bluffs. Table 2.2-5 gives current and projected population of selected communities within 50 miles of the site. Tables 2.2-6, 2.2-7, and 2.2-8 show the 1970, 1983, and 2020 population by compass sectors and by concentric rings from the site center, 0 to 50 miles. Figure 2.2-2 provides a site vicinity map showing present and future population for the same years, 0 to 50 miles.

In addition to permanent residents, transient populations enter the area to use recreational grounds. Important recreational areas are the DeSoto National Wildlife Refuge, located about 2 miles east of the plant site; the Wilson Island State Park, located about 4.5 miles southeast of the plant site; California Bend State Wildlife Refuge, located about 4 miles north of the plant site; Nobles Lake State Wildlife Management Area, located about 5 miles east-southeast of the plant site; and Christ Child Camp, directly across U. S. Highway 73 from the plant site. In 1970, the DeSoto Wildlife Refuge attracted 364,215 visitors. Other recreational grounds attract less individuals.

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Table 2.2-1
Locations of Population Centers in
Vicinity of Fort Calhoun Station

MUNICIPALITY	DISTANCE FROM PLANT (miles)	DIRECTION	1970 POPULATION
Blair, Nebraska	3.5	NNW	6106
California Junction, Iowa	5.0	NNE	na[1]
Ft. Calhoun, Nebraska	5.0	SSE	642
Kennard, Nebraska	7.0	SW	336
Modale, Iowa	8.0	NNE	297
Nashville, Nebraska	9.0	SSE	na[1]
Loveland, Iowa	9.6	ESE	na[1]
Missouri Valley, Iowa	10.0	ENE	3519
Findley, Iowa	10.3	E	na[1]
Washington, Nebraska	10.6	SSW	76

NOTE: [1]Breakout of population for small rural unincorporated communities not available from U.S. Census.

Table 2.2-2
1970 Population by Compass Sectors and by Concentric Rings From the Site Centroid, 0 to 10 Miles

COMPASS SECTORS	CONCENTRIC RINGS						
	0-1	1-2	2-3	3-4	4-5	5-10	0-10
N	0	0	0	0	0	63	63
NNE	0	6	12	8	6	372	404
NE	0	6	0	24	6	69	105
ENE	0	0	0	0	3	2,360	2,363
E	0	0	0	0	3	145	148
ESE	0	0	0	0	6	230	236
SE	0	36	3	9	45	453	546
SSE	12	38	6	9	80	645	790
S	3	3	9	12	43	150	220
SSW	9	9	6	12	15	240	291
SW	9	10	15	9	21	183	247
WSW	0	11	12	135	45	507	710
W	0	9	15	78	27	225	354
WNW	0	0	168	[illegible]	1,140	210	6,782
NW	0	0	58	270	9	144	481
NNW	0	0	46	6	18	90	160
TOTALS	33	128	350	5,336	1,467	6,086	13,900

Note: The 16 sectors are of 22.5 degrees and centered on the cardinal points of the compass.

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Table 2.2-3

1983 Projected Population by Compass Sectors and by Concentric Rings From the Site Centroid, 0 to 10 Miles

COMPASS SECTORS	CONCENTRIC RINGS						
	0-1	1-2	2-3	3-4	4-5	5-10	0-10
N	0	1	0	0	0	56	57
NNE	0	6	13	8	6	358	391
NE	0	6	0	24	7	56	93
ENE	0	0	0	0	3	2,310	2,313
E	0	0	0	0	3	138	141
ESE	0	0	0	0	6	218	224
SE	0	49	7	13	107	523	699
SSE	17	51	9	9	101	980	1,167
S	6	7	12	13	90	215	343
SSW	12	12	7	12	19	267	329
SW	12	12	15	9	29	172	249
WSW	6	16	12	180	48	518	780
W	0	15	27	163	31	221	457
WNW	0	0	188	6,130	1,309	205	7,832
NW	0	0	76	359	22	134	591
NNW	0	0	64	64	22	101	251
TOTALS	53	175	430	6,984	1,803	6,472	15,917

Note: The 16 sectors are of 22.5 degrees and centered on the cardinal point of the compass.

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Table 2.2-4
2020 Projected Population by Compass Sectors and by Concentric Rings From the Site Centroid, 0 to 10 Miles

COMPASS SECTORS	CONCENTRIC RINGS						
	0-1	1-2	2-3	3-4	4-5	5-10	0-10
N	0	6	0	0	0	51	57
NNE	0	6	24	8	6	340	384
NE	0	6	0	24	9	45	84
ENE	0	0	0	0	3	2,310	2,313
E	0	0	0	0	3	120	123
ESE	0	0	0	0	6	200	206
SE	0	60	12	18	180	550	820
SSE	30	60	12	9	160	2,762	3,033
S	9	12	16	30	190	670	927
SSW	15	15	12	12	30	340	424
SW	15	15	18	12	45	300	405
WSW	9	20	15	180	54	900	1,178
W	0	18	90	900	45	330	1,383
WNW	0	0	270	7,058	1,700	260	9,288
NW	0	0	105	450	30	170	755
NNW	0	0	70	12	30	120	232
TOTALS	78	218	644	8,713	2,491	9,468	21,612

Note: The 16 sectors are of 22.5 degrees and centered on the cardinal points of the compass.

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Table 2.2-5
Current and Projected Population of Selected Communities Within 50 Miles of the Site

LOCATION	YEAR		
	1970	1990	2020
Iowa[1]			
Monona County (.7763)			
Mapleton	1,647	1,279	993
Castana	211	164	127
Ute	512	397	308
Moorhead	271	210	163
Onawa[2]	3,154	3,129	2,429
Crawford County (.9433)			
Charter Oak	715	674	636
Dow City	571	539	508
Shelby County (.8825)			
Defiance	392	346	305
Harlan[2]	5,049	6,068	5,355
Shelby	868	766	676
Harrison County (.8844)			
Dunlap	1,292	1,143	1,001
Woodbine	1,349	1,193	1,055
Logan	1,526	1,350	1,194
Missouri Valley[2]	3,519	3,494	3,469
Magnolia	206	182	161
Pisgah	286	253	224
Pottawattamie County (1.0416)			
Avoca	1,535	1,599	1,666
Walnut	870	906	944
Oakland	1,603	1,670	1,739
Carbon	135	141	147
Council Bluffs[2]	60,348	63,014	66,013
Mills County (.8784)			
Silver City	272	239	210
Glenwood[2]	4,421	3,961	3,479
Pacific Junction	505	444	390
Malvern	1,158	1,017	893
Tabor	957	841	739
Nebraska[3]			
Cass County			
Greenwood	506	800	1,097
Weeping Water	1,143	1,353	1,446
Plattsmouth	6,371	7,569	8,057
Cuming County			
Bancroft	545	529	437
West Point	3,388	4,022	4,236
Bent County			
Lyons	1,177	1,530	1,649
Decatur	679	523	362
Oakland	1,355	1,212	939
Tekamah	1,848	1,864	1,722
Dodge County			
Dodge	704	750	683
North Bend	1,350	1,710	1,925
Fremont	22,962	30,270	35,699
Washington County			
Washington	76	139	189
Blair	6,106	9,137	10,393
Fort Calhoun	642	1,253	1,708
Kennard	336	358	311
Douglas County			
Valley	1,595	2,414	3,325
Omaha	389,455	459,589	542,819
Ralston	4,731	6,142	6,715
Sarpy County			
Bellevue	21,953	56,437	77,125
Saunders County			
Ashland	2,176	2,639	3,064
Valparaiso	415	445	433
Wahoo	3,835	4,420	4,765

[1] Projections prepared by the State of Iowa do not extend beyond 1990 and are not prepared for small communities (less than 2500 population in 1970). Where projections are not available, the anticipated county-wide growth rates exclusive of larger towns was applied to the 1970 population to project the 1990 population. The appropriate county rate is parenthesized following the county name. Since no projections to the year 2020 are available in Iowa, the 1970 - 1990 rate of change was applied to year 1990 projections.

[2] Projections 1970 - 1990 prepared by the State of Iowa.

[3] All Nebraska projections were prepared by the State. The Medium projection series has been used throughout.

Table 2.2-6
1970 Population by Compass Sectors and by Concentric Rings From the Site Centroid, 0 to 50 Miles

COMPASS SECTORS	CONCENTRIC RINGS						
	0-5	5-10	10-20	20-30	30-40	40-50	0-50
N	0	63	782	1,186	3,823	2,390	8,244
NNE	32	372	328	843	1,709	4,481	7,765
NE	36	69	1,072	2,035	2,352	2,211	7,775
ENE	3	2,360	3,666	793	1,931	9,143	17,896
E	3	145	447	3,463	3,599	1,624	9,281
ESE	6	230	1,078	1,241	4,043	1,752	8,350
SE	93	453	2,076	2,916	1,881	3,674	11,093
SSE	145	645	197,059	144,410	14,964	1,899	359,122
S	70	150	114,881	69,858	3,808	3,911	142,678
SSW	51	240	7,007	2,313	3,189	4,484	17,284
SW	64	183	3,110	1,960	4,710	2,740	12,767
WSW	203	507	1,572	26,540	1,886	2,752	33,460
W	129	225	703	965	2,129	1,832	5,983
WNW	6,572	210	686	1,756	2,041	4,207	15,472
NW	337	144	765	1,062	8,248	2,983	13,539
NNW	70	90	2,269	917	1,476	2,996	7,818
TOTALS	7,814	6,086	337,501	262,258	61,789	53,079	728,527

Note: The 16 sectors are of 22.5 degrees and centered on the cardinal points of the compass.

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Table 2.2-7
1983 Projected Population by Compass Sectors and by Concentric Rings From the Site Centroid, 0 to 50 Miles

COMPASS SECTORS	CONCENTRIC RINGS						
	0-5	5-10	10-20	20-30	30-40	40-50	0-50
N	1	56	725	1,101	3,861	2,232	7,976
NNE	33	358	304	780	1,568	4,258	7,301
NE	36	56	1,019	2,017	2,302	2,126	7,556
ENE	3	2,310	3,634	738	1,790	9,446	17,921
E	3	138	415	3,523	3,505	1,672	9,256
ESE	6	218	1,089	1,311	4,120	1,682	8,426
SE	175	523	2,320	3,242	1,969	3,534	11,763
SSE	187	980	209,370	201,547	17,482	2,731	432,297
S	129	215	147,471	88,866	5,349	3,992	246,022
SSW	62	267	9,083	5,764	3,506	5,923	24,605
SW	79	172	4,054	2,223	4,991	2,818	14,337
WSW	263	518	1,785	31,589	1,787	2,595	38,537
W	237	221	742	977	2,334	1,710	6,221
WNW	7,627	205	636	2,290	2,077	4,0[illegible]6	16,871
NW	457	134	709	985	8,832	2,908	14,025
NNW	92	101	2,252	850	1,370	3,126	7,791
TOTALS	9,390	6,472	385,608	347,803	66,843	54,789	870,905

Note: The 16 sectors are of 22.5 degrees split by and centered on the cardinal points of the compass.

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Table 2.2-8
2020 Projected Population by Compass Sectors and by Concentric Rings to 50 Miles From the Site Centroid, 0 to 50 Miles

COMPASS SECTORS	CONCENTRIC RINGS						
	0-5	5-10	10-20	20-30	30-40	40-50	0-50
N	6	51	626	950	4,005	1,950	7,588
NNE	44	340	263	665	1,370	3.880	6,562
NE	39	45	633	1,980	2,215	1,980	7,192
ENE	3	2,310	3,947	635	1,545	10,420	18,860
E	3	120	357	4,183	3,345	1,655	9,663
ESE	6	200	1,075	1,542	4,395	1,576	8,794
SE	270	550	3,120	4,110	2,225	3,281	13,556
SSE	271	2,762	242,845	287,484	22,285	4,385	560,032
S	257	670	246,669	170,451	7,685	4,245	429,977
SSW	84	340	14,620	14,400	4,370	9,100	42,914
SW	105	300	5,675	3,110	5,770	3,700	18,660
WSW	273	900	2,350	39,400	1,625	2,320	46,873
W	1,053	330	845	1,018	2,550	1,495	7,291
WNW	9,028	260	550	2,325	2,180	3,740	18,083
NW	585	170	612	850	9,550	2,765	14,532
NNW	112	120	2,218	734	1,185	3,478	7,847
TOTALS	12,144	9,468	526,705	533,837	76,300	59,970	1,218,424

Note: The 16 sectors are of 22.5 degrees and centered on the cardinal points of the compass.

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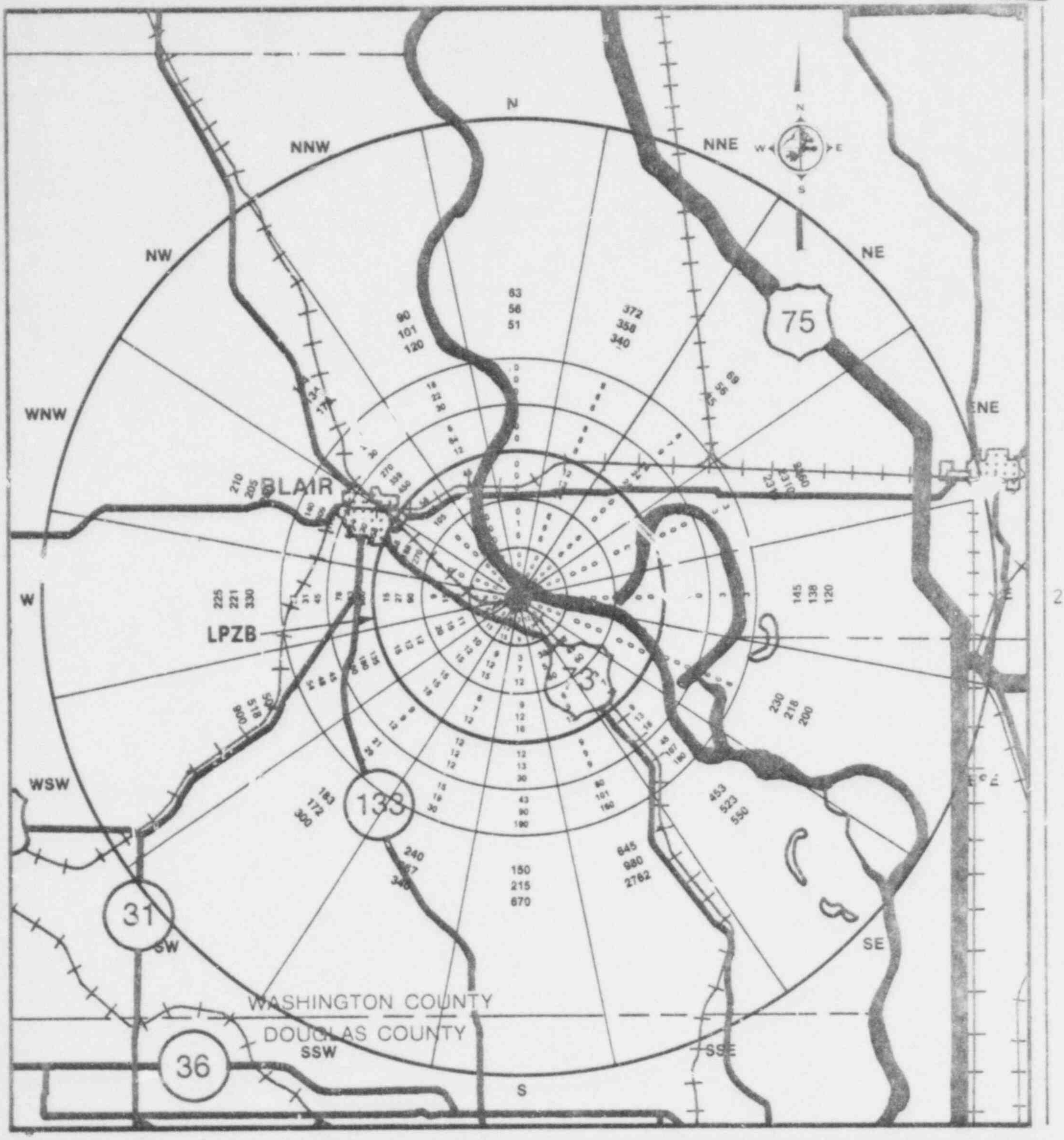

LEGEND

63	ESTIMATED 1970 POPULATION
56	ESTIMATED 1983 POPULATION
51	ESTIMATED 2020 POPULATION
LPZB	LOW POPULATION ZONE BOUNDARY (RADIUS = 3 MILES)

OMAHA PUBLIC POWER DISTRICT FORT CALHOUN STATION	Figure 2.2-1 Site Vicinity Map Showing Present and Future Population, 0 to 10 Miles

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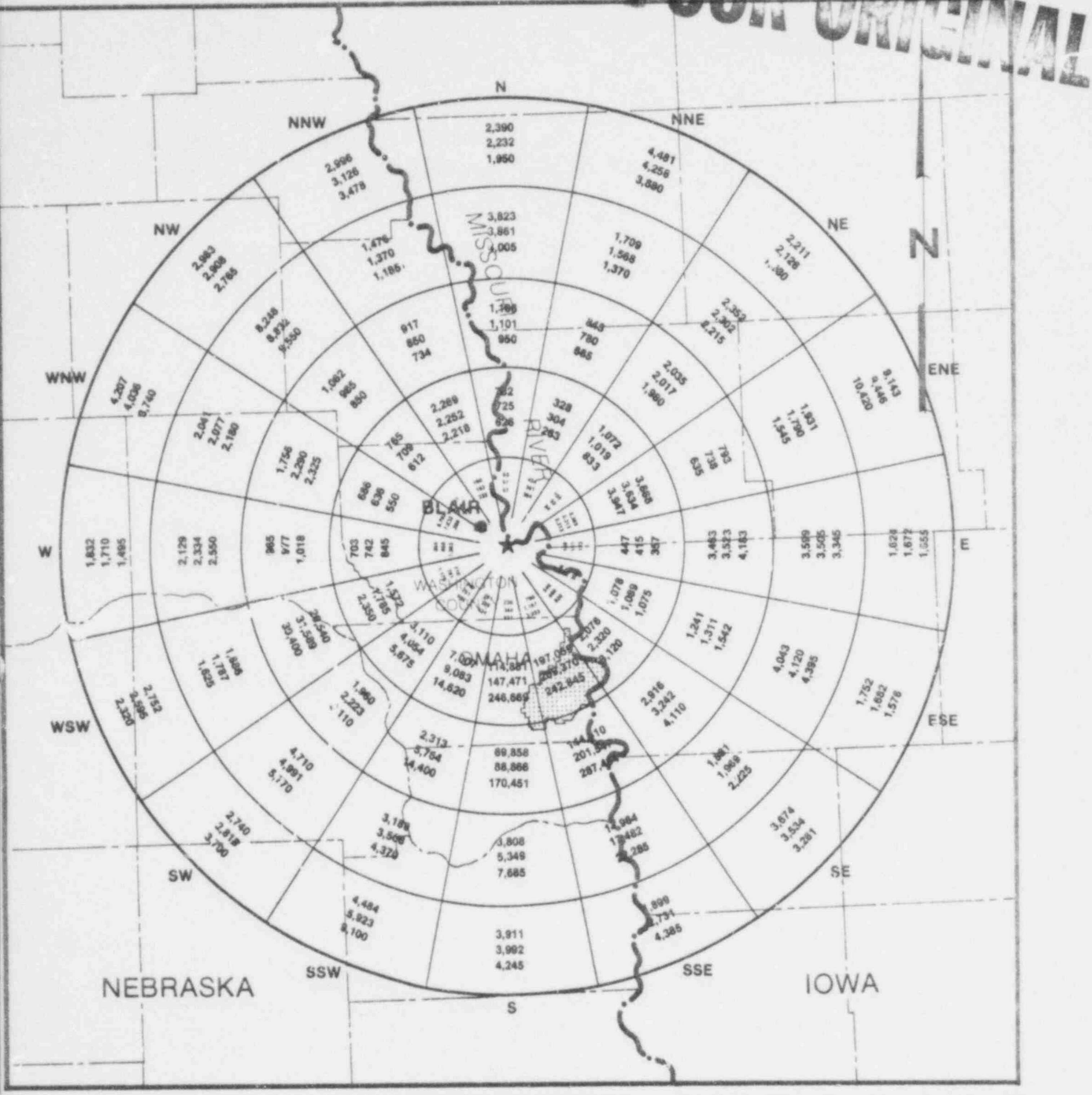

LEGEND

★ PLANT SITE

\# 1970 Population

\# 1983 Population

\# 2020 Population

SCALE IN MILES

0 10 20 30 40 50

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OMAHA PUBLIC POWER DISTRICT FORT CALHOUN STATION	Figure 2.2-2 Regional Map Showing Present and Future Population, 0 to 50 Miles

2.3 Land Use

2.3.1 Land Use of Site and Immediately Adjacent Areas

Almost 70 percent of the existing land use within 5 miles of the Fort Calhoun Station Unit No. 1 site is agricultural, and no large scale changes are foreseen. Major objectives of local land use plans emphasize the preservation of this land in its present form.

Properties adjacent to the plant site are held by a variety of owners, including individuals, the State of Iowa, the federal government, a stone company, and a religious group, and are used primarily for agricultural purposes. The site property controlled by OPPD is approximately 60 percent cultivated and 31 percent covered by natural vegetation. The remaining percentage is modified by plant structures and utilized in other ways. Figure 2.3-1 depicts land use within a 2-mile radius of the Fort Calhoun Station.

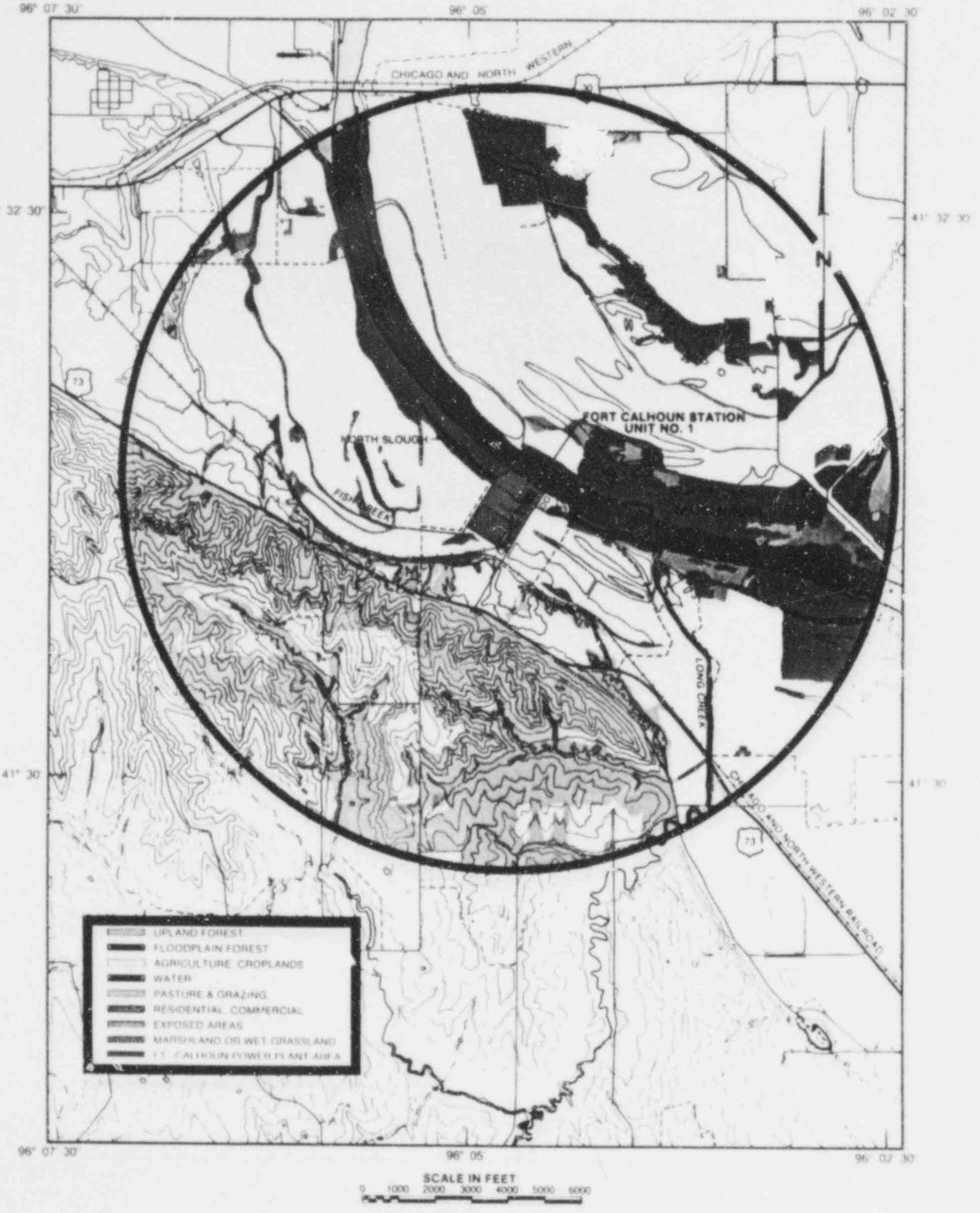
2.3.2 Regional Land Use

As with local land use, regional land use is largely concerned with agriculture. Corn is the most extensively cultivated crop in the region, comprising over 61 percent of all crops harvested in the 3 county area in 1972. In Washington County, Nebraska, alone, approximately 9 million bushels of corn were produced on 85,800 acres of land, for an average yield of 103.1 bushels per acre, compared to 104.0 bushels per acre produced statewide. An additional 5200 acres of corn were harvested as silage, producing 78,000 tons or 15 tons per acre.

Soybeans comprised approximately 18 percent of the harvested crop acreage in Washington County in 1972. Washington County farmers produced soybeans on 27,200 acres, yielding 32.0 bushels per acre, for a total production of 870,000 bushels.

Alfalfa was produced for hay or silage on about 13 percent of the harvested crop acreage. Some alfalfa grown near alfalfa mills is dehydrated and made into livestock pellets or meal. Alfalfa stands are allowed to remain for several years until productivity declines and weeds invade, then alfalfa ground is turned back into row crops. Alfalfa was produced on 19,600 acres, producing 3.90 tons per acre in Washington County in 1972.

497 177



NOTE: MAPPED FROM AERIAL PHOTOGRAPHS TAKEN IN SEPTEMBER 1974 AND VALIDATED FROM THE GROUND DURING THE SPRING AND EARLY SUMMER 1975.

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OMAHA PUBLIC POWER DISTRICT FORT CALHOUN STATION	Figure 2.3-1 Land Use Within 2-Mile Radius of Fort Calhoun Station

2.3 Land Use (Continued)

2.3.2 Regional Land Use (Continued)

Other crops in Washington County are wheat, oats, and sorghum, comprising about 7 percent of the harvested acreage of Washington County in 1972. Pasture in Washington County accounts for 21,219 acres. Most of the pasture is brome-legume mixtures. Some native vegetation still exists along the Missouri River bluffs, but is not extensive. Table 2.3-1 summarizes Washington County agricultural production for 1972, as well as production for Harrison and Pottawattamie Counties.

Livestock production plays an important role in the agricultural economy of Washington County. In 1972, about 12,000 cows calved, 90,000 cattle were grain fed, and the total value of all cattle in Washington County was $15,387,406. Hogs numbered 63,700 with 14,900 sows farrowing. The number of pigs raised was estimated at 108,000. Total chickens numbered 85,400.

Agricultural production and major land use in Harrison and Pottawattamie Counties in Iowa is similar to those in Washington County, Nebraska. Refer to Table 2.3-1 for comparison.

In addition to agricultural use, regional lands are also used for residential, recreational, and industrial/commercial purposes. The distribution of residences is reflected in the population data shown in Table 2.2-2 and Figure 2.2-1. Most families within 5 miles of the plant site live in single family residences. Future residential land use calls for major residential expansion into Washington County by 1990. This will occur primarily from expansion of existing communities, rather than from scattered dwellings along rural roads.

Recreational land use within a 5-mile radius of the Fort Calhoun Station occurs over approximately 16 percent of the area. The 4 major recreational pursuits in the area are fishing, boating, camping, and hunting. These activities, except for hunting, are done primarily on 4 recreational areas in Nebraska and Iowa as follows:

1. DeSoto National Wildlife Refuge (2 miles east).
2. Wilson Island State Park (4.5 miles southeast).
3. California Bend State Wildlife Refuge (3.6 miles north).
4. Nobles Lake State Wildlife Management Area (5.0 miles east-southeast).

Table 2.3-1
Agricultural Production in Washington County, Nebraska, and Harrison and Pottawattamie Counties, Iowa, 1972

LAND USE	HARVESTED ACRES			PERCENT HARVESTED ACRES		
	WASHINGTON	HARRISON	POTTAWATTAMIE	WASHINGTON	HARRISON	POTTAWATTAMIE
Corn	85,800	150,335	210,210	57.7	62.6	61.2
Corn Silage	5,200	6,071	11,893	3.5	2.5	3.5
Oats	3,900	6,237	11,406	2.6	2.6	3.3
Soybeans	27,200	53,865	78,062	13.3	22.4	22.7
Sorghum	3,800	1,612	1,409	1.5	0.7	0.4
Wheat	2,300	2,715	620	1.0	1.1	0.2
Popcorn		4,887	1,118		2.0	0.3
Alfalfa Hay	19,600	12,988	26,626	13.2	5.4	7.8
All Other Hay	800	1,075	1,322	0.5	0.4	0.4
Misc. Crops	200	586	729	0.1	0.3	0.2
TOTALS	247,680	240,371	343,395	100.0	100.0	100.0

2.3 Land Use (Continued)

2.3.2 Regional Land Use (Continued)

The DeSoto National Wildlife Refuge consists of 7800 acres of land and 800 acres of water, designed primarily for the purpose of a wildlife refuge. The refuge offers boating, water skiing, fishing, limited hunting, and picnicking.

The Wilson Island State Park offers picnicking, camping, and boat launch facilities to the Missouri River. The California Bend and Nobles Lake Wildlife Refuges do not offer visitor facilities, other than boat ramps at Nobles Lake, but are available for nature observation and occasionally for hunting. Private lands offer most hunting opportunities.

Industrial and commercial land use within the 5-mile radius of the plant is sparse and limited primarily to the communities of Blair and Missouri Valley. No large commercial developments occur in either town, but the normal community facilities such as gas stations, grocery stores, and small shops provide for local needs and create some employment opportunities. Large industries occur only in the city of Blair. These are 4 in number, serving local and regional markets. The Blair Manufacturing Company, which fabricates farm equipment and employs about 250 people, is the largest in Blair. Other important industries are the Concrete Equipment Company, fabricators of equipment for concrete industries, employing approximately 27 people, and McCrea Manufacturing, manufacturers of hydraulic motors, employing about 30 people. One large industry lies just outside the 5-mile radius to the southeast of the site. This is the Wilkinson Manufacturing Company in Fort Calhoun, which processes and stores bulk aluminum and employs approximately 450 people.

Serving industrial and commercial facilities, as well as regional residents, within a 50-mile radius of the plant is a substantial network of transportation facilities, including railroads, as well as important air and water transportation facilities. Eight major railroads operate mainline or trunk facilities within a 50-mile radius. Currently, the Omaha-Council Bluffs area is the fourth largest rail center in the country, with switching and handling operations for several railroads, as well as important inter-railroad exchanges. The railroads currently operating in the area are Burlington Northern, Inc.; Chicago, Milwaukee, St. Paul and Pacific Company; Chicago and Northwestern Transportation Company; Chicago, Rock Island and Pacific Railroad Company; Illinois Central Gulf Railroad; Missouri Pacific Railroad Company; Norfolk and Western Railway Company; and Union Pacific Railroad Company. Of these, only the Chicago and

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2.3 Land Use (Continued)

2.3.2 Regional Land Use (Continued)

Northwestern Railway operates within 5 miles of the site. Its east-west line passes no closer than 2 miles north of the site and handles about 28 freight trains per day. Figure 2.3-2 shows railroads within a 50-mile radius of the Fort Calhoun Station.

Air transportation is facilitated by 31 airports of varying size and quality. Figure 2.3-3 depicts airports within a 50-mile radius of the Fort Calhoun site. Omaha's Eppley Airport is the region's principal commercial service facility, with over 120 arrivals and departures daily. Eppley Airfield is the focal point with connections to the site via ground transportation. Primary military fields include Offutt Air Force Base at Bellevue and H. J. Paul Army Air Field, located at Ashland.

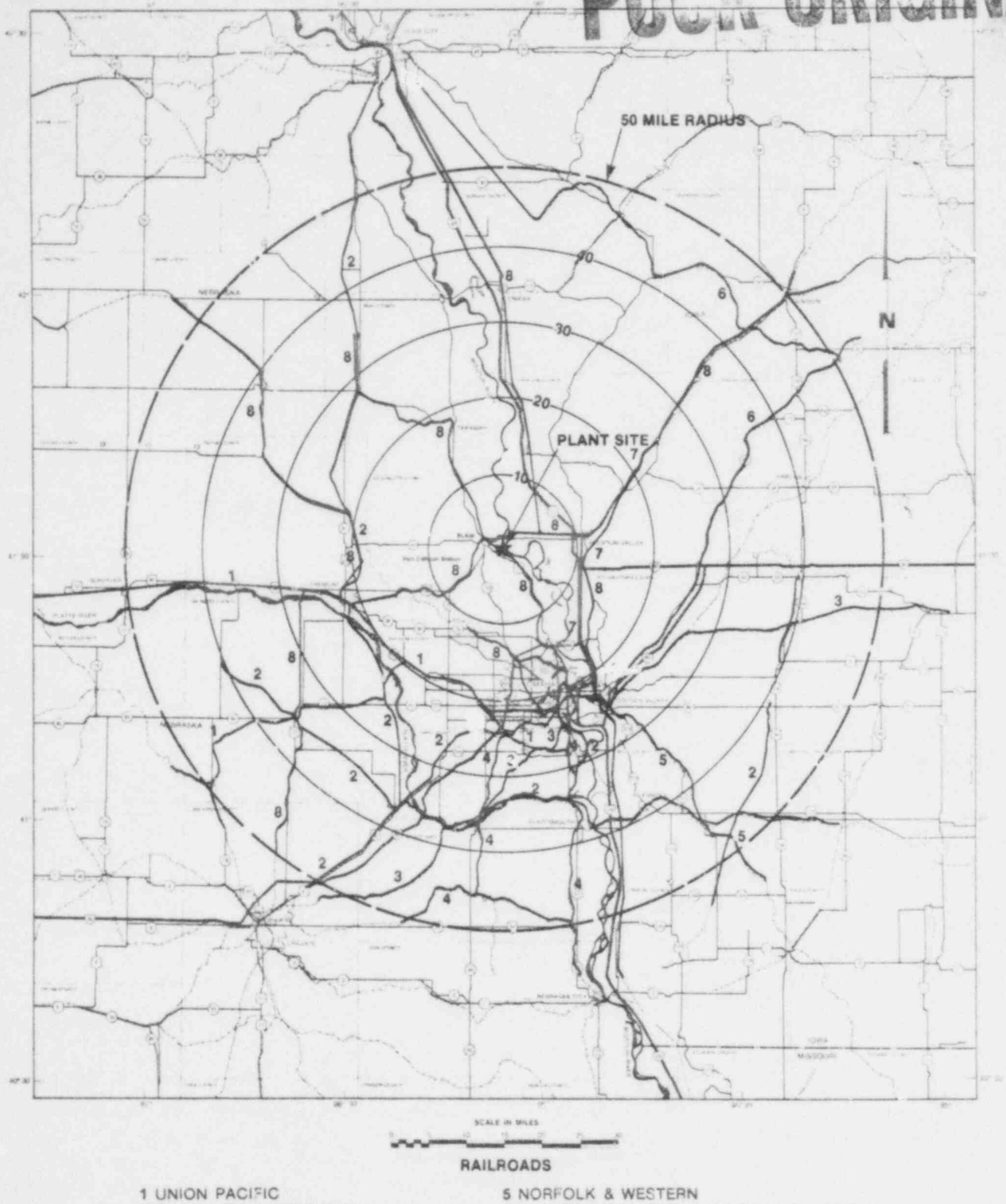
Water transportation occurs exclusively upon the Missouri River, which is an important link in the movement of many bulk commodities. In 1974, the Corps of Engineers reported that 227 round trip barge trains, averaging 3.4 barges per train, carried 1,310,082 tons from the Kansas-Nebraska border north to Sioux City. Four docking facilities exist near the Fort Calhoun Station.

Highway transportation is accomplished using an extensive network of highways, consisting of interstate freeways, "U. S." designated highways, state highways, and country roads, in addition to streets located in city and towns. The major highways are I-80, running east-west through Omaha-Council Bluffs; I-29, passing north-south through Council Bluffs on the Iowa side of the Missouri River; I-680 and I-480 in the Omaha metropolitan area; U. S. Highways 6, 30, and 34, running east-west; U. S. Highways 59, 73, 75, 77, and 275, running north-south; and an interconnecting network of numerous state highways. Figure 2.3-4 is a map of the principal highways shown in relationship to Fort Calhoun Station. Highway 73 provides main access to the site.

2.3.3 Locations of Nearest Indicators From Centerline of Containment Building

The distance (within 5 miles) from the Fort Calhoun Station reactor containment structure to the nearest milk producing animal, pork animal, beef animal, residence, vegetable garden, and site boundary, for each of the 16 major compass points, is shown in Table 2.3-2. Within a distance of 5 miles, there is only one commercial Grade A milk producer. The R. P. Flynn and Sons Dairy is located on the

POOR ORIGINAL



RAILROADS

1 UNION PACIFIC
2 BURLINGTON NORTHERN
3 CHICAGO, ROCK ISLAND, & PACIFIC
4 MISSOURI PACIFIC
5 NORFOLK & WESTERN
6 CHICAGO, MILWAUKEE, ST. PAUL, & PACIFIC
7 ILLINOIS CENTRAL GULF
8 CHICAGO & NORTHWESTERN

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OMAHA PUBLIC POWER DISTRICT FORT CALHOUN STATION	Figure 2.3-2 Railroads Within a 50-Mile Radius of the Fort Calhoun Site

AIRPORTS

1 ONAWA
2 MAPLETON
3 DENISON
4 HARLAN
5 MISSOURI VALLEY
6 COUNCIL BLUFFS
7 MAYNARD
8 PAULEY
9 WOODBINE
10 E-S FARMS
11 UTE
12 EPPLEY AIRFIELD
13 SCRIBNER
14 FREMONT
15 MILLARD
16 NORTH OMAHA
17 FLIGHTLAND
18 TEKAMAH
19 KNIEVEL
20 WAHOO
21 BLAIR
22 BIL-LO
23 DURAND
24 U. OF NEBRASKA LAB
25 BROWN
26 SOUTH OMAHA
27 KOKE
28 WAR BONNET
29 WEINTZELMAN
30 OFFUTT AIR FORCE BASE
31 H. J. PAUL ARMY AIR FIELD

SCALE IN MILES

NUMBERS REFER TO NUMBERS IN TEXT

OMAHA PUBLIC POWER DISTRICT FORT CALHOUN STATION	Figure 2.3-3 Airports Within a 50-Mile Radius of the Fort Calhoun Site

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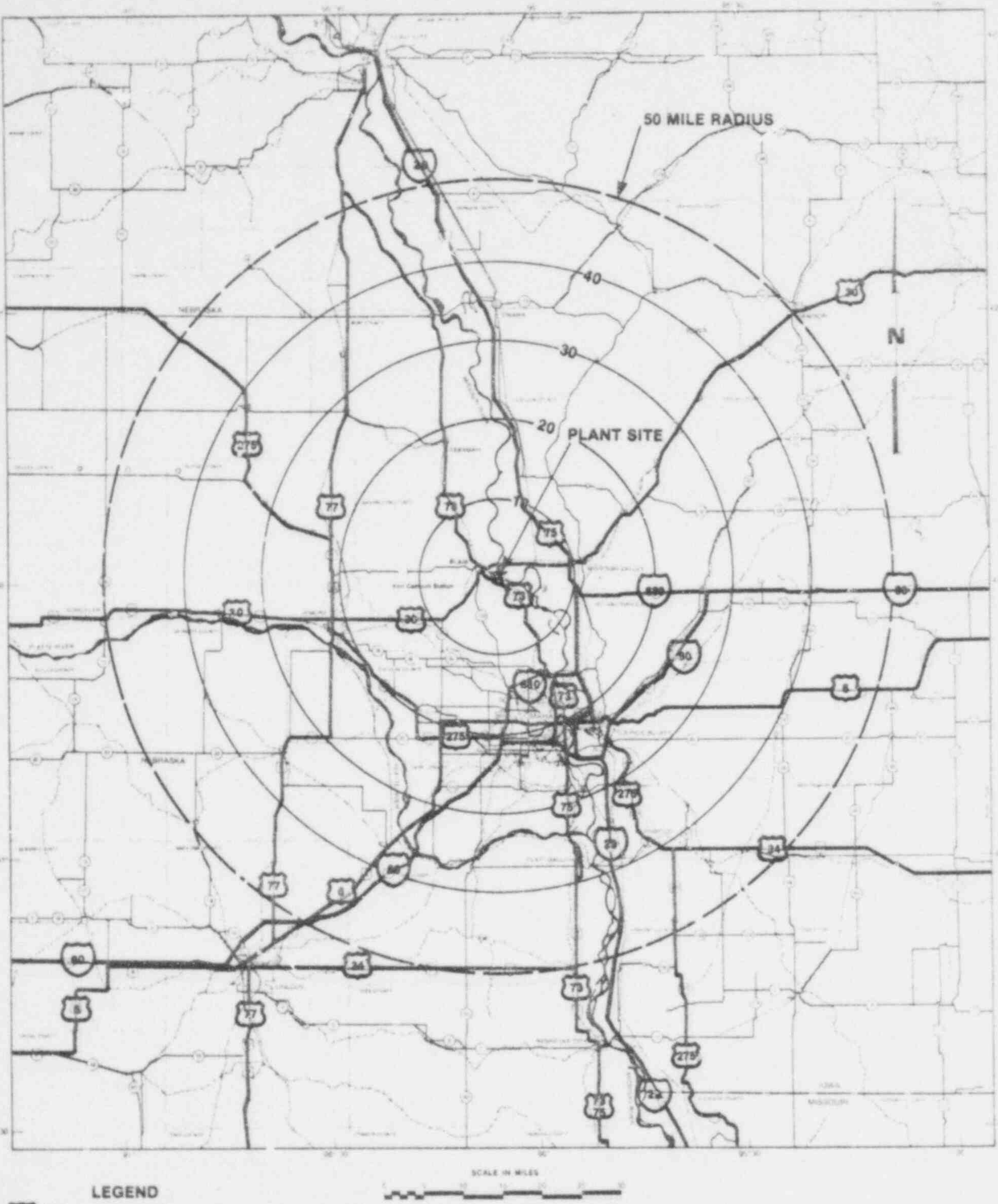

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OMAHA PUBLIC POWER DISTRICT FORT CALHOUN STATION	Figure 2.3-4 Major Highways Within a 50-Mile Radius of the Fort Calhoun Site

2.3 Land Use (Continued)

2.3.3 Locations of Nearest Indicators From Centerline of Containment Building

north edge of Blair, approximately 3.1 miles northwest of Fort Calhoun Station. This producer milks an average of 131 cows per day, with a maximum of 150 per day. Assuming an average daily production of 5 to 6 gallons of milk per head, the 131 cows within the 5-mile radius produce between 655 and 786 gallons per day; 150 head would produce between 750 and 900 gallons per day.

In keeping with close agricultural ties, many rural residences in the 5-mile radius cultivate small vegetable gardens where crops such as sweet corn, tomatoes, green beans, cucumbers, rhubarb, etc. are harvested, eaten fresh, or preserved for winter consumption. The vegetable garden closest to the site is 0.75 mile to the south-southwest. The residence closest to the site is 0.7 mile to the southwest.

2.4 Water Use

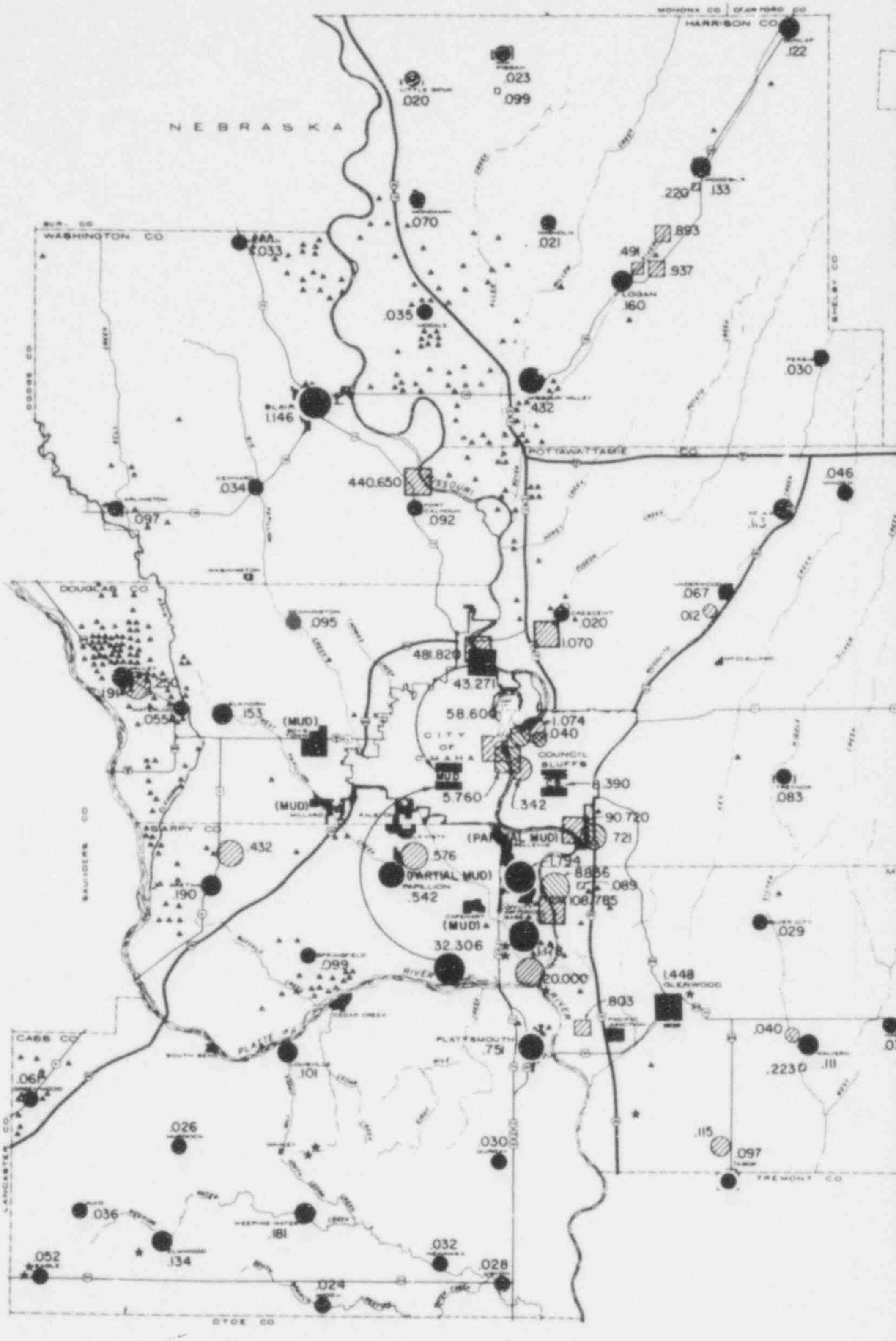
Water is used for recreation, transportation, and municipal, industrial, and agricultural uses. Both surface and ground water supplies are used. Recreational and transportation water use is discussed in section 2.3. Figure 2.4-1 illustrates the location and magnitude of industrial, municipal, and agricultural water usage in the 7-county Omaha-Council Bluffs area.

Agricultural water usage is primarily for irrigation. Washington County has 32 registered irrigation wells and 4926 irrigated acres. Irrigation wells in the county average about 910 gallons per minute. Harrison County has 14,708 irrigated acres and 73 registered irrigation wells, averaging a rate of 1600 gallons per minute. Pottawattamie County has 3079 irrigated acres from 17 irrigation wells and 6 surface water sources. Only 1 irrigation well is registered within 2 miles of Fort Calhoun Station. This has an appropriation of 1000 acre-feet per year for irrigating 1000 acres in Iowa north of the station.

Industrial water users in the vicinity of the Fort Calhoun Station site are shown in Figure 2.4-2. Only the industrial users whose source of supply is the Missouri River or the alluvial aquifer could interact with liquid effluent from the plant. Most of the industrial users in the Omaha-Council Bluffs area use Metropolitan Utilities District water, of which approximately 60 percent comes from the Missouri River intake located 19.7 river miles downstream.

NEAREST DISTANCE FROM ℄ OF CONTAINMENT TO VARIOUS RECEPTORS (METERS)

WIND DIRECTION	AFFECTED WIND DIRECTION	℄ CONT. TO STRUCTURE	MILK COW	PORK ANIMAL	BEEF ANIMAL	MILK GOAT	RESIDENCE	VEGETABLE GARDEN 500 FT.^{2} OR LARGER	SITE BOUNDARIES
S	N	75	—	—	—	—	6436	—	1567
SSW	NNE	89	—	—	3057	—	3057	3057	1036
SW	NE	88	—	—	—	—	2414	2414	1082
WSW	ENE	49	—	—	—	—	—	—	1097
W	E	32	—	—	—	—	7723	—	1367
WNW	ESE	18	—	—	—	—	—	—	1332
NW	SE	18	—	3218	—	—	2816	2816	1152
NNW	SSE	18	—	3057	3379	—	1609	1609	975
N	S	32	—	5632	2896	—	2896	2896	959
NNE	SSW	40	1207	—	2092		1207	1207	975
NE	SW	40	2574	3862	1287	—	1126	3682	989
ENE	WSW	47	—	1931	1287	—	1287	1287	1082
E	W	52	—	4183	965	—	3218	1609	1113
ESE	WNW	43	—	4183	2574	—	2574	2574	1346
SE	NW	43	—	—	4023	—	4023	4023	1571
SSE	NNW	50	—	—	6034	—	3379	3379	1593


NEBRASKA
WASHINGTON CO.
HARRISON CO.
DOUGLAS CO.
SARPY CO.
CASS CO.
OTOE CO.
POTTAWATTAMIE CO.
FREMONT CO.
CITY OF OMAHA
COUNCIL BLUFFS
BLAIR
1.146
LOGAN
PAPILLION
PLATTSMOUTH
GLENWOOD
(MUD)
(PARTIAL MUD)
440.650
481.820
43.271
58.600
5.760
32.306
20.000
90.720
8.390
1.074
1.070
1.448

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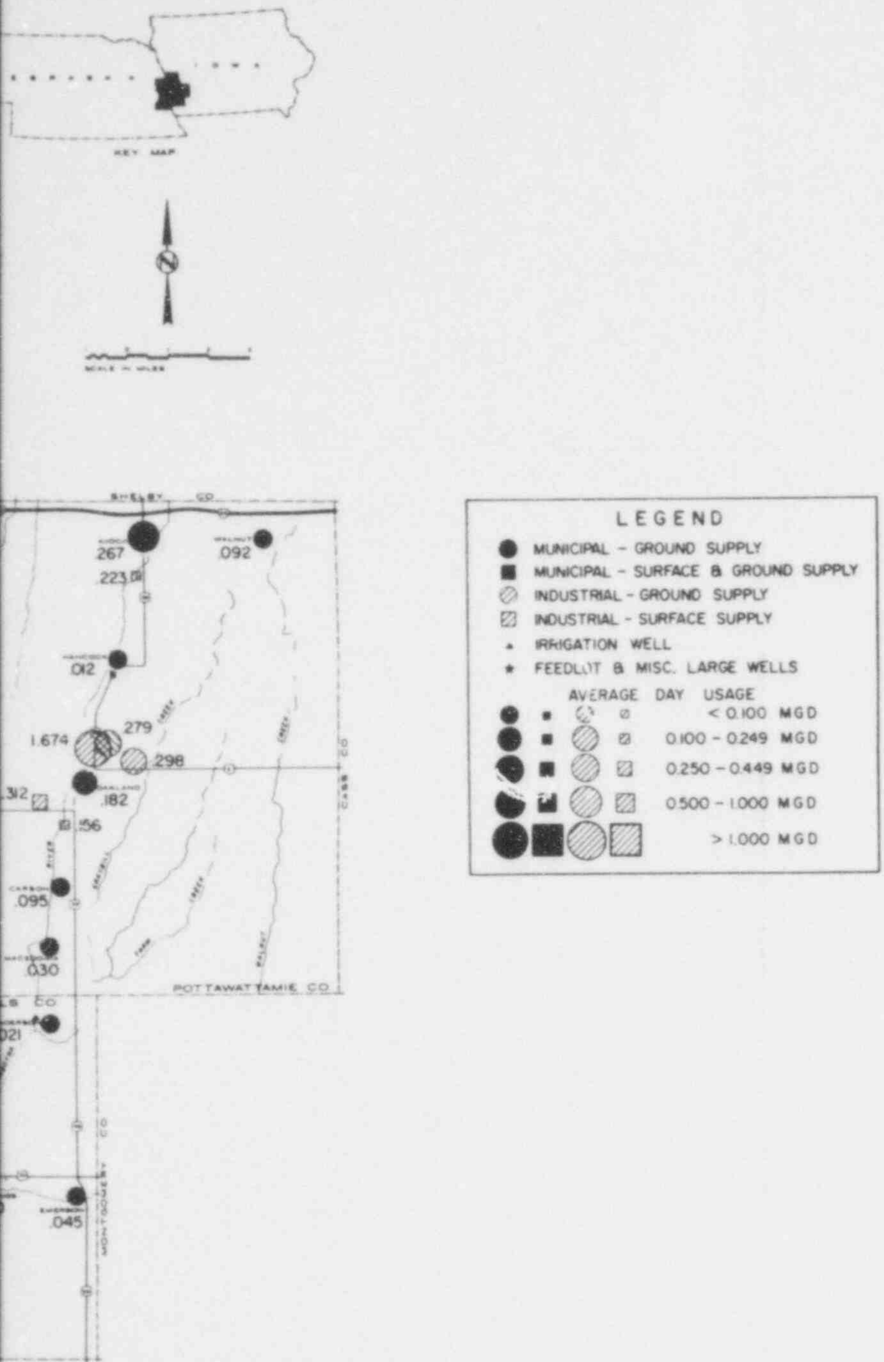

OMAHA PUBLIC POWER DISTRICT FORT CALHOUN STATION	Figure 2.4-1 Location and Magnitude of Water Users in Omaha-Council Bluffs Region

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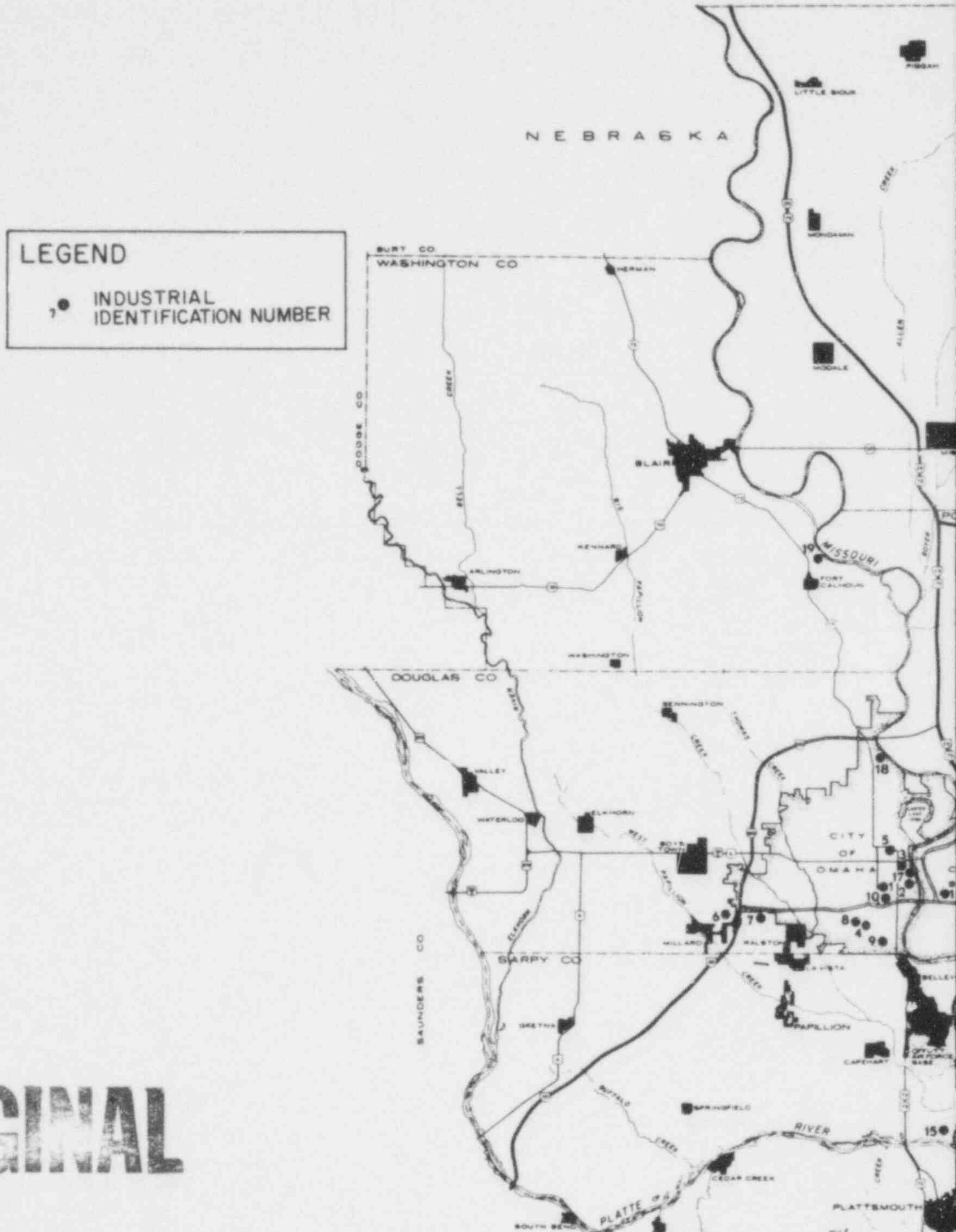

POOR ORIGINAL

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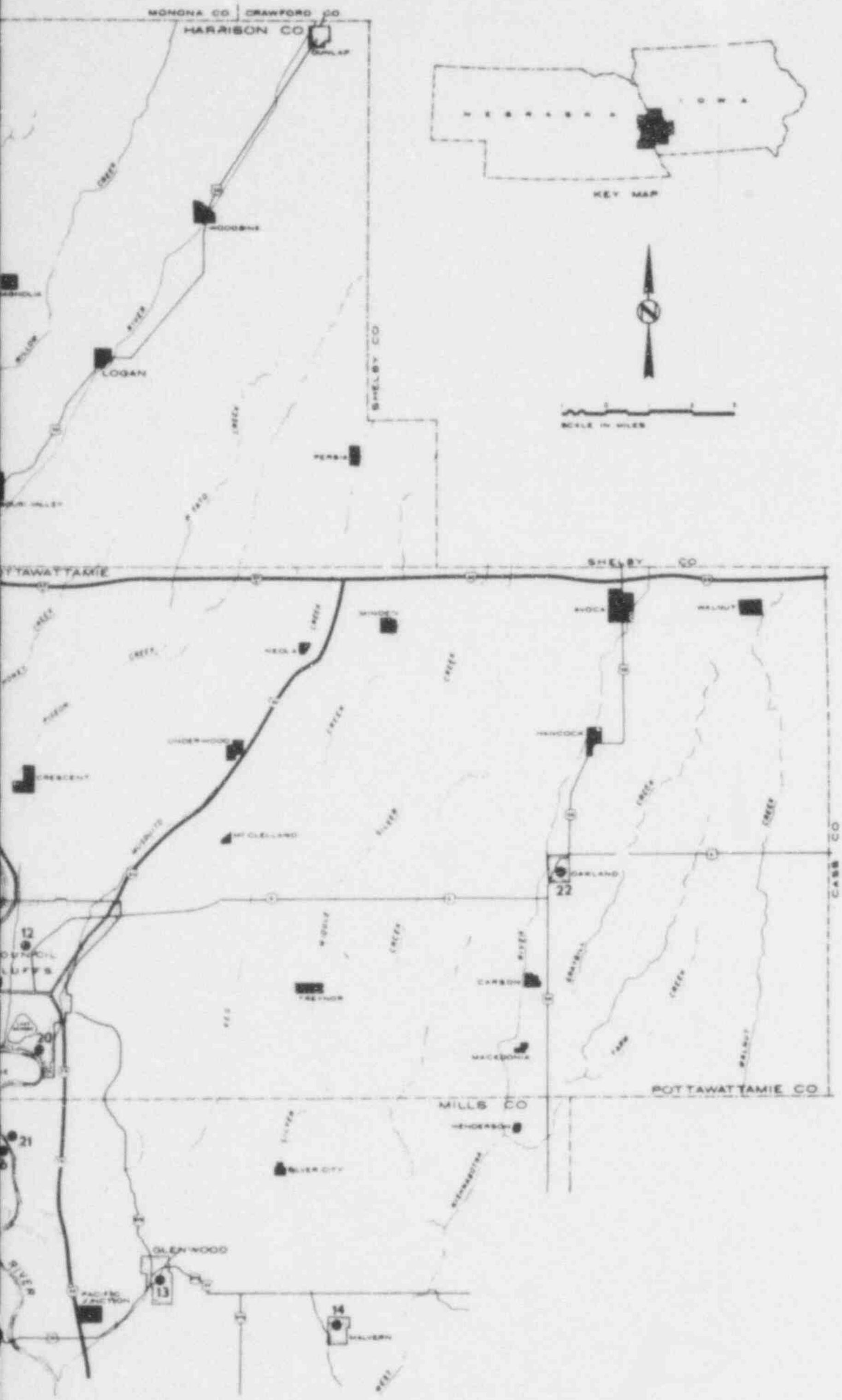

OMAHA PUBLIC POWER DISTRICT FORT CALHOUN STATION	Figure 2.4-2 Location of Industrial Water Users

2.4 Water Use (Continued)

Wells for domestic and livestock water supply are fairly common within a 2-mile radius of the plant location. There are a total of 61 wells within 2 miles, with only 7 of these wells located within a 1-mile radius. More than one-half of the wells are found above the flood plain, southwest of the Chicago and Northwestern Railway track. Of those wells located along the flood plain, 14 are centered around the community of DeSoto, downstream of the project area. The remaining wells in the flood plain are in Iowa, upstream from the project location. Generally, the wells are of 2 types, drilled in wells, with well screens, and driven sand point wells.

The Fort Calhoun Station is 1 of the major water users in the area. Water for cooling and in-plant needs is drawn by pumps through a concrete intake structure on the river edge. Maximum use, which normally occurs during the summer, is considered to be 365,500 gallons per minute (gpm). Minimum use, occurring during reduced load periods and during some winter operations, is considered to be 245,000 gpm.

Of the maximum use of 365,500 gpm, 365,000 gpm is used for circulating cooling water, with 360,000 gpm pumped by the 3 main circulating water pumps and 5000 gpm pumped by the raw water pumps. The additional 500 gpm pumped by the raw water pumps is supplied to the water treatment plant. After pretreatment, the water supply is divided into 2 streams: 1 stream is the source of potable and service water (approximately 200 gpm), and the other stream is diverted to the ion exchange units (approximately 300 gpm), from which demineralized water is supplied for the condensate makeup system and the primary water makeup system.

All 365,000 gpm of circulating water is returned to the Missouri River. About 3000 gpm of this circulating water is diverted for the purpose of washing the traveling screens and is returned to the river at the intake structure. The remaining circulating water is returned to the river via the discharge structure after passing through the condensers.

Most of the 500 gpm supplied to the water treatment plant is consumed by in-plant uses, but some wastewater is returned to the river following treatment.

2.5 Ecology

2.5.1 Terrestrial Ecology

The plant site is located on the Missouri River flood plain adjacent to the river. The river at the site is near the western edge of the flood plain, approximately 2000 feet from bluffs rising to rolling uplands. The flood plain extends east from the site for approximately 9 miles. Flood plain

SECTION 2 - SITE AND ENVIRONMENTAL INTERFACES (Continued)

2.5 Ecology (Continued)

2.5.1 Terrestrial Ecology (Continued)

forests are concentrated along the river and at the base of the bluff. Within the strip of forest along the river there are lateral sloughs in various stages of biological succession, ranging from open water to dense cattail marshes. Two creeks flow into the Missouri River from the west in the vicinity of the plant; Fish Creek to the north and Long Creek to the south. A narrow strip of forest occurs along these creeks, where they flow through crop lands. The forests on the flood plain are dense and are characterized by willows, cottonwoods, boxelder, and hackberry. These forests have well developed shrubbery or herbaceous understory. There are a few small marshes on the flood plain occurring next to the lateral sloughs or the creeks, where there is an abundant water supply. These marshes are dominated by cattails in the wettest areas and by goldenrod and numerous grass species in the drier areas. Muskrat, water fowl, and beaver inhabit the marshy areas.

The uplands are separated from the flood plain by steep irregular bluffs formed by loess which erodes to form deep gullies. The bluffs and other steep areas are primarily covered by upland forest, oak-dominated in the most mature stands, and there is usually a dense layer of shrubby undergrowth. The uplands are primarily covered by farmland, including pastures and are inhabited by deer, various species of rodents, pheasant, and other birds.

Terrestrial flora are divided among individual habitat types, including flood plain forest, upland forest, pasture and planted grass lands, marsh lands, crop lands, and exposed areas. The distribution of these habitat types within a 2-mile radius of the Fort Calhoun Station is shown in Figure 2.3-1. The percentage of the area occupied by each of these habitat types is listed in Table 2.5-1. Of the terrestrial flora species identified as possibly existing near the site, two are on the Department of Interiors' list of Threatened or Endangered Fauna or Flora. These are the prairie orchis (Platanthera leucophaea) and the small white lady's slipper (Cypripedium candidum). Neither has been collected on the site.

Flood plain forest occupies 939 acres (11.7 percent) of the 2-mile radius. Most of this vegetation type is restricted to the areas adjacent to the Missouri River, with a small tract occurring at the base of the bluff. The flood plain forest in eastern Nebraska is dominated by a number of

Table 2.5-1
Habitat Types Within a 2-Mile Radius
of the Fort Calhoun Station

HABITAT TYPE	PERCENTAGE OF 2-MILE RADIUS	ACRES
Croplands	55.21	4,438.00
Floodplain forest	11.68	938.89
Upland forest	11.16	897.08
Pasture and grazing	9.57	769.27
Water	5.44	437.29
Roads	2.17	174.43
Marshland or grassland	1.92	154.34
Residential, commercial	1.46	117.36
Exposed areas	1.15	92.44
Fort Calhoun Station Unit No. 1 Structures	0.24	19.29
TOTAL	100.00	8,038.40 (12.56 sq. mi.)

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2.5.1 Terrestrial Ecology (Continued)

tree species, each of which is characteristic of certain stages of succession. The more immature stages of succession are found in relatively unstable areas; for example, on the bank of the river or adjacent to a marsh. Later successional stages are found in more stable areas, with the most advanced stages being located in areas which have remained undisturbed for the longest periods of time. Peachleaf willow and black willow are dominant tree species in the earliest stages of succession. The general succession on the flood plain is from willows, to cottonwood, to mulberry-boxelder-hackberry dominated forest.

Upland forest, located primarily in areas too steep or otherwise unsuitable for crop cultivation, occupies approximately 897 acres (11.2 percent) of the area included within a 2-mile radius of the plant. It is dominated primarily by bur oak at maturity. Immature sections are dominated by box-elder, mulberry, and elm.

Areas of pasture or planted grass land have replaced much of the original forest and prairie in the uplands and occupy almost 10 percent (769 acres) of the land within a 2-mile radius of the plant. Pasture and planted grass land are composed primarily of introduced vegetation, but some native species are present. Important species found in this habitat are smooth brome, black alfalfa, and Kentucky bluegrass.

Marsh lands occupy less than 2 percent of the area within a 2-mile radius of the plant. These remain wet throughout spring and most of the summer, but generally dry out in autumn and reestablish in spring with the melting snow. Dominant species in dry marshes are goldenrod and horsetail. Wetter marshes are composed primarily of cattails and arrowheads.

Fifty-five (55) percent of the land (4438 acres) within the 2-mile radius, including most of the flood plain, is crop land with corn most commonly planted. Approximately 1 percent of the area is exposed, without crops or any identifiable ecological succession.

In addition to a diverse population of flora, a wide variety of terrestrial animals occur in the vicinity of the plant. Table 2.5-2 provides a comprehensive species list, which includes all of the vertebrates that have been observed or that may occur near the site. The habitat types in which each species is expected and in which each has been observed

Table 2.5-2
Comprehensive Vertebrate Species List
(Estimates of Abundance in the Terminology of the Authors Cited - See Key Below. Habitat Preferences Based on the Authors Cited and on Field Observations at the Site.)
(Page 1 of 9)

KEY

P = Present, observed, but density not known.
I = Inferred, likely to be present. Range includes the study area and suitable habitat exists, but potential density is unknown.
C = Observed or inferred, relative abundance known or estimated to be common or abundant.
U = Observed or inferred, relative abundance known or estimated to be uncommon.
O = Observed or inferred, relative abundance known or estimated to be occasional.
R = Observed or inferred, relative abundance known or estimated to be rare.
A = Observed or inferred, relative abundance known or estimated to be accidental.
Q = Questionable.
() = Observed or collected in a pond.
E = Edge of range.
N = Birds recorded since 1968 at the DeSoto National Wildlife Refuge, but not rated for abundance.
x = Known from literature to occur in this habitat type.
* = Observed during the applicant's preoperational ecological monitoring program.

REPTILES:

1. Loth, 1974 (Ref. 2.2-118).
2. Dunlap and Kruse, 1973 (Ref. 2.2-35).
3. Hudson, 1972 (Ref. 2.2-49).
4. Conant, 1958 (Ref. 2.2-3).
5. Lynch, 1975 (Ref. 2.2-119).

BIRDS:

1. U.S. Department of the Interior, 1968, and E. Loth, 1968 (Refs. 2.2-120 and 121).
2. Fontennelle Forest Nature Center (Ref. 2.2-122).
3. Rapp, et al., 1958 (Ref. 2.2-28).
4. Checklist of T. Kain (Ref. 2.2-123).

MAMMALS:

1. Loth, 1974 (Ref. 2.2-124).
2. Dunlap and Kruse, 1973 (Ref. 2.2-35).
3. Nebraska Game & Parks, 1972 (Ref. 2.2-18).
4. Burt & Grossenheider, 1964 (Ref. 2.2-6).
5. Hall & Kelson, 1959 (Ref. 2.2-45).

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Table 2.5-2
(Continued)
Comprehensive Vertebrate Species List
(Page 2 of 9)

SPECIES	RIVER AND DE SOTO LAKE	MARSH	SLOUGH	FLOODPLAIN FOREST	AGRICULTURE	UPLAND FOREST	PASTURE	DE SOTO	UNIVERSITY OF SOUTH DAKOTA	HUDSON	CONANT	LYNCH
AMPHIBIANS												
Salamanders												
Eastern tiger salamander		*		x	x			P	P	I	I	P
Frogs and Toads												
Plains spadefoot		*			x		x	P	C	I	E	P
Great plains toad					x		x	P	C	I	I	I
American toad			*	x				P		E		P
Rocky Mountain toad	*	*	*	x	*	x	*	P	C	I	I	P
Blanchard's cricket frog	*	*						P	C	I	I	P
Western gray treefrog *(Hyla chrysoscelis)*		*	*	x				P	C	I	I	P
Striped chorus frog *(Pseudacris triseriata)*	*	*		x	*		x	P	C		I	P
Bullfrog	*	*	*			(*)		P	C	I	I	P
Northern leopard frog	*	*	*				(*)	P	C	C	I	P
Western leopard frog *(Rana blairi)*	*	*	*			(*)	(*)					P
REPTILES												
Turtles												
Snapping turtle	*	*	*					P	[illegible]	I	I	P
Ornate box turtle				x				P	[illegible]	Q	I	
False map turtle	*		x					P	I	O	I	P
Ouachita map turtle	x		x								I	
Western painted turtle	*	*	x					P	[illegible]	I	I	P
Blanding's turtle		x	x					[illegible]	E	O	[illegible]	
Western spiney softshell			x					P	[illegible]	I	I	
Smooth softshell	*		*									P
Lizards												
Six-lined racerunner				x	x	x	x	I	I	I	I	I
Five-lined skink				x		x		I	Q	I		
Northern prairie skink				x	x		x	I	I	I	I	I
Snakes												
Northern water snake	x	x	x					I	I	C	I	I
Graham's water snake	x	x	x									I
Texas brown snake		x	x	x	x	x		P		O	I	I
Red-sided garter snake			x	x	x		x	P	I	I	I	I
Plains garter snake	x	*	*	x	x		x	P	C	I	I	I
Western ribbon snake		x	x	x				I	K	Q	E	I
Northern lined snake						x	x	I	U	I	I	I
Plains hognose snake							x	I	Q	Q	I	
Eastern hognose snake				*	*	x		P	I	I	I	P
Prairie ringneck snake		x	x	x		*		I	I	I	I	P
Western worm snake								I		O	E	
Eastern yellow-bellied racer				x	x		x	I	I	I	I	I
Smooth green snake		x	x	x				I	U	R	I	I
Western fox snake		x	x	x				P	I	P	I	I
Milk snake *(L. triangulum)*				x	x	x	x	I	U	P	I	I
Black rat snake				x		x		I		O	K	I
Bullsnake *(P. catenifer)*					*	*	*	P	I	C	I	P
Speckled kingsnake		x	x	x	x	x	x	I		Q	E	
Prairie kingsnake				x	x	x	x	I		O		
Western massasauga		x	x					I		O		
Timber rattlesnake						x		I		O		

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Table 2.5-2
(Continued)
Comprehensive Vertebrate Species List
(Page 3 of 9)

SPECIES (BIRDS)	RIVER AND DE SOTO LAKE	MARSH	SLOUGHS, STREAMS AND PONDS	FLOODPLAIN FOREST	AGRICULTURAL FIELDS	UPLAND FOREST	PASTURE	BUILDINGS	DE SOTO	FONTANELLE	RAPP, ET AL.	KAIN
Loons												
Common loon			x						O	U	R	I
Red-throated loon			x								R	I
Grebes												
Horned grebe			x						R	U	U	I
Eared grebe			x						O	U	U	I
Western grebe			x						R	OR	R	I
Pied-billed grebe	*		x						U	C	C	I
Pelicans												
White pelican			x						U	U	C	I
Cormorants												
Double-crested cormorant	*	x	x	x	x		x		C	U	U	I
Herons, Bitterns and Egrets												
Great blue heron		*	x	*	*				C	U	C	I
Green heron	*	x	*						U	U	C	I
Little blue heron		x	x	x						R	R	I
Common egret		x	x		x				O	O	C	I
Snowy egret		x	x	x			x			R	R	R
Black-crowned night heron		*	*						R	O	R	I
Yellow-crowned night heron		x	x	x						R	R	I
Least bittern		x	x						N	U	U	I
American bittern		x	x						O	U	C	I
Ibises												
White-faced ibis		x	x							R	R	I
Waterfowl												
Whistling swan			x						R	A	U	I
Canada goose	*	x	x		x		x		C	C	C	I
Brandt			x						R		A	I
White-fronted goose		x	x		x		x		C	U	C	I
Snow goose	*	x	x		x		x		C	C	C	I
Ross' goose		x	x		x		x		R	P		
Mallard	*	*	x		x		x		C*	C	C	I
Black duck		x			x		x		C		R	
Gadwall	*	x	x						C	C	C	I
Pintail		x	x		x				C	C	C	I
Green-wing teal	*	*	x						C	U	C	I
Blue-wing teal	*	*	*						C*	C	C	I
American widgeon		x	x		x				C	C	C	I
Northern shoveller	*	*	x						C	C	C	I
Wood duck	*	*	*	x					C*	C	U	I
Redhead		x	*						O	C	C	I
Ring-necked duck	*	*	*						C	U	U	I
Canvasback		x	x						O	U	U	I
Greater scaup			x						R		R	O
Lesser scaup		x	x						C	C	C	I
Common goldeneye			x						U	U	U	I
Bufflehead			x						C	U	U	I
Old squaw			x						R	R	R	I
White-winged scoter			x							R	U	R
Ruddy duck		x	x						U	U	C	I
Hooded merganser	*		x						U	U	O	I
Common merganser	*		x						C	C	C	I

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SPECIES (BIRDS)	RIVER AND DE SOTO LAKE	MARSH	SLOUGHS, STREAMS AND PONDS	FLOODPLAIN FOREST	AGRICULTURAL FIELDS	UPLAND FOREST	PASTURE	BUILDINGS	DE SOTO	FONTANELLE	RAPP, ET AL.	KAIN
Vultures, hawks and eagles												
Turkey vulture		x	x	*	x	*	x		U	U	UC	I
Goshawk				x		x			R	O	O	I
Sharp-shinned hawk				x		x			O	O	C	I
Cooper's hawk				*		x			U	O	I	I
Red-tailed hawk		x		*	*	*	*		C*	C	C	I
Red-shouldered hawk		x		x	x	x	x		O	U	U	I
Broad-winged hawk		x		x	x	x	x		N	U	U	I
Swainson's hawk		x		x	x	x	x		N	U	C	I
Rough-legged hawk		x			x		x		O	C	U	I
Ferruginous hawk					x		x			R	R	R
Golden eagle		x		x	x		x		R	O	U	I
Bald eagle	*	x	x	*					C	U	U	I
Marsh hawk		x			x		x		U	U	C	I
Ospreys												
Osprey		x	x						U	U	U	I
Falcons												
Peregrine falcon		x	x		x		x		R	O	O	I
Merlin		x			x		x			O	R	I
American kestrel		*			x	*	*		O	C	C	I
Gallinaceous Birds												
Bobwhite		x		x	x	*	*	*	C*	U	C	I
Pheasant		*		*	*	*	x	x	C*	U	C	I
Cranes												
Sandhill crane		x							R	A	R	I
Rails and Coot												
King rail		x								R	R	I
Virginia rail		x	x						R	R	U	I
Yellow rail		x	x							R	R	
Sora		x	x		x		x		O	U	C	I
Common gallinule		x	x							A	R	I
American coot	*	x	x		x		x		C	C	C	I
Shorebirds												
Semipalmated plover		x	x		x		x		O	O	P	I
Piping plover		x	x						C*	O	U	I
Killdeer		*	x		*		x		C*	C	C	I
American golden plover		x	x		x		x		N	R	U	I
Black-bellied plover		x	x							R	U	T
Ruddy turnstone		x	x						U	R	R	I
American woodcock		x		x	x		x		U	O	R	I
Common snipe		x	x						C	U	CU	I
Upland sandpiper		x	x						O	U	U	I
Spotted sandpiper		*	*	x	x		x		C*	U	C	I
Solitary sandpiper		x	x	x	x				U	U	C	I
Greater yellowlegs		x	x						C	U	C	I
Lesser yellowlegs		x	x						U	C	C	[illegible]
Willet		x	x						U	U	U	I
Knot		x	x						O		R	
Pectoral sandpiper		x	x							U	C	I
White-rumped sandpiper		x	x						U	O	C	I
Baird's sandpiper		x	*						U	C	C	I

Table 2.5-2
(Continued)
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SPECIES (BIRDS)	RIVER AND DE SOTO LAKE	MARSH	SLOUGHS, STREAMS AND PONDS	FLOODPLAIN FOREST	AGRICULTURAL FIELDS	UPLAND FOREST	PASTURE	BUILDINGS	DE SOTO	FONTANELLE	RAPP, ET AL.	KAIN
Least sandpiper		*	x						U	C	C	I
Dunlin		x	x						U	O	O	I
Semipalmated sandpiper		x	x							U	C	I
Western sandpiper		x	x						O	O	R	I
Sanderling		x	x						C	U	R	I
Dowitcher (sp)		x	x							U		I
Short billed dowitcher		x	x						U		U	
Long-billed dowitcher		x	x								C	
Stilt sandpiper		x	x						O	O	C	I
Buff breasted sandpiper		x	x		x		x			O	U	I
Marbled godwit		x	x				x			O	U	I
Hudsonian godwit		x	x							O	U	I
American avocet		x	x						R	O	U	I
Wilson's phalarope		x	x		x		x		C	U	C	I
Northern phalarope		x	x						U	A	A	A
Gulls and Terns												
Herring gull		x	x		x		x		U	O	U	I
Ring-billed gull	*	x	x		x		x		C	C	C	I
Franklin's gull		x	x		x		x		O	C	C	I
Bonaparte's gull		x	x		x		x			R	U	I
Fouster's tern		x	x						O	U	C	I
Common tern		x	x						U	U	U	I
Least tern		x	x						C*	U	U	I
Caspian tern		x	x						R	R	U	I
Black tern		x	x						U	U	C	I
Doves												
Rock dove					*		*			C	C	I
Mourning dove		*		*	*	*	*		C*	C	C	I
Cuckoos												
Yellow-billed cuckoo		*		*		x			C*	U	C	I
Black-billed cuckoo				x		x			C*	U	C	I
Owls												
Barn owl		x		x	x	x	x			R	U	I
Screech owl		x		x	x	x	x	*	U*	U	C	I
Great horned owl		x	x	x	x	x	x		C*	U	C	I
Snowy owl		x			x		x		R	R	R	I
Barred owl			*	x		x			C*	U	U	I
Long-eared owl				x		x				O	U	I
Short-eared owl		x			x		x		O	U	U	I
Saw-whet owl				x		x			O*	R	U	I
Goatsuckers												
Chuck-will's widow				x		x				O		I
Whip-poor-will				x		x			O*	U	C	I
Common nighthawk		x		x	x		x		U	C	C	I
Swifts and Hummingbirds												
Chimney swift	*	*	*	x	x	x	x		O	C	C	I
Ruby-throated hummingbird			*	x		x			R	U	C	I
Kingfishers												
Belted kingfisher	x	*	*	*					O*	U	C	I

Table 2.5-2
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SPECIES (BIRDS)	RIVER AND DE SOTO LAKE	MARSH	SLOUGHS, STREAMS AND PONDS	FLOODPLAIN FOREST	AGRICULTURAL FIELDS	UPLAND FOREST	PASTURE	BUILDINGS	DE SOTO	FONTANELLE	RAPP, ET AL.	KAIN
Woodpeckers												
Common flicker		*		*	*	*	*		C*	C	C	I
Red-bellied woodpecker				*		*			U*	U	C	I
Red-headed woodpecker		*		*	*	*			C*	C	C	I
Yellow-bellied sapsucker				x		x			O	O	U	I
Hairy woodpecker				x		x			C*	U	C	I
Downy woodpecker		*		*		*			C*	C	C	I
Perching Birds												
Eastern kingbird		*		*	*	*	*		C*	C	C	I
Western kingbird		x			*		*		O*	U	C	I
Great-crested flycatcher				x		x			U*	U	C	I
Eastern phoebe		x		*	x	x	x		O*	U	C	I
Yellow-bellied flycatcher				x		x				U	U	
Acadian flycatcher		x	x	x		x			U*	U	R	
Willow flycatcher		x	x						C*	U	C	I
Least flycatcher		x			x		x		C*	U	C	I
Eastern wood pewee				x		x			C*	U	C	I
Olive-sided flycatcher				x		x				U	R	I
Horned lark					*		*		C*	C	C	I
Tree swallow	x	*	*	*	x		x		U*	U	C	I
Bank swallow	x	*	*						C*	U	C	I
Rough-winged swallow	x	*	*		*		x		U	U	C	I
Barn swallow	x	*	*		*		x	*	C	C	C	I
Cliff swallow	*	x	x		x		x	x	C	U	C	I
Purple martin				x		x			U*	C	C	I
Blue jay		*		*	*	*	x	x	C*	C	C	I
Black-billed magpie				x	x				R			I
Common crow					*	*	*		U*	C	C	I
Black-capped chickadee				*	x	*	x	x	C*	C	C	I
Tufted titmouse				x		*			R	U	C	I
White breasted nuthatch				x		*			P	C	U	I
Red-breasted nuthatch				x		x		x		U	C	I
Brown creeper				x		x			U	U	C	I
House wren		*		*	*	*	x	x	C*	C	C	I
Winter wren		x	x	x		x				U	R	I
Bewick's wren				x		x				R		I
Carolina wren		*	x	x		x				O	R	I
Long-billed marsh wren		x	x						O	D	C	I
Short-billed marsh wren		x	x						O*	R	U	I
Mockingbird				x		x			R	O	U	I
Gray catbird		*		*	x	*	x		C*	C	C	I
Brown thrasher				*	*	*			C*	C	C	I
American robin		*		*	*	*	x	x	C*	C	C	I
Wood thrush				x		x			C*	U	CU	I
Hermit thrush				x		x				O	U	I
Swainson's thrush				x		*			U	U	C	I
Gray-cheeked thrush				x		x			U	O	C	I
Veery				x		x				O	R	I
Eastern bluebird		*			x	*	x		U*	U	C	I
Townsends solitaire				x		x				R		I
Blue-gray gnatcatcher				x		x				U	U	I
Golden-crowned kinglet				*		*				U	C	I
Ruby-crowned kinglet				*		*			C	U	U	I
Water pipit		x	x		x		x			O	C	I
Sprague's pipit		x	x		x		x			R	P	I
Bohemian waxwing				x	x	x	x		N	R	R	I

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SPECIES (BIRDS)	RIVER AND DE SOTO LAKE	MARSH	SLOUGHS, STREAMS AND PONDS	FLOODPLAIN FOREST	AGRICULTURAL FIELDS	UPLAND FOREST	PASTURE	BUILDINGS	DE SOTO	FONTANELLE	RAPP, ET AL.	KAIN
Cedar waxwing				x	x	x	x		U*	U	C	I
Northern shrike					x		x			O	U	I
Loggerhead shrike					x		x		U	U	C	I
Starling				*	*	x	x	*	C*	C	C	I
White-eyed vireo				x		x				O	U	I
Bell's vireo		x	x		x		x		C*	U	C	I
Yellow-throated vireo				x		x				U	U	I
Solitary vireo				x		x				U	U	I
Red-eyed vireo				x	x	x	x	x	O*	C	C	I
Philadelphia vireo				x		x				O	U	I
Warbling vireo		*		*	x	x	x	x	C*	C	C	I
Black-and-white warbler				x		x			U*	U	CU	I
Prothonotary warbler		x	x							U	U	I
Tennessee warbler				*		x			O	C	C	I
Orange-crowned warbler				x		x				C	C	I
Nashville warbler				*		x			O	C	C	I
Northern parula				x		x				O	R	I
Yellow warbler				*	x	x	x	x	C	C	C	I
Magnolia warbler				x		x				U	U	I
Black-throated blue warbler				x	x	x	x			O	R	I
Yellow rumped warbler				*	x	x	x		C	C	C	I
Black-throated green warbler				x	x	x	x		C	R	U	I
Cerulean warbler				x		x				U	U	I
Blackburnian warbler				x		x				O	U	I
Yellow-throated warbler				x		x				A		I
Chestnut-sided warbler				x		x			U*	O	U	I
Bay-breasted warbler				x		x			U	O	U	I
Blackpoll warbler				*		x			C	U	C	I
Palm warbler				x		x			C	O	C	I
Ovenbird		x	x	x		x			C*	U	C	I
Northern waterthrush		x	x	*					N	O	C	I
Louisiana waterthrush		x	x							U	UR	I
Kentucky warbler				x		x				O		I
Connecticut warbler				x		x				O	U	I
Mourning warbler				x		x				O	U	I
Common yellowthroat		x	x	*		x			C*	C	C	I
Yellow-breasted chat		x	x	*		x				U	C	I
Wilson's warbler		x	x	x		x			C	U	C	I
Canada warbler				x		x				O	O	I
American redstart				*		x			C*	C	C	I
House sparrow					*		*	*	C*	C	C	I
Bobolink					x		x		O*	U	C	I
Western meadowlark					*		*		C*	C	C	I
Eastern meadowlark		x	x		*		*		C*	U	C	I
Yellow-headed blackbird		x	*		x		x		O*	C	C	I
Red-winged blackbird		*	*	*	*		x		C*	U	C	I
Orchard oriole				*	*	x	x		C*	C	C	I
Northern oriole		*	*	*	*	*	x		C*	C	C	I
Rusty blackbird		x	x	*					O	U	C	I
Brewer's blackbird		x	x							O	C	I
Common grackle		*	*	*	*	*	x	x	C*	U	C	I
Brown-headed cowbird		x	x	*	*	*	x		C*	U	C	I
Scarlet tanager				x		x				U	C	I
Summer tanager				x		x			N	R		I
Cardinal			*	*	x	*	x	x	C*	C	C	I
Rose-breasted grosbeak			*	*		*			C	C	C	I
Blue grosbeak					x		x			U	U	I

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SPECIES (BIRDS)	RIVER AND DE SOTO LAKE	MARSH	SLOUGHS, STREAMS AND PONDS	FLOODPLAIN FOREST	AGRICULTURAL FIELDS	UPLAND FOREST	PASTURE	BUILDINGS	DE SOTO	FONTANELLE	RAPP, ET AL.	KAIN
Indigo bunting			*	*	x	x	x		C*	C	C	I
Lazuli bunting				x	x	x	x			A	O	A
Dickcissel					x		*		C*	C	C	I
Evening grosbeak				x		x				O	R	I
Purple finch				x		x			O	U	R	I
Pine grosbeak				x		x				R	R	I
Common redpoll				x	x	x	x		R	U	R	I
Pine siskin				x	x	x	x			U	C	I
American goldfinch		*	*	*	x	*	x		C*	C	C	I
Red crossbill				x		x				U	C	I
White-winged crossbill				x		x				O	R	I
Rufous-sided towhee				*		*			C*	C	C	I
Lark bunting				x		*				R		I
Savannah sparrow					x		*			C	C	I
Grasshopper sparrow					x		*		U*	U	C	I
Baird's sparrow					x		x				R	I
Henslow's sparrow		x	x		x		x		O*	O	U	I
Sharp-tailed sparrow		x	x		x		x				R	
Le Conte's sparrow		x	x		x		x			O	C	I
Vesper sparrow		x	x		x		-		U*	U	C	I
Lark sparrow					x		*		U*	U	C	I
Dark-eyed junco		*	*	*	*	x	x	x	C	C	C	I
Tree sparrow		*		*	x	*	*		C	C	C	I
Chipping sparrow					x		x			U	C	I
Clay-colored sparrow					x		x		R	U	C	I
Field sparrow					*		*		C*	C	C	I
Harris sparrow		*		*	x	x	x		C	C	C	I
White-crowned sparrow				x	x	x	x		U	U	C	I
White-throated sparrow				x	x	x	x		U	C	C	I
Fox sparrow				*	*	x			O	U	R	I
Lincoln's sparrow				x		x				C	C	I
Swamp sparrow				x		x			R	O	C	I
Song sparrow			*	x	*	x	x		C*	U	C	I
Lapland longspur					x		x			O	C	I
Smith's longspur					x		x				R	
Snow bunting					x		x		R	R	P	I

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SPECIES (MAMMALS)	RIVER AND DE SOTO LAKE	MARSH	SLOUGHS, STREAMS, PONDS	FLOODPLAIN FOREST	AGRICULTURAL FIELD	UPLAND FOREST	PASTURE	BUILDINGS	DE SOTO[1]	UNIVERSITY OF SOUTH DAKOTA[2]	NEBRASKA GAME AND PARKS[3]	BURT AND GROSSENHEIDER[4]	HALL AND KELSON[5]
Marsupials													
Opossum		x	x	•	x	x	x		P	I	C	I	I
Insectivores													
Masked shrew		x	x	x					I	I		I	I
Least shrew							x		I	I		I	I
Short-tailed shrew		x		•	x	x	x		P	I		I	I
Eastern mole		x	x	•	x		x		I	I		I	I
Bats													
Little brown myotis				x					I	I		I	I
Keen myotis				x		x			I	I		I	I
Small footed myotis				x		x		x		I		I	I
Silver-haired bat				x		x			I	I		I	I
Eastern pipistrel				x		x				I			E
Big brown bat				x		x		x	I	I		I	I
Red bat				x		x			I	I		I	I
Hoary bat				x		x			I	I		I	I
Western big-eared bat						x		x	I				
Big free-tailed bat						x		x	I			E	
Rabbits													
Eastern cottontail		•	•	•	x	•	x		P	C	C	I	I
White-tailed jackrabbit					x		x		Q	I		I	I
Black-tailed jackrabbit					x		x		Q	I	U	I	I
Rodents													
Eastern chipmunk				x		x			I			E	E
Woodchuck						x			P		I	I	I
Thirteen-lined ground squirrel					•		•		P		I	I	I
Franklin ground squirrel			x		•		•		P	UR		I	I
Eastern gray squirrel				x		x			I	U		I	I
Eastern fox squirrel				x	•	•			P	C	C	I	I
Southern flying squirrel				x		x			I			I	E
Plains pocket gopher					x		x		P	C		I	I
Plains pocket mouse				x					I	E		I	I
Hispid pocket mouse							x		I	C		I	E
Beaver	•	•	•	•					P	C	C	I	I
Plains harvest mouse						x						I	I
Western harvest mouse		•	x				•		P	CA		I	I
Deer mouse		•		•	•	•	•		P	CA		I	I
White-footed mouse				•		x			P	C		I	I
Northern grasshopper mouse			x				x					E	E
Meadow vole		x	x						I	CA		I	I
Prairie vole		x	x			•			I	CA		I	I
Muskrat		•	•						P	C	C	I	I
Southern bog lemming		x							I	U		I	I
Norway rat								x	P	I		I	I
House mouse					•		•	x	P	CA		I	I
Meadow jumping mouse		x				•	x		I	PA		I	I
Porcupine				x		x							I
Carnivores													
Coyote				•		x			P	C	C	I	I
Gray wolf			x	x		x							I
Red fox						x			P	C	C	I	I
Swift fox							x						I
Gray fox				x		x	x		I	U	U	I	I
Black bear						x							I
Raccoon		x	•	•	x				P	C	C	I	I
Least weasel				x	x	x	x		P	U	U	I	I
Long-tailed weasel		x	x						P	C	U	I	I
Black-footed ferret							x			Q		I	I
Mink			x						P	I	P	I	I
Badger				x		x	•		P	I	C	I	I
Spotted skunk			x	x		x			I	U	UR	I	I
Striped skunk		x		x	x	x	•		P	C	C	I	I
River otter	x								I	Q		I	I
Mountain lion						x							I
Lynx						x							I
Bobcat				x		x				U	U	I	I
Artiodactyls													
Elk						x							I
Mule deer			x	x		x	x		P	E	R	I	
Whitetail deer		•	•	•	x	•	•		P	C	C	I	I

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2.5 Ecology (Continued)

2.5.1 Terrestrial Ecology (Continued)

and the relative abundance of each species are indicated. Certain species are of particular importance in the area because of their economic or recreational value or because of their rarity or importance in the ecosystem. Of recreational importance among the amphibians is the bullfrog. Bullfrogs are hunted during state controlled hunting seasons in both Iowa and Nebraska.

Some birds near the Fort Calhoun Station are also considered to be of particular significance, either because of their economic or recreational value, or because of their rare or endangered status. The birds most heavily utilized recreationally in the area are waterfowl. Fourteen (14) species of ducks and 2 species of geese are common and most of these species pass through the study area during the fall and spring migration along the Missouri River corridor of the Mississippi Flyway. The plant is not in an area of high waterfowl production, with only 3 species of ducks (wood ducks, mallards, and blue-winged teal) known to nest at the DeSoto National Wildlife Refuge. In addition to waterfowl, upland game birds, notably the bobwhite quail and ring-necked pheasant, are also hunted recreationally near the plant.

Four (4) species of birds which are listed as rare, threatened, or endangered may occur in the area. These are the American peregrine falcon, the American osprey, and the northern bald eagle. The American peregrine falcon, considered endangered nationally and in Nebraska, does not breed in Nebraska, but occurs as an occasional migrant and an occasional winter resident, most commonly observed in the central and northwestern regions of the state. The American osprey, classified as status undetermined, has been observed nesting in the DeSoto Wildlife Refuge on one occasion, but the bird is considered an uncommon migrant, most abundant along the Missouri River. Northern bald eagles, classified as rare in Nebraska, are considered uncommon migrants and winter residents. The summer tanager, listed as a rare species in Nebraska, is probably at the extreme northern edge of its range within the study area.

Three (3) species of mammals, potentially occurring near the site, are rare or endangered. Some species of larger mammals occupying the site are used for commercial or recreational purposes. The species hunted for recreational purposes are the whitetail deer, eastern cottontail rabbit, and eastern fox squirrels. Commercially harvested mammals,

2.5 Ecology (Continued)

2.5.1 Terrestrial Ecology (Continued)

trapped for pelts, are muskrat, beaver, mink, raccoon, skunk, opossum, badger, bobcat, coyote, and fox. Rare or endangered mammals potentially occurring in the area include the southern flying squirrel, eastern chipmunk, and swift fox. The swift fox, listed as a endangered species by the Nebraska Game and Parks Commission, is most likely to occur in the southwestern portion of the state many miles from the plant.

2.5.2 Aquatic Ecology

The aquatic habitat within a 2-mile radius of the Fort Calhoun Station are the Missouri River, Long Creek, Fish Creek, and several sloughs. The Missouri River near the plant is highly controlled and channelized. It is approximately 600 feet wide and is confined to a sinuous artificial channel. The concave banks of the channel have been stabilized by boulder riprap, while the convex banks have filling dikes. The main channel has current of 4 to 6 feet per second, a depth of 9 to 20 feet, and a substrate of fine to coarse shifting sand. In summer and fall, the bottom consists of undulating dunes which cause turbulence cells that appear as boils on the water surface. Sediment load is quite high, resulting in reduced light penetration. Water temperatures vary from 32°F in winter to 85°F in summer. In winter, the river may freeze approximately halfway across along the convex bank, and the remainder of the channel often contains floating ice cakes. The water flow is regulated to meet the needs of barge traffic, flood control, irrigation, pollution control (at low flows), and generation of hydroelectric power by releases from upstream impoundments. During winter, when there is no barge traffic, the discharge from the impoundments is reduced, causing the water level to drop several feet in addition to the drop caused by low temperature and bottom changes. A more detailed description of the river, along with water quality and temperature data. is presented in the hydrology discussion in section 2.6.

Long Creek is a small tributary of the Missouri River that drains the upland terrain south of the site. It crosses the flood plain in a northerly direction and enters the river approximately 0.75 mile south of Fort Calhoun Station Unit No. 1. The creek is 6.8 miles long and its banks are well vegetated. Submerged logs and brush are common. The upper portion of the creek is approximately 6 to 8 feet wide and 0.5 to 1.5 feet deep, and the bottom substrate is sand with soft silt in the eddies around submerged logs. The lower

2.5 Ecology (Continued)

2.5.2 Aquatic Ecology (Continued)

portion is about 35 feet wide and 3 to 6 feet deep with a soft silt bottom. The depth varies with river level and was 6 to 8 feet during the summer of 1975. Flow rates have not been measured for Long Creek, but flows appear to be low to moderate most of the year and very low to nonexistent in winter.

The sloughs were formed by the channelization of the Missouri River when a portion of the old channel was cut off. These are normally very shallow (1.5 to 4 feet), with soft silt bottoms. The slough is similar in water quality to the Missouri River.

Fish Creek is a small intermittent stream that drains a flood plain marsh northwest of the site. The lower portion is 3 to 5 feet wide, and the water level depends on upstream drainage and river level. Runoff from the cleared area of the Fort Calhoun Station drains into the creek.

The biological makeup of the various aquatic habitats near the plant is similar in many aspects. Sixty-four (64) species of fish have been reported for the Missouri River and tributaries near the station, and these are listed in Table 2.5-3. Of these, 19 taxa are representative of commercially or recreationally valuable species and species critical to the functioning of the ecosystem. These species are listed in Table 2.5-4. Of the commercial species, the channel catfish, flathead catfish, and carp have made up most of the commercial catch in recent years. Carp appear to consistently dominate the catch in weight harvested; however, the dollar value of the catfish exceeds that of carp, and catfish may produce a larger percentage of commercial fishermen's income than carp. The recreational species listed in the table are those most sought after by sport fishermen, and the list of species critical to the functioning of the ecosystem is composed of representatives selected from all trophic levels of the food web, which are relatively abundant at the Fort Calhoun Station.

Some of the fish potentially inhabiting the waters near the plant are considered threatened in Nebraska, although none is considered endangered nationally. Table 2.5-5 provides a list of these. The status of these species near the site is unknown. Table 2.5-6 shows the relative abundance of all fish collected near the site.

Table 2.5-3
Fish Collected Near Fort Calhoun Station, 1970 Through 1975

COMMON NAME	SCIENTIFIC NAME	MISSOURI RIVER				[illegible] CREEK		SLOUGHS
		NGAP[1]	BIO-TEST[2]	OPPD[3]	GMDR[4]	BLISS &[5] SCHAINOST	GMDR	GMDR
Shovelnose sturgeon	*Scaphirhynchus platorynchus*	X		X	X			
Paddlefish	*Polyodon spathula*	X			X		X	
Longnose gar	*Lepisosteus osseus*	X			X		X	
Shortnose gar	*Lepisosteus platostomus*	X	X	X	X	X	X	X
American eel	*Anguilla rostrata*			X				
Gizzard shad	*Dorosoma cepedianum*	X	X	X	X	a[6]	X	X
Skipjack herring	*Alosa chrysochloris*	X		X				
Goldeye	*Hiodon alosoides*	X	X	X	X		X	X
Mooneye	*Hiodon tergisus*			X				
Rainbow smelt	*Osmerus esperlantus*				X			
Northern pike	*Esox lucius*	X		X	X		X	o[7]
Muskellunge	*Esox masquinongy*			X				
Burbot	*Lota lota*	X					X	
Carp	*Cyprinus carpio*	X	X			a[6]	X	X
Goldfish	*Carassius auratus*	X						
Silvery minnow	*Hybognathus nuchalis*	X		X			X	X
Speckled chub	*Hybopsis aestivalis*	X			X			
Flathead chub	*Hybopsis gracilis*	X						
Silver chub	*Hybopsis storeriana*	X			X			
Spotfin shiner	*Notropis spilopterus*				X			
Emerald shiner	*Notropis atherinoides*	X	X		X		X	X
River shiner	*Notropis blennius*	X	X				X	
Bigmouth shiner	*Notropis dorsalis*	X	X		X	X	X	X
Red shiner	*Notropis lutrensis*	X	X		X	X	X	X
Sand shiner	*Notropis stramineus*	X	X			X	X	X
Stoneroller	*Campostoma anomalum*	X						
Fathead minnow	*Pimephales promelas*	X	X		X	X	X	X
Creek chub	*Semotilus atromaculatus*	X		X	X	X	X	X
Suckermouth minnow	*Phenacobius mirabilis*				X			
Silverjaw minnow	*Ericymba buccata*			X				
Shortnose dace	*Rhinichthys atratulus*			X				
Largemouth buffalo	*Ictiobus cyprinellus*	X	X	X	X	X	X	X
Smallmouth buffalo	*Ictiobus bubalus*	X	X	X	X		X	X
Black buffalo	*Ictiobus niger*			X				
River carpsucker	*Carpiodes carpio*	X	X	X	X		X	X
Quillback carpsucker	*Carpiodes cyprinus*		X		X	a[6]	X	X
Highfin carpsucker	*Carpiodes velifer*			X				
Northern redhorse	*Moxostoma macrolepidotum*	X	X	X	X		X	X
Silver redhorse	*Moxostoma anisurum*						X	
White sucker	*Catostomus commersoni*	X		X		X	X	
Blue sucker	*Cycleptus elongatus*	X	X	X	X			X
Flathead catfish	*Pylodictis olivaris*	X	X	X	X			
Black bullhead	*Ictalurus melas*	X	X	X	X		X	X
Yellow bullhead	*Ictalurus natalis*	X		X	X	a[6]	X	X
Brown bullhead	*Ictalurus nebulosus*			X	X			
Channel catfish	*Ictalurus punctatus*	X	X	X	X		X	
Stonecat	*Noturus flavus*	X		X	X		X	
Tadpole madtom	*Noturus gyrinus*	X						
Plains killifish	*Fundulus kansae*	X						
White bass	*Morone chrysops*	X	X	X	X	a[6]	X	X
White perch	*Morone americana*				X			
Largemouth bass	*Micropterus salmoides*	X	X		X	X	X	X
Bluegill	*Lepomis macrochirus*	X	X	X	X	X	X	X
Green sunfish	*Lepomis cyanellus*	X	X	X	X	a[6]	X	X
Orangespotted sunfish	*Lepomis humilis*	X	X	X	X		X	
Longear sunfish	*Lepomis megalotis*			X				
Redear sunfish	*Lepomis microlophus*						X	
White crappie	*Pomoxis annularis*	X	X	X	X	a[6]	X	X
Black crappie	*Pomoxis nigromaculatus*	X	X	X	X		X	X
Johnny darter	*Etheostoma nigrum*	X						
Yellow perch	*Perca flavescens*	X		X	X		X	X
Sauger	*Stizostedion canadense*	X	X	X	X		X	X
Walleye	*Stizostedion vitreum*	X		X	X	X	X	X
Freshwater drum	*Aplodinotus grunniens*	X	X	X	X		X	X

[1]Morris, et al., 1971, and Stucky, et al., 1972.

[2]Bio-Test, 1973b&c; Bremer, 1974; Wetzel, 1975.

[3]OPPD impingement computer printout.

[4]GMDR impingement.

[5]Bliss and Schainost, 1973.

[6]Found in other streams in the area.

[7]Observed but not collected.

Table 2.5-4
Selected Representative Fish Species in the Missouri River, Associated Backwaters, and Creeks Near Fort Calhoun

SPECIES	CATEGORY OF IMPORTANCE		
	COMMERCIAL	RECREATIONAL	ECOSYSTEM
Channel catfish	x	x	
Flathead catfish	x	x	
Carp	x	x	
Carpsuckers	x	x	
Buffalofishes	x	x	
Freshwater drum		x	
Sauger		x	
Walleye		x	
Goldeye		x	
Shortnose gar			x
Gizzard shad			x
Emerald shiner			x
Red shiner			x
Silver chub			x
Crappies		x	x
Green sunfish		x	x
Blue sucker			x
Shovelnose sturgeon			x
Paddlefish		x	x

Table 2.5-5
Threatened Fishes of Nebraska
as Listed by R. R. Miller (1972)

Chestnut lamprey (endangered)	*Ichthyomyzon castaneus*
Silver lamprey (endangered)	*Ichthyomyzon unicuspis*
Lake sturgeon (endangered)	*Acipenser fulvescens*
Pallid sturgeon (endangered)	*Scaphirhynchus albus*
Mooneye (endangered)	*Hiodon tergisus*
Sturgeon chub (endangered)	*Hybopsis gelida*
Hornyhead chub (rare)	*Nocomis biguttatus*
Blacknose shiner (rare)	*Notropis heterolepis*
Topeka shiner (endangered)	*Notropis topeka*
Northern redbelly dace (rare and endangered)	*Phoxinus eos*
Finescale dace (endangered)	*Phoxinus neogaeus*
Bluntnose minnow (endangered)	*Pimephales notatus*
Blacknose dace (endangered)	*Rhinichthys atratulus*
Pearl dace (rare)	*Semotilus margarita*
Highfin carpsucker (endangered)	*Carpiodes velifer*
Black buffalo (indeterminate)	*Ictiobus niger*
Golden redhorse (rare)	*Moxostoma erythrurum*
Blue catfish (indeterminate)	*Ictaluras furcatus*

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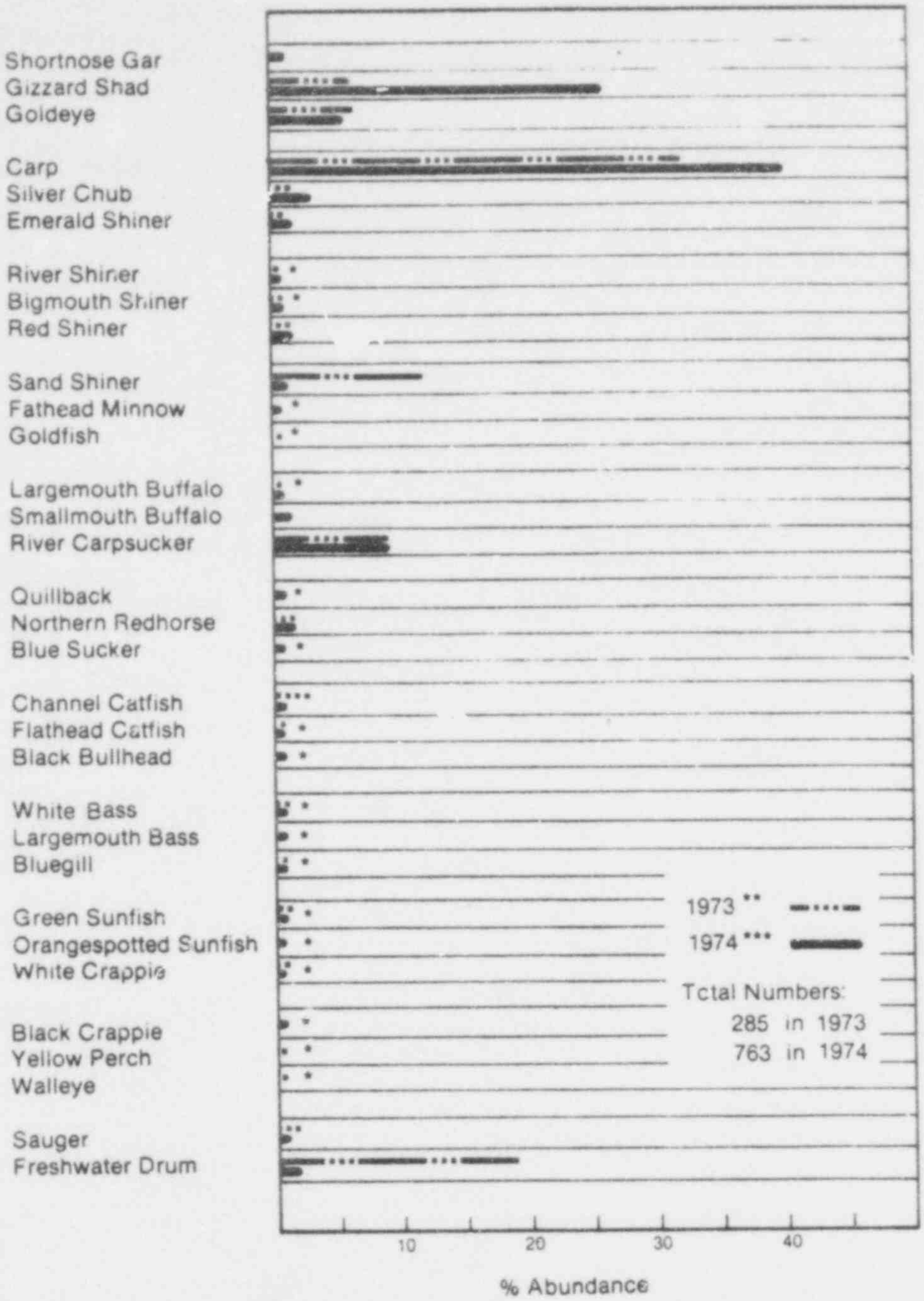

* ≤0.5
** Bio-test, 1973
*** Bremer, 1974, and Wetzel, 1975.

NOTE: RELATIVE ABUNDANCE OF FISH COLLECTED IN THE MISSOURI RIVER NEAR FORT CALHOUN STATION BY BIO-TEST IN 1973 AND 1974.

OMAHA PUBLIC POWER DISTRICT FORT CALHOUN STATION	Table 2.5-6 (Sheet 1 of 2) Relative Abundance of Fish Collected in the Missouri River Near Fort Calhoun Station by Bio-Test

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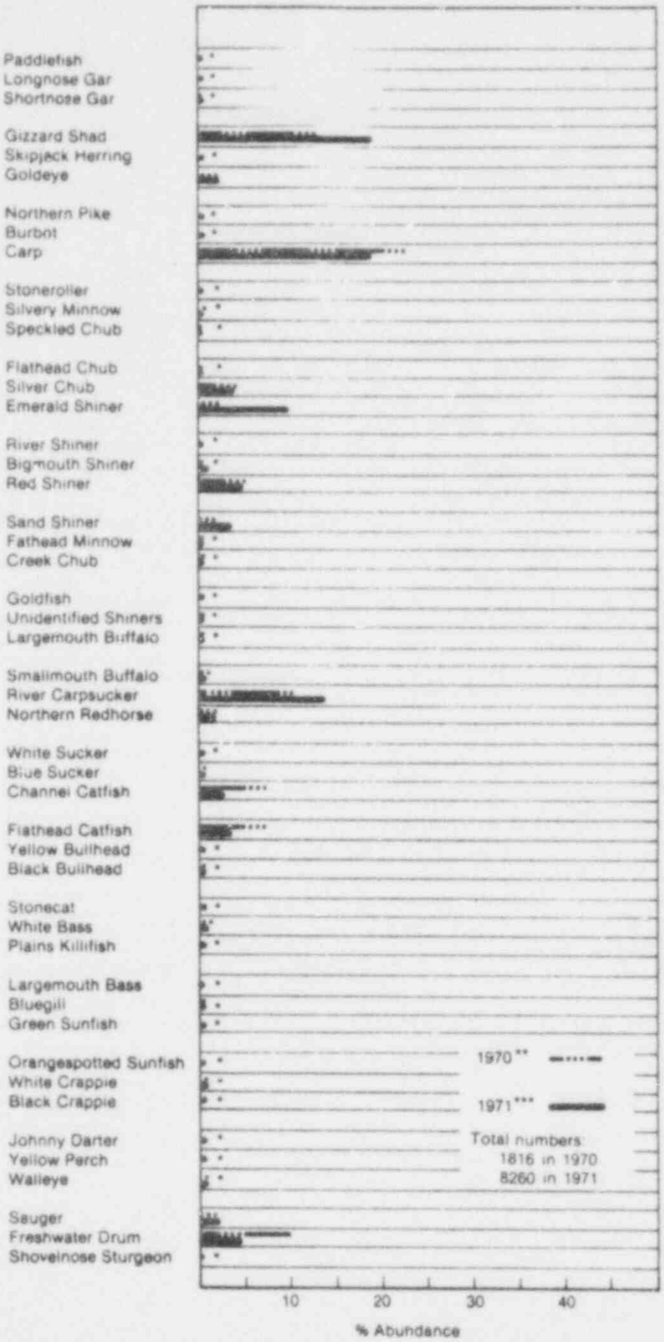

* ≤ 0.5%
** Morris, et al., 1971
*** Stucky, et al., 1972

NOTE: RELATIVE ABUNDANCE OF FISH COLLECTED IN THE MISSOURI RIVER NEAR FORT CALHOUN STATION BY THE NEBRASKA GAME AND PARKS COMMISSION IN 1970 AND 1971.

OMAHA PUBLIC POWER DISTRICT FORT CALHOUN STATION	Table 2.5-6 (Sheet 2 of 2) Relative Abundance of Fish Collected in the Missouri River Near Fort Calhoun Station by Nebraska Game & Parks Commission

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2.5 Ecology (Continued)

2.5.2 Aquatic Ecology (Continued)

Stomach content analysis of fish in the area showed that an important food source is drift macroinvertebrates. These can be of terrestrial origin, washed into the river by rain, or organisms which spend part of their life cycle in the river. Approximately 140 taxa of drift macroinvertebrates were collected during 1974 in the vicinity of the plant, as shown in Table 2.5-7. The most abundant organisms collected during 1974 were the caddis fly and may fly. Seasonal shifts were identified with respect to species composition and density. In general, highest densities were observed during the spring.

In addition to fish and drift macroinvertebrates, the area aquatic habitat's makeup with respect to aufwuchs, benthic macroinvertebrates, zooplankton, macrophytes, periphyton, and phytoplankton was assessed. Aufwuchs (those organisms living attached or in close association with a submerged substrate) have been collected from various artificial and natural substrates in the Missouri River. Taxa reported from the middle Missouri River, including those collected from artificial substrates exposed in the vicinity of the plant, are listed in Table 2.5-8. The macroinvertebrate assemblage was composed almost exclusively of caddis fly, may fly, and midge fly larvae. The most abundant organisms collected were the same organisms. The largest abundance of total organisms occurred during July through September. In general, the abundances of organisms immediately downstream from the station were as large or larger than the abundances at any of the other transects upstream or further downstream from the station.

Approximately 100 benthic macroinvertebrate taxa were collected in the middle Missouri River, as shown in Table 2.5-9. The number of taxa collected from the channelized areas was generally lower than the number of taxa collected from unchannelized areas. The benthic community was dominated by four groups: Oligochaeta, Ephemeroptera, Tricoptera, and Chironomidae. The average standing crop of benthic macroinvertebrates in the channelized Missouri River near the station was estimated to be approximately 36.6 grams per square meter.

Zooplankton (those invertebrates less than 500 microns in length which drift with the current) are represented by 136 taxa collected from the middle Missouri River. Table 2.5-10 provides a list of these. The zooplankton community in this area consists primarily of copepods, cladocerans, rotifers, and protozoans. The abundance, species composition, and species

Table 2.5-7
Drift Macroinvertebrates Collected in the Missouri
Ri.er and Adjacent Backwaters
(Page 1 of 2)

TAXA	LOCATION				
	FORT CALHOUN PRE-TEST[1]	LOWER MISSOURI RIVER[2]	PLATTSMOUTH[3]	NEBRASKA CITY[4]	PLATTSMOUTH[5]
Platyhelminthes					
Turbellaria					
Tricladida					
Planariidae					
Dugesia tigrina	x				
Aschelminthes					
Nematoda (unident.)	x				
Annelida (unident.)		x			
Oligochaeta					
Plesiopora					
Glossoscolecidae					
Sparganophilus tamesis	x				
Enchytraeidae (unident.)	x				
Naididae					
Dero digitata	x				
Nais behningi	x				
Nais sp.	x				
Paranais frici	x				
Pristina sp.	x				
Tubificidae (unident., immature w/o cappiliforma)	x				
Tubificidae (unident., immature w/ cappiliforma)	x				
Limnodrilus cervix	x				
L. claparedianus	x				
L. hoffmeisteri	x				
L. udekemianus	x				
Hirudinea					
Rhynchobdellida					
Piscicolidae					
Piscicola geometra	x				
Arhynchobdellida					
Hirudidae					
Haemopsis grandis	x				
Mollusca					
Gastropoda					
Basommatophora					
Physidae					
Physa sp.	x				
Arthropoda					
Crustacea					
Cladocera					
Daphnidae (unident.)			x	x	
Leptodoridae					
Leptodora kindtii			x	x	x
Isopoda					
Asellidae					
Asellus sp.	x				
Copepoda (unident.)			x	x	
Amphipoda					
[illegible]litridae					
Hyalella azteca	x				
Decapoda					
Astacidae (unident.)	x				
Cambarinae (unident.)	x				
Arachnida					
Chelonethida (unident.)	x				
Aranea (unident.)	x				
Acarina					
Hydracarina (unident.)	x				
Insecta					
Thysanura					
Japygidae (unident.)	x				
Phloeothripidae (unident.)	x				
Collembola (unident.)			x		x
Isotomidae					
Isotomurus palustris	x				
Ephemeroptera					
Ephemeridae (unident.)		x			
Ephoron sp.			x	x	x
Hexagenia sp.	x				
Potamanthus sp.	x				
Caenidae					
Brachycercus sp.	x			x	
Caenis sp.	x			x	
Tricorythodes sp.	x			x	
Heptageniidae					
Anepeorus sp.	x				
Heptagenia sp.	x				
Stenonema sp.	x		x	x	x
Baetidae					
Ameletus sp.			x	x	x
Bachycerus sp.			x		x
Baetis sp.	x				
Caenis sp.			x		x
Isonychia sp.	x		x	x	x
Siphlonurus sp.	x				
Odonata (unident.)		x		x	
Gomphidae (unident., immature)	x				
Agrionidae					
Hetaerina sp.	x				
Coenagrionidae (unident.)			x		x
Ischnura sp.	x				

[1] [illegible], 1974; Wetzel, 1975.

[2] Berner, 1951.

[3] Morris et al., 1968.

[4] [illegible], 1969.

[5] [illegible], 1965.

NOTE: THIS LIST COMPRISES COLLECTIONS MADE AT SEVERAL LOCATIONS. THE COLLECTING TECHNIQUES AND SPECIFICITY OF TAXONOMIC IDENTIFICATION VARIES AMONG LOCALITIES. THE LISTING OF TAXA AT ONLY ONE LOCALITY DOES NOT NECESSARILY IMPLY THAT THE TAXA DO NOT OCCUR AT THE OTHER LOCALITIES AS WELL - IT MEANS ONLY THAT THEY WERE EITHER NOT COLLECTED OR NOT IDENTIFIED.

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Table 2.5-7
(Continued)
Drift Macroinvertebrates Collected in the Missouri
River and Adjacent Backwaters
(Page 2 of 2)

TAXA	LOCATION				
	FORT CALHOUN BIO-TEST[1]	LOWER MISSOURI RIVER[2]	PLATTSMOUTH[3]	NEBRASKA CITY[4]	PLATTSMOUTH[5]
Plecoptera					
Perlodidae					
Isoperla sp.	x				
Perlidae					
Perlesta sp.	x			x	
Hemiptera					
Corixidae (unident.)			x	x	x
Unident., immature	x				
Sigara sp.	x				
Trichocorixa sp.	x				
Pleidae					
Plea striola	x				
Veliidae (unident.)	x				
Trichoptera (unident.)		x			
Psychomyiidae					
Cyrnellus fraternus	x				
Neureclipsis sp.	x		x	x	x
Hydropsychidae					
Arctopsyche sp.			x		x
Cheumatopsyche sp.	x		x	x	x
Hydropsyche frisoni	x				
H. orris	x				
H. simulans	x				
H. sp.			x	x	x
Potamyia sp.			x	x	x
Hydroptilidae					
Agraylea sp.	x				
Mayatrichia sp.	x				
Leptoceridae					
Athripsodes tarsi-punctatus	x				
Leptocella candida	x				
L. diarina	x				
Lepidoptera					
Pyralidae (unident.)	x				
Hymenoptera					
Formicidae (unident.)	x				
Coleoptera (unident.)				x	
Haliplidae (unident.)	x				
Dytiscidae (unident.)	x		x		x
Hydrophilidae (unident.)	x				
Staphylinidae (unident.)	x				
Elmidae					
Dubiraphia sp.	x				
Chrysomelidae (unident.)	x				
Curculionidae (unident.)	x				
Diptera (unident.)		x		x	x
Tipulidae					
Helius sp.	x				
Psychodidae (unident.)				x	x
Pericoma sp.	x				
Psychoda sp.	x				
Culicidae (Chaoborinae)			x	x	x
Chaoborus americanus	x				
C. punctipennis	x				
C. sp.		x			
Simuliidae (unident.)	x		x	x	x
Chironomidae (unident.)		x	x	x	x
Ablabesmyia sp.	x				
Chironomus sp.	x				
Cladotanytarsus sp.	x				
Coelotanypus sp.	x				
Cricotopus sp.	x				
Cryptochironomus sp.	x				
C. fulvus	x				
Near *Demicryptochironomus* sp.	x				
Near *D. demeijerei*	x				
Near *D. fulvus monotronus*	x				
Endochironomus sp.	x				
Epoicocladius sp.	x				
Glyptotendipes sp.	x				
Microcricotopus sp.	x				
Micropsecta sp.	x				
Orthocladius sp.	x				
Near *Parachaetocladius* sp.	x				
Parachironomus sp.	x				
Paracladopelma sp.	x				
Paralauterborniella sp.	x				
Paratendipes sp.	x				
Near *P.* "connectens"	x				
Polypedilum (*Tripodura* group) sp.	x				
Procladius (*Procladius*) sp.	x				
Procladius (*Psilotanypus*) sp.	x				
Pseudosmittia sp.	x				
Rheotanytarsus sp.	x				
Stenochironomus sp.	x				
Stictochironomus sp.	x				
Tanypus sp.	x				
Tanytarsus sp.	x				
Thienemannimyia Group	x				
Trissocladius sp.	x				
Xenochironomus sp.	x				
Xenochironomus (*Xenorus*) sp.	x				
Ceratopogonidae (unident.)	x				
Bezzia sp.		x			
Tabanidae (unident.)	x				
Dolichopodidae (unident.)	x				
Empididae (unident.)				x	
Hemerodromia sp.	x				
Ephydridae (unident.)	x				
Stratiomyidae (unident.)				x	
Chilopoda (unident.)	x				

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POOR ORIGINAL

Table 2.5-8
Aufwuchs Organisms Collected in the Missouri River and Adjacent Backwaters
(Page 1 of 3)

TAXA	LOCATION				
	COOPER[1]	FORT CALHOUN[2]	GEORGE NEAL[3]	DESOTO[4]	NEBRASKA CITY[5]
Coelenterata (Cnidaria)					
Hydrozoa					
Hydridae					
Hydra sp.	x	x	x		
Clavidae					
Cordylophora lacustris	x				
C. sp.		x			
Platyhelminthes					
Turbellaria					
Tricladida					
Planariidae (unident.)	x				
Dugesia sp.		x			
Planaria sp.		x			
Bryozoa (unident.)	x				
Aschelminthes					
Nematoda			x		
Mollusca					
Pelecypoda					
Heterodonta					
Sphaeriidae					
Sphaerium sp.	x		x		
Gastropoda (unident.)			x		x
Physa sp.			x	x	
Annelida					
Oligochaeta (unident.)		x			
Plesiopora					
Naididae					
Aulophorus sp.	x				
Dero digitata	x				
D. sp.	x				
Nais pardalis	x				
N. sp.	x				
Pristina longiseta	x				
Stylaria lacustris	x				
Tubificidae (unident.)		x		x	
(unident. immatures w/cap. chaetae)	x				
(unident. imm. w/out cap. chaetae)	x				
Aulodrilus limnobius	x				
A. pigueti	x				
Branchiura sowerbyi	x				
Limnodrilus cervix	x				
L. hoffmeisteri	x				
L. spiralis	x				
L. udekemianus		x		x	
Enchytraeidae (unident.)	x				
Glossoscolecidae					
Sparganophilus sp.	x				
Hirudinea (unident.)		x	x		
Arhynchobdellida					
Erpobdellidae					
Dina (M.) fervida	x				
Arthropoda					
Arachnida					
Hydracarina (unident.)	x	x	x		
Crustacea					
Isopoda					
Asellidae					
Asellus sp.	x	x	x		x
Amphipoda (unident.)					
Talitridae					
Hyalella azteca	x	x	x	x	
Gammaridae					
Gammarus sp.	x				
Cladocera					
Daphnidae					
Daphnia sp.			x		
Decapoda					
Orconectes sp.		x			
Insecta					
Ephemeroptera					
Ephemeridae (unident.)					x
Ephemera simulans	x				
Hexagenia limbata	x				
H. sp.	x		x		
Pentagenia sp.		x	x		
Caenidae (unident.)		x			
Caenis sp.	x	x	x		x
Tricorythodes					
Tricorythodes sp.	x	x	x		x
Baetidae (unident.)		x			
Baetis sp.	x	x			
Isonychia sp.	x	x	x		
Pseudocloeon sp.	x				
Heptageniidae (unident.)		x			
Cinygma sp.		x			
Heptagenia sp.	x	x	x		
Stenonema sp.	x	x	x		x
Polymitarcidae					
Ephoron album	x				
Ephemerellidae					
Ephemerella sp.	x	x			
Leptophlebiidae (unident.)		x			
Paraleptophlebia sp.		x			
Siphlonuridae					
Ameletus sp.		x			x
Polymitarcidae					
Tortopus sp.		x			

[1]Bio-Test, 1971, 73a, 74, and 75; Busby, 1973.

[2]Morris et al., 1971; Stucky et al., 1972.

[3]Hey and Baldwin, 1976.

[4]Hoggins, 1968.

[5]Hola, 1969.

NOTE: THIS LIST COMPRISES COLLECTIONS MADE AT SEVERAL LOCATIONS. THE COLLECTING TECHNIQUES AND SPECIFICITY OF TAXONOMIC IDENTIFICATION VARIES AMONG LOCALITIES. THE LISTING OF TAXA AT ONLY ONE LOCALITY DOES NOT NECESSARILY IMPLY THAT THE TAXA DO NOT OCCUR AT THE OTHER LOCALITIES AS WELL - IT MEANS ONLY THAT THEY WERE EITHER NOT COLLECTED OR NOT IDENTIFIED.

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Table 2.5-8
(Continued)
Aufwuchs Organisms Collected in the Missouri River and Adjacent Backwaters
(Page 2 of 3)

TAXA	LOCATION				
	COOPER[1]	FORT CALHOUN[2]	GEORGE NEAL[3]	DESOTO[4]	NEBRASKA CITY[1]
Odonata (unident.)					x
Gomphidae					
Gomphus intricatus	x				
G. sp.	x		x		
Libellulidae (unident.)		x			
Neurocordulia molesta	x				
Coenagrionidae (Agrionidae) (unident.)	x				
Argia sp.	x	x			
Amphiagrion sp.			x		
Enallagma sp.				x	
Ischnura sp.	x				
Plecoptera					
Nemouridae					
Taeniopteryx sp.	x				
Perlodidae (unident.)		x			
Isoperla sp.	x	x			
Chloroperlinae					
Alloperla sp.		x			
Hastaperla sp.		x			
Perlidae (unident.)		x			
Acroneuria sp.	x				
Paragnetina sp.		x			
Perlinata sp.	x	x			
Trichoptera					
Psychomyiidae (unident.)		x			
Cyrnellus sp.		x			
Neureclipsis sp.	x	x			
Polycentropus sp.		x			
Hydropsychidae (unident.)		x			
Cheumatopsyche sp.	x	x			x
Hydropsyche bettoni	x				
H. frisoni	x	x			
H. orris	x	x			
H. simulans	x	x			
H. sp.		x			x
Mayatrichia sp.	x				
Potamyia flava	x	x			
P. sp.					x
Hydroptilidae (unident.)		x			
Hydroptila sp.	x	x			
Neotrichia sp.		x			
Oxyethira sp.	x	x			
Leptoceridae (unident.)		x			
Athripsodes sp.		x			
Leptocella candida	x	x			
L. sp.	x	x			
Mystacides sp.		x			
Oecetis inconspicua	x				
O. sp.	x	x			
Rhyacophilidae (unident.)		x			
Coleoptera					
Dytiscidae (unident.)	x		x		
Hydrophilidae (unident.)			x		
Berosus sp.	x				
Elmidae					
Dubiraphia sp.		x			
Psephenidae					
Ectopria sp.	x				
Collembola (unident.)		x			
Orthoptera					
Tridactylidae					
Tridactylus minutus	x				
Diptera (unident.)			x		x
Ceratopogonidae (unident.)		x			
Palpomyia tibialis	x				
Empididae (unident.)	x	x			x
Tipulidae (unident.)	x				
Simuliidae (unident.)	x	x			x
Simulium sp.		x			
Chironomidae (unident.)		x	x		x
Ablabesmyia sp.	x	x			
Chironomus sp.	x	x			
Cladotanytarsus sp.	x	x			
Conchapelopia sp.		x			
Corynoneura sp.	x	x			
Cricotopus sp.	x	x			
Cryptochironomus sp.	x	x			
Dicrotendipes sp.	x				
Endochironomus sp.	x				
Glyptotendipes sp.	x	x			
Harnischia sp.	x				
Labrundinia sp.	x				
Hemerodromia sp.	x	x			
Microcricotopus sp.	x	x			
Micropsectra sp.	x	x			
Nanocladius sp.	x	x			
Orthocladius sp.	x	x			
Paracladopelma sp.	x				
Parachironomus sp.	x	x			
Paralauterborniella sp.	x				
Pentaneura sp.	x				
Polypedilum (*Tripodura* Group)	x	x	x		
Polypedilum (*Fallax*)	x				
Procladius sp.	x	x			
Psectrocladius sp.	x	x			
Rheotanytarsus sp.	x	x			
Stenochironomus sp.	x	x			
Tanypus sp.	x	x			
Tanytarsus sp.	x	x			
Thienemannimyia Group	x	x			
Trissocladius sp.	x				
Anthomyiidae (unident.)			x		
Hemiptera					
Corixidae (unident.)					x
Tardigrada	x				

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Table 2.5-8
Addendum
Additional Aufwuchs Species Identified Too Late for Inclusion in Table 2.5-8 (from OPPD Rock Basket Samplers at Fort Calhoun Station, 1973-1974)
(Page 3 of 3)

TAXA	LOCATION				
	COOPER[1]	FORT CALHOUN[2]	GEORGE NEAL[1]	DESOTO[4]	NEBRASKA CITY[1]
Annelida					
Oligochaeta (unident.)		X			
Plesiopora					
Naididae					
Nais bretscheri (Pardalis type)		?			
N. bretscheri (*Nais* sp. type)		X			
Arthropoda					
Insecta					
Ephemeroptera					
Ephemeridae (unident.)		X			X
Ephoron sp.		X			
Heptageniidae (unident.)		X			
Anepeorus sp.		X			
Heptagenia diabasia		X			
H. flavescens		X			
Stenonema interpunctatum		X			
S. pulchellum		X			
S. tripunctatum		X			
Plecoptera					
Perlidae (unident.)		X			
Perlesta placida		X			
Trichoptera					
Psychomyiidae (unident.)		X			
Cyrnellus fraternus		X			
Hydroptilidae (unident.)		X			
Mayatrichia ayama		X			
M. sp.		X			
Leptoceridae (unident.)		X			
Leptocerus americanus		X			
Diptera (unident.)			X		X
Chironomidae (unident.)		X	X		X
Eukiefferiella sp.		X			
Larsia sp.		X			
Microtendipes sp.		X			
Polypedilum (s.s.) *convictum* type		X			
P. (s.s.) *scalaenum* type		X			

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Table 2.5-9
Benthic Organisms Collected in the Missouri River and Adjacent Backwaters
(Page 1 of 2)

TAXA	LOCATION: CALLAWAY[1]	COOPER[2]	DESOTO[3]	PLATTSMOUTH[4]	LOWER MISSOURI RIVER[5]	PLATTSMOUTH[6]
Aschelminthes						
Nematomorpha (unident.)						x
Annelida (unident.)					x	
Oligochaeta						x
Enchytraeidae (unident.)	x					
Lumbriculidae (unident.)	x					
Tubificidae (unident. & immature)	x	x	x			
Aulodrilus limnobius		x				
A. pignoti	x	x				
Branchiura sowerbyi	x	x				
Ilyodrilus templetoni	x					
Limnodrilus cervix	x	x				
L. claparedeanus	x	x				
L. hoffmeisteri	x	x				
L. udekemianus	x	x				
L. spp.	x					
Tubifex tubifex		x				
T. sp.	x					
Peloscolex sp.	x					
Naidae						
Aulophorus sp.	x					
Dero digitata	x	x				
D. sp.		x				
Nais elinguis	x					
N. sp.	x	x				
Paranais frici	x					
Mollusca						
Gastropoda (unident.)				x		
Ferrissia sp.	x					
Pelecyyoda (unident.)				x		
Corbiculidae						
Corbicula sp.	x					
Sphaeriidae (unident.)						x
Arthropoda						
Arachnida						
Acari						
Hydracarina (unident.)	x					
Crustacea						
Amphipoda						
Hyalella azteca	x					
Isopoda (unident.)				x		
Insecta						
Collembola (unident.)	x					
Ephemeroptera						
Ephemeridae (unident.)					x	
Ephoron sp.				x		x
Hexigenia c.f. *limbata*		x				
H. sp.	x			x		
Pentagenia vittigena	x					
P. sp.	x			x		x
Caenidae						
Brachycercus sp.				x		x
Caenis sp.	x		x			
Ephemerellidae						
Ephemerella frisoni	x					
Heptageniidae (unident.)			x			
Stenonema femoratum	x					
S. sp.		x				
Baetidae (unident.)		x				
Isonychia sp.	x					
Odonata (unident.)				x	x	
Argia sp.	x					
Gomphus sp.	x		x			
Octogomphus sp.				x		x
Plecoptera (unident.)					x	
Hemiptera						
Corixidae (unident.)				x		
Coleoptera (unident.)	x			x		
Dubiraphia sp.	x					
Trichoptera (unident.)	x					
Cheumatopsyche sp.	x			x		
Hydropsyche orris	x					
H. sp.		x	x			x
Neureclipsis sp.	x		x			x
Polycentropus sp.				x		
Ptilostomis sp.				x		x
Diptera (unident.)		x		x		x
Culicidae						
Chaoborus punctipennis	x					
C. sp.	x		x		x	

[1] USNRC, 1975.
[2] Bio-Test, 1975; Busby, 1972.
[3] Huggins, 1968.
[4] Morris et al., 1968.
[5] Berner, 1951.
[6] Langemeier, 1965.

NOTE: DESOTO LAKE IS THE SITE CLOSEST TO FORT CALHOUN STATION FROM WHICH DATA ARE AVAILABLE, BUT IT IS A HABITAT MUCH DIFFERENT THAN THE MISSOURI RIVER. THE MISSOURI RIVER LOCALITY CLOSEST TO FORT CALHOUN STATION IS COOPER STATION. THIS LIST COMPRISES COLLECTIONS MADE AT SEVERAL LOCATIONS. THE COLLECTING TECHNIQUES AND SPECIFICITY OF TAXONOMIC IDENTIFICATION VARIES AMONG LOCALITIES. THE LISTING OF TAXA AT ONLY ONE LOCALITY DOES NOT NECESSARILY IMPLY THAT THE TAXA DO NOT OCCUR AT THE OTHER LOCALITIES AS WELL - IT MEANS ONLY THAT THEY WERE EITHER NOT COLLECTED OR NOT IDENTIFIED.

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Table 2.5-9
(Continued)
Benthic Organisms Collected in the Missouri
River and Adjacent Backwaters
(Page 2 of 2)

TAXA	LOCATION					
	CALLAWAY[1]	COOPER[2]	DESOTO[3]	PLATTSMOUTH[4]	LOWER MISSOURI RIVER[5]	PLATTSMOUTH[6]
Chironomidae (unident.)	x	x			x	x
Ablabesmyia janta	x					
Chironomus plumosus		x				
C. spp.	x	x	x	x		
Coelotanypus sp.	x	x				
Conchapelopia sp.	x					
Cricotopus exilis	x					
Cryptochironomus blarina	x					
C. fulvus	x					
C. sp.	x	x				
Dicrotendipes sp.	x					
Glyptotendipes lobiferus	x					
G. senilis	x					
G. sp.	x					
Orthocladius sp.	x					
Paracladopelma sp.	x	x				
Paralauterborniella sp.	x					
Paratendipes sp.	x					
Pelopia sp.			x			
Polypedilum halterale	x					
P. scalaenum	x					
P. sp.	x	x				
Procladius adumbratus	x					
P. riparius	x					
P. sp.		x	x			
Pseudochironomus sp.	x					
Rheotanytarsus sp.	x					
Stictochironomus sp.	x					
Tendipedini sp.	x					
Trichocladius sp.	x					
Zavrelimyia spp.	x					
Ceratopogonidae (unident.)	x		x			x
Bezzia sp.	x				x	
Pentaneurini (unident.)		x				
Psychodidae						
Psychoda sp.	x					

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Table 2.5-10
Zooplankton Collected in the Missouri River and Adjacent Backwaters
(Page 1 of 2)

TAXA	LOCATION: MIDDLE MISSOURI RIVER[1]	FORT CALHOUN BIO-TEST[2]	COOPER[3]	NORTH OMAHA BIO-TEST[4]	CALLAWAY[5]	GEORGE NEAL[6]
Protozoa (unident.)	x					
Sarcodina						
Amoebida						
Amoeba sp.	x					
Heliozoida						
Actinosphaerium	x					
Ciliata						
Amphileptus sp.	x					
Codonella sp.	x					
Colpoda sp.	x					
C. steini	x					
Didinium sp.	x					
Enchelys sp.	x					
Epistylis sp.	x					
Frontonia sp.	x					
Kahlia sp.	x					
Oxytricha sp.	x					
Paramecium aurelia	x					
Pseudoprorodon sp.	x					
Spirostomum sp.	x					
Strombidium sp.	x					
Strombilidium sp.	x					
Vaginicola sp.	x					
Vorticella sp.	x					
Aschelminthes						
Rotatoria (Rotifera)	x		x			
Ascomorpha sp.			x		x	
Asplanchna priodonta					x	
A. sp.			x		x	
Brachionus angularis					x	
B. bidentata					x	
B. calyciflorus					x	
B. caudatus					x	
B. havanaensis					x	
B. plicatilis					x	
B. quadridentata					x	
B. variabilis					x	
B. sp.			x			
Cephalodella sp.			x			
Chromogaster sp.					x	
Collotheca sp.			x		x	
Colurella sp.					x	
Conochiloides sp.			x			
Conochilus sp.			x			
Encentrum sp.			x			
Euchlanis sp.			x			
Filinia longiseta					x	
F. opoliensis					x	
F. sp.			x			
Kellicottia bostoniensis					x	
K. longispina					x	
K. sp.					x	
Keratella cochlearis					x	
K. earlinae					x	
K. quadrata					x	
K. sp.			x		x	x
Lecane sp.					x	
Lepadella ovalis					x	
Monostyla sp.					x	
Notholca sp.			x		x	
Platyias patulus					x	
P. sp.			x		x	x
Ploesoma sp.					x	
Polyarthra sp.			x		x	
Synchaeta sp.			x		x	x
Testudinella sp.					x	
Trichocerca sp.			x		x	
T. [illegible]					x	
[illegible] sp.					x	
Gastrotricha (unident.)	x					
Nematoda (unident.)	x				x	
Arthropoda						
Arachnida						
Acarina						
Hydracarina (unident.)						x
Crustacea (Branchiopoda)						
Diplostraca (Cladocera)						
(immature, unident.)		x	x	x		
Alona costata			x			
A. guttata			x			
A. intermedia			x			
A. monacantha			x	x		
A. quadrangularis			x			
A. rectangula		x	x	x		
A. sp.			x			
Alonella diaphana			x			
A. nana			x			
Bosmina coregoni						x
B. longirostris		x	x	x		
Bunops serricaudata			x			
Camptocercus rectirostris			x			
Ceriodaphnia lacustris			x	x		
C. quadrangula		x	x	x		
C. reticulata			x		x	
Chydorus sphaericus		x	x	x	x	

[1] Dillon and Hansen, 197[illegible]

[2] Bremer, 1974; Wetzel, 1975.

[3] Bio-Test, 1971, 73a, 74, and 75; Busby, 1972.

[4] Busby, 1972.

[5] [illegible], 1975.

[6] Hey and Baldwin, 1974.

NOTE: THIS LIST COMPRISES COLLECTIONS MADE AT SEVERAL LOCATIONS. THE COLLECTING TECHNIQUES AND SPECIFICITY OF TAXONOMIC IDENTIFICATION VARIES AMONG LOCALITIES. THE LISTING OF TAXA AT ONLY ONE LOCALITY DOES NOT NECESSARILY IMPLY THAT THE TAXA DO NOT OCCUR AT THE OTHER LOCALITIES AS WELL - IT MEANS ONLY THAT THEY WERE EITHER NOT COLLECTED OR NOT IDENTIFIED.

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Table 2.5-10
(Continued)
Zooplankton Collected in the Missouri
River and Adjacent Backwaters
(Page 2 of 2)

TAXA	LOCATION					
	MIDDLE MISSOURI RIVER[1]	FORT CALHOUN BIO-TEST[2]	COOPER[3]	NORTH OMAHA BIO-TEST[4]	CALLAWAY[5]	[illegible] NEAL[6]
Daphnia ambigua			x			
D. catawba		x	x	x		
D. galeata mendotae		x	x	x		
D. longiremis					x	
D. parvula		x	x	x		
D. pulex		x	x	x		
D. retrocurva		x	x	x		
D. schodleri		x	x	x		
D. sp.	x		x			x
Diaphanosoma brachyurum		x	x	x	x	
D. leuchtenbergianum		x	x	x		
Eurycercus gibberum					x	
Ilyocryptus sordidus		x	x			
I. spinifer			x			
I. sp.			x			
Kurzia latissima			x	x		
Latonopsis sp.					x	
Leptodora kindtii			x	x		
Leydigia quadrangularis		x	x	x		
Macrothrix laticornis			x	x		
Moina affinis			x			
M. brachiata			x			
M. micrura		x	x	x		
Moinodaphnia macleayi			x			
Pleuroxus denticulatus			x	x		
P. hamulatus		x	x			
Scapholeberis aurita				x		
S. kingi		x	x	x		
Sida crystallina		x	x	x		
Simocephalus expinosus			x			
S. serrulatus			x	x		
Ostracoda (unident.)			x			
Copepoda (unident.)	x					
Nauplii (unident.)		x	x	x	x	
Calanoida						
Diaptomus ashlandi		x	x	x		
D. clavipes		x	x	x		
D. forbesi		x	x	x	x	
D. minutus			x			
D. pallidus			x			
D. sicilis			x			
D. siciloides		x	x	x	x	
D. sp.						x
Harpacticoida		x	x	x	x	
Cyclopoida						
Cyclops bicuspidatus thomasi		x	x	x	x	
C. varicans rubellus			x			
C. vernalis		x	x	x	x	
C. sp.						x
Eucyclops agilis		x	x	x		
E. prionophorus			x			
E. speratus		x	x	x		
Macrocyclops albidus			x	x		
Mesocyclops edax		x	x	x		
M. leuckarti			x	x		
Paracyclops fimbriatus			x			
P. f. poppei		x	x	x		
Tropocyclops prasinus		x	x	x		
T. p. mexicanus			x			
Ergasilidae						
Ergasilus chautauquaensis			x			
E. spp.		x				

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2.5 Ecology (Continued)

2.5.2 Aquatic Ecology (Continued)

diversity of riv zooplankton populations fluctuate seasonally. In general, zooplankton densities are low during the fall and winter, reach a maximum in late spring, and subsequently decline through the summer. Total zooplankton densities ranged from 13,557 per cubic meter in June to 185 per cubic meter in August.

Fifty-seven (57) taxa of periphyton (algal species growing on artificial or natural submerged substrates) were identified from glass slides exposed to the Missouri River near Fort Calhoun Station, as listed in Table 2.5-11. The seasonal development of periphytic communities in the Missouri River near Fort Calhoun Station has generally reflected a succession of diatom (Bacillariophyta) species. Comphonema, Fragilaria, and Nitzschia were most prevelent in spring to mid-summer; Navicula, Gomphonema, Cocconeis, and Biddulphia in late summer; and Biddulphia, Cocconeis, Navicula, and Nitzschia in the fall.

A 103 taxa of phytoplankton were reported from the Missouri River in the vicinity of the station; however, 342 taxa were identified downstream at 2 other power stations (30 and 114 miles downstream). Most species collected at these other 2 power stations probably occur at the Fort Calhoun Station. Table 2.5-12 lists species collected. The phytoplankton assemblage of the Fort Calhoun Station consisted primarily of diatoms (Bacillariophyta) and green algae (Cryptophyta). Groups infrequently observed included cryptomonads (Cryptophyta), euglenoids (Euglenophyta), and dinoflagellates (Pyrrophyta). These phytoplankton species were primarily responsible for the seasonal variation in total phytoplankton densities. In general, green algae were dominant during the spring and summer months, except for a pulse of blue-green algae in August and September, while diatoms comprised the majority of phytoplankton in the winter.

No aquatic macrophytes have been observed along the channelized banks of the Missouri River.

Additional detailed data on characteristics of the ecological makeup of the area is available in the U2 ER.

2.6 Meteorology

2.6.1 Regional Climatology

The general climate of the region is classified as continental, i.e., hotter in summer and colder in winter than

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Table 2.5-11
Periphyton Collected in the Missouri River and Adjacent Backwaters

TAXA	SUBSTRATES AND MICROHABITAT	
	FORT CALHOUN[1]	COOPER[2]
Chlorophyta (green algae)		
Cladophora glomerata		PP, NS, S, F
C. sp.		PP, NS
Oedogonium sp.		PP, NS, S
Schizomeris sp.		NS, S
Spirogyra sp.		PP, NS, F
Stigeoclonium tenue		NS, F, S
S. sp.		PP, NS, F, S
Chrysophyta (diatoms)		
Achnanthes exigua		PP, NS, S
A. lanceolata		PP, NS, F, S
A. lanceolata var. *rostrata*		NS, F, S
A. linearis		NS, F
A. minutissima		NS, S
A. sp.		NS, F, S
Amphipleura pellucida		NS, S
Amphora ovalis		PP, NS, S
A. perpusilla		PP, NS, F, S
A. venata		NS, F
A. sp.		NS, F
Asterionella sp.	GS	
Biddulphia laevis		PP, NS, F, S
B. sp.	GS	
Cocconeis bohemicum		PP
C. diminuta		PP, NS, F, S
C. disculus		NS, F, S
C. pediculus		PP, NS, F, S
C. placentula		PP, NS, F, S
C. placentula var. *euglypta*		PP
C. sp.	GS	NS, F, S
Caloneis lewisii		NS, S
Cyclotella sp.		NS, F
Cylindrotheca gracilis		NS, S
Cymatopleura solea		NS, S
Cymbella cistula		NS, F, S
C. prostrata		NS, F, S
C. tumida		NS, F, S
C. turgida		NS, F
C. ventricosa		NS, S
C. sp.	GS	NS, F, S
Diatoma heimale		NS, F
D. tenue elongatum		NS, S
D. vulgare		PP, NS, F, S
D. vulgare var. *vulgare*		NS, F, S
D. vulgare var. cf. *linearis*		NS, F
D. sp.	GS	NS, F, S
Fragilaria construens		PP, NS, F, S
F. construens var. *binodis*		NS, F, S
F. construens var. *construens*		NS, F
F. construens var. *subsalina*		NS, F, S
F. capucina		PP, NS, F, S
F. capucina var. *mesolepta*		NS, F, S
F. crotonensis		NS, F, S
F. intermedia		NS, F, S
F. lapponica		NS, F, S
F. pinnata		PP, NS, F, S
F. sp.	GS	NS, F, S
Gomphonema angustissima		PP
G. bohemicum		PP, NS, F, S
G. lanceolatum		NS, S
G. lanceolatum insignis		NS, S
G. olivaceum		PP, NS, F, S
G. parvulum		PP, NS, F, S
G. parvulum var. *micropus*		NS, F, S
G. spenceri		NS, F, S
G. sphaerophorum		NS, [illegible]
G. sp.	GS	PP, NS, F, S
Gyrosigma acuminatum		NS, [illegible]
G. scalproides		NS, F, [illegible]
G. spenceri		NS, F, [illegible]
G. sp.		NS, S
Melosira granulata		PP, NS, F, S
M. granulata angustissima		NS, S
M. varians		PP, NS, F, S
M. sp.		NS, S
Navicula accomoda		NS, F, S
N. angelica		NS, S
N. atomus		PP, NS, F, S
N. cf. *biconica*		NS, S
N. cincta		PP
N. confervacea		PP, NS, S
N. cryptocephala		PP, NS, F, S
N. cryptocephala venata		NS, F, S
N. cuspida		NS, S

TAXA	SUBSTRATES AND MICROHABITAT	
	FORT CALHOUN[1]	COOPER[2]
Chrysophyta (continued)		
N. dacephala neglecta		NS, S
N. decysis		NS, F
N. exigua		NS, S
N. cf. *graciloides*		PP, NS, F, S
N. heurflouri		PP, NS, F, S
N. inflata		NS, S
N. minnewaukonensis		PP
N. muralis		NS, S
N. mutica		NS, F, S
N. mutica cohnii		NS, F, S
N. mutica var. *tropica*		NS, F, S
N. mutica var. *ventricosa*		NS, F
N. rivalis		NS, S
N. notha		PP
N. oblonga		NS, S
N. pygmaea		NS, S
N. rudiosa		PP, NS, F, S
N. tropica		NS, S
N. tripunctata		PP, NS, S
N. viridula		PP, NS, S
N. viridula avenacea		NS, F, S
N. vitabunda		PP, NS, S
N. zononi		PP, NS, S
N. spp.	GS	NS, F, S
Nitzschia acicularis		PP, NS, F, S
N. acuta		NS, S
N. amphibia		NS, F, S
N. angustata		NS, F, S
N. apiculata		NS, F, S
N. closterium		PP, NS, F, S
N. dissipata		PP, NS, F, S
N. cf. *elliptica*		NS, F, S
N. filiformis		PP, NS, F, S
N. fonticola		PP, NS, S
N. frustulum		PP
N. gaudersheimiensis		NS, F, S
N. hungarica		PP, NS, F, S
N. ignorata		NS, F, S
N. kutzingiana		NS, F, [illegible]
N. linearis		NS, S
N. lorenziana		NS, S
N. microcephala		PP
N. obtusa		NS, F, S
N. cf. *palea*		PP, NS, F, S
N. paradoxa		NS, F, S
N. parvula		NS, S
N. sigmoidea		NS, F, S
N. sublinea		NS, F, S
N. trybl.		PP, NS, F, S
N. trybli		NS, S
N. vermicul.		NS, S
N. sp.	GS	PP, NS, F, S
Opephora martyi		NS, S
Pinnularia sp.		NS, S
Pleurosigma delicatulum		NS, S
P. sp.		NS, S
Rhoicosphenia curvata		PP, NS, F, S
Rhopalodia gibba		NS, F
R. gibberula		NS, F
R. sp.		NS, F, S
Stauroneis anceps		NS, S
Stephanodiscus sp.		PP
Surirella angustata		NS, F, S
S. ovalis		NS, S
S. ovata		NS, F, S
S. sp.	GS	
Synedra acus		NS, F, S
S. amphicephala		NS, S
S. rumpens		NS, F, S
S. tabulata		NS, S
S. ulna		NS, F, S
S. ulna oxyrhynchos		NS, F, S
S. vaucheriae		NS, S
S. sp.		NS, F, S
Tabellaria flocculosa		NS, S
T. sp.	GS	
Cyanophyta (blue-green algae)		
Aphanothece castagnei		NS
Arthrospira fonneri (*Oscillatoria agardii*)		NS, F, S
Chlorosarcina sp.		NS
Lyngbya martensiana		NS, S
L. sp.		PP, NS, S
Nostoc paludosum		NS
Phormidium tenue (*Schizothrix calcicola*)		PP, NS, S
Plectonema notatum		PP, NS, F, S

[1]Morris et al., 1971; Stucky et al., 1972.

[2]Bio-Test, 1971, 73a, 74, 75; Busby, 1972.

LEGEND:

GS - Glass slides
NS - Natural substrate
F - Fast water
S - Slow water
PP - Plexiglas plate

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POOR ORIGINAL

Table 2.5-12
Phytoplankton Collected in the Missouri River and Adjacent Backwaters
(Page 1 of 5)

TAXA	LOCATION: MIDDLE MISSOURI RIVER[1]	LOWER MISSOURI RIVER[2]	FORT CALHOUN BIO-TEST[3]	DESOTO[4]	NORTH OMAHA BIO-TEST[6]	COOPER[5]	CALLAWAY[7]	GEORGE NEAL[8]
Euglenophyta (Euglenoids)								
Euglena acus					x	x		
E. acus var. *rigida*					x	x		
E. minuta					x			
E. polymorpha					x	x		
E. proxima					x	x		
E. rostrifera					x	x		
E. spirogyra							x	
E. sp.	x		x	x	x		x	x
Chilomonas sp.	x							
Lepocinclis acuta					x			
L. ovum					x	x		
L. sp.	x				x	x		
Phacus caudatus					x	x		
P. orbicularis					x	x		
P. sp.					x		x	
Trachelomonas crebea					x	x		
T. hispida					x	x		
T. schauinslandii			x					
T. tambowika					x	x		
T. variana					x	x		
T. sp.	x		x	x	x	x	x	
Chlorophyta (Green Algae)								
Actinastrum hantzschii			x		x	x	x	
A. hantzschii var. *fluviatile*			x					
A. sp.								x
Agmenellum sp.								x
Ankistrodesmus braunii			x					
A. convolutus			x					
A. falcatus			x		x	x	x	
A. falcatus var. *mirabilis*					x	x		
A. spiralis					x	x		
A. sp.				x			x	x
Arthrodesmus sp.					x	x		
Carteria sp.			x	x				
Characium sp.							x	
Chlamydomonas sp.			x	x	x	x	x	
Chlorella sp.								x
Chlorogonium elongatum					x	x		
C. euchlorum					x	x		
Chladophora peeta							x	
Chodatella subsalsa			x					
C. quadriseta			x					
Closteriopsis longissima			x		x	x		
C. longissima var. *tropica*					x	x		
C. sp.							x	
Closterium gracilis							x	
C. setaceum							x	x
C. sp.			x				x	
Coelastrum cambricum					x	x		
C. microporum			x		x	x		
C. sphaericum					x	x		
C. sp.	x							x
Cosmarium sp.					x	x		
Crucigenia apiculata					x	x		
C. crucifera							x	
C. fenestrata					x			
C. irregularis			x		x	x		
C. quadrata			x		x	x		
C. rectangularis					x	x		
C. tetrapedia			x		x	x	x	
C. sp.				x			x	
Dicellula planctonica					x	x		
Dictyosphaerium pulchellum			x	x	x	x		
D. sp.				x				
Diaspora crucigenoides			x					
Elakatothrix gelatinosa							x	
E. viridis			x		x	x		
Errerella bornhemiensis					x	x		
Eudorina sp.		x						
Franceia ovalis					x	x		
F. tuberculata			x		x	x		
Gloeocystis sp.				x				
Golenkinia radiata			x		x	x	x	
Gonium sociale			x					
Kirchneriella lunaris					x	x		
K. obesa			x		x	x		
K. sp.							x	
Lagerheimia ciliata					x	x		
L. quadriseta			x					
L. subsalsa					x	x		
Micractinium pusillum			x		x	x	x	
M. quadrisetum					x			
Microspora floccosa							x	
Mougeotia sp.					x			
Nephrocytium agardhianum					x			

[1] Dillon and Hansen, 1974.

[2] Berner, 1951.

[3] Kremer, 1974; Wetzel, 1975.

[4] Huggins, 1968.

[5] Busby, 1972.

[6] Bio-Test, 1971, 73a, 74, and 75; Busby, 1972.

[7] USNRC, 1975a.

[8] Hey and Baldwin, 1974.

NOTE: THIS LIST COMPRISES COLLECTIONS MADE AT SEVERAL LOCATIONS. THE COLLECTING TECHNIQUES AND SPECIFICITY OF TAXONOMIC IDENTIFICATION VARIES AMONG LOCALITIES. THE LISTING OF TAXA AT ONLY ONE LOCALITY DOES NOT NECESSARILY IMPLY THAT THE TAXA DO NOT OCCUR AT THE OTHER LOCALITIES AS WELL - IT MEANS ONLY THAT THEY WERE EITHER NOT COLLECTED OR NOT IDENTIFIED.

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Table 2.5-12
(Continued)
Phytoplankton Collected in the Missouri River and Adjacent Backwaters
(Page 2 of 5)

TAXA	LOCATION							
	MIDDLE MISSOURI RIVER[1]	LOWER MISSOURI RIVER[2]	FORT CALHOUN BIO-TEST[3]	DESOTO[4]	NORTH OMAHA BIO-TEST[5]	COOPER[6]	CALLAWAY[7]	GEORGE NEAL[8]
Oocystis borgei			x		x	x		
O. lacustris			x		x	x		
O. parva			x		x			
O. pusilla					x	x		
O. solitaria					x			
O. sp.							x	x
Pandorina morum			x		x	x		
Pediastrum biradiatum			x					
P. boryanum					x	x	x	
P. duplex			x		x	x	x	
P. duplex var. *clat[illegible]tum*					x	x		
P. integrum							x	
P. simplex			x		x		x	
P. simplex var. *[illegible]odenarium*					x	x		
[illegible] tetras					x	x		
[illegible] sp.		x		x			x	
P[illegible]					x	x		
P[illegible]					x			
Qu[illegible]			x		x	x		
[illegible]					x	x		
[illegible] acuminatus			x		x	x	x	
[illegible]							x	
[illegible]					x	x		
S. [illegible] var. *platydis[illegible]*					x	x		
[illegible] armat[illegible]					x	x		
S. bernar[illegible]					x	x		
S. bijuga			x		x	x	x	
S. bijuga var. *alternans*					x	x		
S. bijuga var. *flexuosus*					x	x		
S. denticulatus					x	x		
S. dimorphus					x	x	x	
S. incrassatulus					x	x		
S. intermedius					x	x		
S. longispina					x	x		
S. longus					x	x		
S. longus var. *naegelii*					x	x		
S. obliquus					x	x		
S. opoliensis					x	x		
S. quadricauda			x		x	x	x	
S. sp.				x			x	x
Schroederia ancora					x			
S. setigera			x		x	x		
Selenastrum gracile					x	x		
S. minutum					x	x		
S. westii			x		x	x		
Spermatozoopsis exultans					x			
Sphaerocystis schroeteri			x		x	x		
Spirogyra sp.					x		x	x
Spondylosium planum					x	x		
Staurastrum sp.					x	x		x
S. paradoxum			x				x	
S. pentacerum							x	
Tetradesmus sp.							x	
Tetraedron caudatum			x		x	x		
T. caudatum var. *longispinum*			x		x	x		
T. hastatum var. *palatinum*					x	x		
T. minimum			x		x	x		
T. muticum			x		x	x		
T. pentaedricum						x		
T. regulare						x		
T. regulare var. *incus*						x		
T. setigerum							x	
T. trigonum			x		x	x		
T. sp.					x	x		
Tetrallantos lagerheimii					x	x		
Tetraspora lamellosa					x	x		
Tetrastrum elegans					x	x		
T. heteracanthum					x			
T. staurogeniaeforme			x		x	x	x	
T. sp.				x				
Treubaria setigerum			x				x	
T. triappendiculata					x	x		
Ulothrix cylindricum							x	
U. sp.							x	x
Volvox sp.							x	
Chrysophyta								
Xanthophyceae (Yellow-Green Algae)								
Characiopsis sp.							x	
Tribonema sp.							x	
Chrysophyceae (Golden-brown Algae)								
Chrysamoeba sp.							x	
Cladomonas fruticulosa					x	x		
Dichotomococcus lunatus					x	x		
Dinobryon cylindricum						x		
D. divergens			x		x	x		
D. sertularia							x	
D. sociale			x		x	x		
D. sp.	x				x	x	x	
Harpochytrium sp.					x			
Kephyrion anctum			x					
Mallomonas acaroides					x	x		
M. caudata			x					
M. pseudocoronata			x					
M. sp.		x						
Monosiga sp.					x			

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Table 2.5-12
(Continued)
Phytoplankton Collected in the Missouri
River and Adjacent Backwaters
(Page 3 of 5)

TAXA	LOCATION: MIDDLE MISSOURI RIVER[1]	LOWER MISSOURI RIVER[2]	FORT CALHOUN BIO-TEST[3]	DESOTO[4]	NORTH OMAHA BIO-TEST[5]	COOPER[6]	CALLAWAY[7]	GEORGE NEAL[8]
Nephrocytium agardhianum						x		
Ophiocytium capitatum					x	x		
O. capitatum var. longispinum					x	x		
Stipitococcus urceolatus					x	x		
Baccillariophyceae (Diatoms)								
Achnanthes clevei					x	x		
A. exigua					x	x		
A. exigua var. constricta					x	x		
A. hauckiana var. rostrata					x			
A. hungarica					x	x		
A. lanceolata					x	x		
A. lanceolata var. dubia					x	x		
A. lanceolata var. rostrata					x	x		
A. minutissima					x	x		
A. minutissima var. cryptocephala					x	x		
A. peragalli					x	x		
A. pinnata					x	x		
A. sp.		x			x	x	x	
Amphipleura pellucida					x	x		
A. sp.		x						x
Amphiprora ornata					x	x		
A. sp.		x						
Amphora coffeaeformis						x		
A. ovalis					x	x	x	
A. ovalis var. pediculus					x	x		
A. sp.		x			x	x	x	
Anomoeoneis sp.		x	x				x	
Asterionella formosa				x	x	x	x	
A. gracillima					x	x		
A. sp.		x						x
Bacillaria paradoxa					x	x		
Biddulphia laevis					x	x		
Caloneis bacillum					x	x		
C. ventricosa var. minuta					x	x		
C. sp.		x				x	x	x
Cocconeis diminuta					x	x		
C. disculus						x		
C. pediculus					x	x		
C. placentula var.			x		x	x	x	
C. placentula euglypta					x	x		
C. sp.	x		x		x	x	x	
Coscinodiscus rothii					x			
C. rothii var. subsalsa					x	x		
C. sp.							x	x
Cyclotella atomus					x	x		
C. meneghiniana					x	x		
C. meneghiniana var. plana					x	x		
C. michiganiana					x			
C. ocellata					x	x		
C. pseudostelligera					x	x		
C. stelligera					x	x		
C. sp.	x		x		x	x	x	x
Cylindrotheca gracilis					x	x		
Cymatopleura solea			x		x	x		
C. sp.	x				x			
Cymbella affinis					x	x		
C. microcephala					x	x		
C. prostrata					x	x		
C. sinuata					x			
C. tumida					x			
C. turgida					x			
C. ventricosa					x	x		
C. sp.	x				x	x	x	x
Denticula tenuis					x	x		
D. sp.	x				x	x		
Diatoma hiemale							x	
D. tenue var. elongatum					x	x		
D. vulgare						x		
D. sp.	x		x					
Diploneis oblongella					x			
D. oculata					x			
D. pseudovalis					x	x		
D. puella					x	x		
D. smithii					x			
D. sp.	x				x	x		
Epithemia turgida					x	x		
E. turgida var. granulata					x	x		
E. sp.	x				x	x		x
Eunotia major							x	
E. praerupta							x	
E. valida					x	x		
E. sp.	x				x	x	x	
Fragilaria brevistriata					x	x	x	
F. brevistriata var. inflata						x		
F. capucina					x	x	x	
F. capucina var. mesolepta					x	x		
F. construens					x	x	x	
F. construens var. binodis					x	x		
F. crotonensis			x		x	x	x	
F. intermedia					x	x	x	
F. leptostauron					x	x		
F. pinnata			x		x	x		
F. pinnata var. lancettula						x		
F. vaucheriae					x	x		
F. sp.	x	x	x	x	x	x	x	x
Frustulia sp.	x				x	x		
Gomphonema acuminatum					x	x	x	
G. angustatum					x	x	x	

Table 2.5-12
(Continued)
Phytoplankton Collected in the Missouri River and Adjacent Backwaters
(Page 4 of 5)

TAXA	LOCATION							
	MIDDLE MISSOURI RIVER[1]	LOWER MISSOURI RIVER[2]	FORT CALHOUN BIO-TEST[3]	DESOTO[4]	NORTH OMAHA BIO-TEST[5]	COOPER[6]	CALLAWAY[7]	GEORGE NEAL[8]
G. constrictum							x	
G. olivaceum					x	x	x	
G. parvulum					x	x		
G. sp.	x		x		x	x	x	x
Gyrosigma scalproides					x	x		
G. spencerii					x	x		
G. sp.	x				x	x	x	x
Hantzschia amphioxys					x	x		
Mastogloia braunii							x	
M. smithii					x	x		
M. sp.	x							
Melosira ambigua					x	x		
M. distans					x	x		
M. granulata			x		x	x	x	
M. granulata var. angustissima					x	x		
M. islandica			x					
M. italica					x	x		
M. varians					x	x	x	
M. sp.	x			x			x	x
Meridion circulare						x	x	
M. sp.	x							
Microsiphona potamos			x		x	x		
Navicula binodis					x			
N. capitata					x	x		
N. cari					x	x		
N. cincta					x			
N. cryptocephala					x	x		
N. cryptocephala var. veneta					x	x		
N. cuspidata					x	x		
N. cuspidata var. ambigua					x			
N. decussis					x	x		
N. exigua					x		x	
N. gastrum						x		
N. gracilis					x	x		
N. halophila fo. tenuirostris					x			
N. heufleri var. leptocephala					x			
N. hungarica					x	x		
N. menisculus					x	x		
N. notha					x	x		
N. pupula					x	x	x	
N. pupula var. capitata					x			
N. pupula var. mutata					x			
N. pupula var. rostrata					x	x		
N. pygmaea					x	x		
N. rhynchocephala					x	x	x	
N. salinarum					x	x		
N. salinarum var. intermedia					x	x		
N. simplex					x			
N. viridula					x	x		
N. vitabunda					x	x		
N. sp.	x		x		x	x	x	x
Neidium sp.	x			x	x			
Nitzschia acicularis			x		x	x	x	
N. angustata					x	x		
N. apiculata					x	x		
N. closterium			x		x	x		
N. dissipata					x	x		
N. filiformis							x	x
N. frustulum var. subsalina					x			
N. holsatica			x		x	x		
N. hungarica					x	x	x	
N. linearis			x				x	
N. longissima var. closterium					x	x		
N. longissima var. reversa			x		x			
N. lorenziana							x	
N. palea					x	x		
N. paleacea					x	x		
N. parvula							x	
N. sigmoidea			x				x	
N. tryblionella					x	x		
N. tryblionella var. debilis					x			
N. tryblionella var. levidensis					x	x		
N. sp.	x		x		x	x	x	x
Opephora martyi					x	x		
O. sp.	x							x
Pinnularia divergens					x			
P. microstauron						x		
P. sp.	x		x		x	x	x	
Pleurosigma delicatulum					x	x		
P. microstauron					x			
P. sp.	x				x	x		x
Rhoicosphenia curvata			x		x	x	x	
R. sp.	x							x
Rhopalodia gibba					x	x		
R. gibberula					x	x		
R. sp.	x				x	x		x
Rhizosolenia eriensis			x					
R. minima			x					
Stauroneis anceps							x	
S. phoenicenteron							x	
S. smithii					x			
S. sp.	x				x	x	x	
Stephanodiscus alpinus					x	x		

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Table 2.5-12
(Continued)
Phytoplankton Collected in the Missouri
River and Adjacent Backwaters
(Page 5 of 5)

TAXA	LOCATION: MIDDLE MISSOURI RIVER[1]	LOWER MISSOURI RIVER[2]	FORT CALHOUN BIO-TEST[3]	DESOTO[4]	NORTH OMAHA BIO-TEST[5]	COOPER[6]	CALLAWAY[7]	GEORGE NEAL[8]
S. astraea								
S. binderanus			x		x	x		
S. hantzschii					x	x		
S. hantzschii-tenuis					x	x		
S. invisitatus					x	x		
S. minutus					x	x		
S. niagarae					x	x		
S. tenuis					x	x		
S. transilvanicus			x		x	x		
S. spp.					x	x		
Surirella angusta	x		x	x	x	x	x	x
S. brightwellii					x	x	x	
S. ovalis					x	x		
S. ovata					x	x		
S. spiralis					x	x	x	
S. tenera					x	x		
S. sp.					x	x		
Synedra actinastroides			x		x	x	x	x
S. acus								x
S. delicatissima					x	x	x	
S. filiformis					x	x		
S. parasitica var. subconstricta			x		x	x		
S. radians					x	x		
S. rumpens						x		
S. ulna					x			
S. ulna var. chaseana			x		x	x	x	
S. ulna var. obtusa					x	x		
S. ulna var. oxyrhynchus					x			
S. sp.					x	x		
Tabellaria fenestrata	x		x		x	x	x	x
T. flocculosa							x	
T. sp.					x		x	
Unidentified centrics							x	x
Unidentified pennates					x	x	x	
Pyrrhophyta					x	x	x	
Dinophyceae								
Amphidium sp.	x							
Ceratium hirundinella	x							
C. sp.	x						x	
Glenodinium sp.	x		x	x				
Gymnodinium sp.	x						x	
Peridinium sp.	x							
Cryptophycea					x	x		
Chilomonas sp.	x							
Chroomonas acuta			x					
C. spp.			x					
Cryptomonas erosa			x					
C. ovata			x					
C. spp.	x		x					
Rhodomonas sp.	x							
Cyanophyta (Blue-Green Algae)								
Anabaena circinalis								
A. sp.					x	x		
Anabaenopsis elenkinii				x	x	x	x	
A. sp.			x					
Anacystis sp.				x				
Aphanizomenon flos-aquae								x
Aphanocapsa elachista					x	x	x	
A. sp.					x	x		
Aphanothece nidulans			x					
A. sp.					x	x		
Chroococcus minutus					x	x		
C. sp.					x			
Coelosphaerium naegelianum				x			x	
Dactylococcopsis fascicularis			x					
D. smithii					x	x		
Glaucocystis sp.							x	
Gloeocapsa aeruginosa							x	
Gloeotrichia echinulata			x					
Gomphosphaeria lacustris							x	
G. sp.					x	x	x	
Lyngbya contorta				x				
L. sp.				x				
Merismopedia elegans			x			x	x	
M. glauca					x			
M. punctata					x	x		
M. tenuissima						x		
M. sp.			x		x	x		
Microcystis aeruginosa				x		x		
M. flos-aquae						x	x	
M. sp.			x				x	
Nostoc sp.				x				
Oscillatoria amoena					x	x		
O. tenuis					x	x		
O. sp.			x					
Phormidium mucicola			x	x	x	x	x	x
Plectonema notatum					x	x		
Rivularia sp.					x			
Spirulina sp.					x	x		
Stichosiphon sp.							x	
Synechococcus aeruginosus					x	x		
Unidentified colonial		x	x					
Unidentified filamentous		x						

2.6 Meteorology (Continued)

2.6.1 Regional Climatology (Continued)

in lands near the ocean. However, Nebraska is located midway between 2 distinctive climatic zones, the humid east and the dry west. Thus, cyclic weather conditions representative of either zone, and combinations of both, occur. Changes in weather result from the invasion of large masses of air with dissimilar properties, such as warm, moist air from the Gulf of Mexico, hot, dry air from the southwest, and cold, dry air from the northwest. The region is also affected by many storms or cyclones (areas of low pressure) which travel across the country, generally from west to east. Thus, periodic and rapid changes in the weather are normal, especially in the winter.

Annual average precipitation for the region is about 28.4 inches, but annual amounts vary widely from year to year. For example, at Omaha in 1934, the total was 14.9 inches, while in 1965 the total was 44.85 inches. About 75 percent of the precipitation occurs during showers and thunderstorms during April through September. Snowfall amounts to about 32.0 inches of snow for an annual average, but total annual amounts vary widely from year to year.

The surface wind direction and speed is quite varied during all seasons of the year. The prevailing direction from May through December is from the south-southeast with the north-northwesterly winds prevailing during the remainder of the year. The mean annual wind speed is 10.9 miles per hour.

The mean annual temperature for the region is 50.9°F. The January monthly mean is 23.2°F, while that for July is 74.6°F. Relative humidity in the region varies from an average of about 73 percent for the period midnight-to-noon and about 63 percent for the period noon-to-midnight. The mean percentage of possible sunshine over the area is about 50 percent in winter and about 70 percent in summer.

Data on air pollution levels in non-urban areas of the region, except for levels of total suspended particulates, are sparse or nonexistent. In the case of total suspended particulates, both the annual and 24-hour federal primary standards have been exceeded at some sampling locations. However, the existing levels of air pollution are not expected to affect plant operations. The plant's contributions to air pollution levels are insignificant.

2.6 Meteorology (Continued)

2.6.2 Local Meteorology

Data from proximal long-term National Weather Service Stations are used to supplement the existing Fort Calhoun data in formulating the description of the local meteorology.

The on-site weather program currently utilizes 1 weather tower, 110 meters tall, which has been in operation for approximately 4 years and provides wind and temperature gradient information. Two other weather towers, 40 feet tall and 100 feet tall, were utilized in the past. Section 5.1.3 provides a historical perspective of the on-site meteorological programs and provides specific information in regard to monitoring capabilities.

Surface (68 to 71 feet above ground level) wind data from Omaha Municipal Airport, Eppley Airfield in Nebraska, for the years 1951 through 1960, are used as a climatological base to approximate the normals that may be expected at the site. On an annual basis, south-southeast is the most frequent (18.8 percent) wind direction. The wind is from the southeast through the south 37 percent of the time and from the northwest through the north 29.8 percent of the time. The least frequent directions are southwest through west and northwest through east. These frequencies are 6.5 percent and 7.7 percent, respectively. Calms occurred slightly over 3 percent of the time, and the average wind speed for the total of all observations was 11.6 miles per hour. The maximum wind speed recorded at Eppley Airfield in Omaha for each month of the year during a 39-year period (1936 through 1974) is shown in Table 2.6-1.

Table 2.6-2 shows the climatological normal and mean temperatures for the period 1941 through 1970 at Eppley Airfield. It also shows extreme temperatures for the period August, 1963, through December, 1974. Two of the record low temperatures shown in the table were broken during 1975. An extreme minimum temperature of -19°F was recorded on February 9, 1975, and a minimum of -1°F was recorded on March 14, 1975, as a new record low for that month. This data correlates closely with data from Blair, Nebraska, and North Omaha Airport, thus showing applicability to the Fort Calhoun Station.

The average relative humidity values for the Fort Calhoun site for 4 times of the day can be estimated from 11 years of relative humidity data from Eppley Airfield. These data are shown in Table 2.6-3.

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Table 2.6-1
Maximum Wind Speed for Eppley Airfield,
Omaha, Nebraska, 1936 Through 1974

MONTH	MPH	DIRECTION	YEAR
January	57	NW	1938
February	57	NW	1947
March	73	NW	1950
April	65	NW	1937
May	73	NW	1936
June	72	N	1942
July	109	N	1936
August	66	N	1944
September	47	E	1948
October	62	NW	1966
November	56	NW	1951
December	52	NW	1938
Maximum	109	N	1936

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Table 2.6-2
Monthly Temperature Statistics (°F) for
Eppley Airfield, Omaha, Nebraska

PERIOD	EXTREME MAXIMUM	AVERAGE MAXIMUM	MEAN TEMPERATURE	AVERAGE MINIMUM	EXTREME MINIMUM
January	64.0	32.7	22.6	12.4	-22.0
February	78.0	38.5	28.0	17.4	-17.0
March	89.0	47.7	37.1	26.4	1.0
April	93.0	64.4	52.3	40.1	18.0
May	97.0	74.4	63.0	51.5	31.0
June	103.0	83.1	72.2	61.3	40.0
July	110.0	88.6	77.2	65.8	44.0
August	107.0	87.2	75.6	64.0	43.0
September	100.0	78.6	66.3	54.0	31.0
October	95.0	69.1	55.9	42.6	13.0
November	80.0	50.9	40.0	29.1	-9.0
December	67.0	37.8	28.0	18.1	-13.0
Maximum	110.0	62.8	51.5	40.2	-22.0

Table 2.6-3
Relative Humidity Values for Eppley Airfield, Omaha, Nebraska (1964-1974)

PERIOD	MEAN RELATIVE HUMIDITY (percent)				
	0000[1]	0600[1]	1200[1]	1800[1]	24-HOUR AVERAGE
January	74	76	65	68	71
February	73	76	61	61	68
March	71	76	55	52	64
April	68	75	51	47	60
May	71	78	54	50	63
June	75	81	55	53	66
July	77	82	57	56	68
August	80	87	59	58	71
September	83	88	62	62	74
October	77	82	56	58	68
November	77	81	63	66	72
December	78	80	68	71	74
Monthly Average	75	80	59	58	68

[1] Local standard time.

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2.6 Meteorology (Continued)

2.6.2 Local Meteorology (Continued)

Monthly and annual normal and extreme precipitation amounts for Eppley Airfield are presented in Table 2.6-4. Average monthly precipitation follows a seasonal trend, reaching a maximum in June (4.94 inches) and a minimum in January (0.76 inch). During the period 1936 through 1974, extreme amounts have been as follows:

Minimum annual total	18.43 inches (1953)
Maximum monthly total	13.75 inches (9/65)
Minimum monthly total	Trace (12/43, 10/52)
Maximum 24-hour total	6.47 inches (1965)

The mean number of days with measurable precipitation varies between a 12-day maximum in May to a minimum of 5 days in November. The normals and extremes for amounts of snow and ice pellets (including sleet) for Eppley Airfield are shown in Table 2.6-5. During the period 1936 through 1974, extreme amounts of frozen precipitation have been as follows:

Maximum season total	58.5 inches (1947-1948)
Minimum season total	8.0 inches (1953-1954)
Maximum monthly total	27.2 inches (3/48)
Minimum monthly total	0 inches
Maximum 24-hour total	18.3 inches (2/65)

An on-site program was conducted to assess representative annual and monthly joint frequency distributions of wind speed and direction by atmospheric stability class in order to evaluate compliance with 10 CFR 50, Appendix I. These data were submitted to the Commission in a report entitled "Evaluation of Fort Calhoun Station Unit No. 1 in Accordance With 10 CFR Part 50, Appendix I, June 1976", with a letter dated June 2, 1976. The data presented in the report cover the periods January 1, 1974, through January 31, 1974, and January 1, 1975, through January 31, 1975. Self-explanatory data tables are provided therein. The stability classes used are based on Pasquill's class structure as follows:

Pasquill Class	Delta T (Degree C.100m)	Description
A	<-2.0	Extremely unstable
B	-1.9 to -1.7	Unstable
C	-1.6 to -1.5	Slightly unstable
D	-1.4 to -0.5	Neutral
E	-0.4 to +1.5	Slightly stable
F	+1.6 to +4.0	Stable
G	>+4.0	Extremely stable

Table 2.6-4
Normal and Extreme Precipitation Amounts (Inches)
for Eppley Airfield, Omaha, Nebraska (1941-1970)

PERIOD	PERIOD NORMAL	PERIOD MAXIMUM	PERIOD MINIMUM	24-HOUR MAXIMUM
January	0.70	3.70	0.05	1.52
February	0.98	2.97	0.10	2.24
March	1.59	5.96	0.12	1.45
April	2.97	6.45	0.23	2.56
May	4.11	10.33	0.56	3.58
June	4.94	10.81	1.03	3.48
July	3.71	9.60	0.52	3.37
August	3.97	9.12	0.73	3.40
September	3.27	13.75	0.41	6.47
October	1.93	4.99	T[1]	3.13
November	1.11	4.05	0.04	2.53
December	0.84	3.30	T	1.79
Year	30.18	44.85	18.43	6.47

[1]T = trace

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Table 2.6-5
Normal and Extreme Snow and Ice Pellet Amounts (Inches)
for Eppley Airfield, Omaha, Nebraska (1936-1974)

PERIOD	PERIOD NORMAL	PERIOD MAXIMUM	PERIOD MINIMUM	24-HOUR MAXIMUM
January	8.2	25.7	0.1	13.1
February	7.3	25.4	0.1	18.3
March	6.9	27.2	T[1]	13.0
April	0.8	8.6	0.0	8.6
May	0.1	2.0	0.0	2.0
June	0.0	0.0	0.0	0.0
July	0.0	0.0	0.0	0.0
August	0.0	0.0	0.0	0.0
September	T	T	0.0	T
October	0.3	7.2	0.0	7.2
November	2.5	12.0	0.0	8.7
December	6.1	19.9	T	10.2
Year	32.2	58.5	8.0	18.3

[1]T = Trace

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2.6 Meteorology (Continued)

2.6.2 Local Meteorology (Continued)

Coupled with atmospheric stability and derived therefrom are long-term ground release dispersion factors. These are provided in terms of χ/Q values in various wind directions at evaluated receptors, out to 5 miles, in the report regarding Appendix I, referenced above.

The Fort Calhoun site experiences occasional severe weather, usually associated with thunderstorms which occur about 48 days per year on a statewide basis, with the most frequent activity in the month of June. Hail is observed 4 days per year in most locations. The average number of tornadoes expected in a 1 degree square in the general site area is about 2 per year. Other severe weather conditions include heavy precipitation, ice storms, and extreme winds. The probability of a tornado hitting the site in any given year is estimated to be .00158, with a return frequency of once every 633 years.

2.7 Hydrology and Water Quality

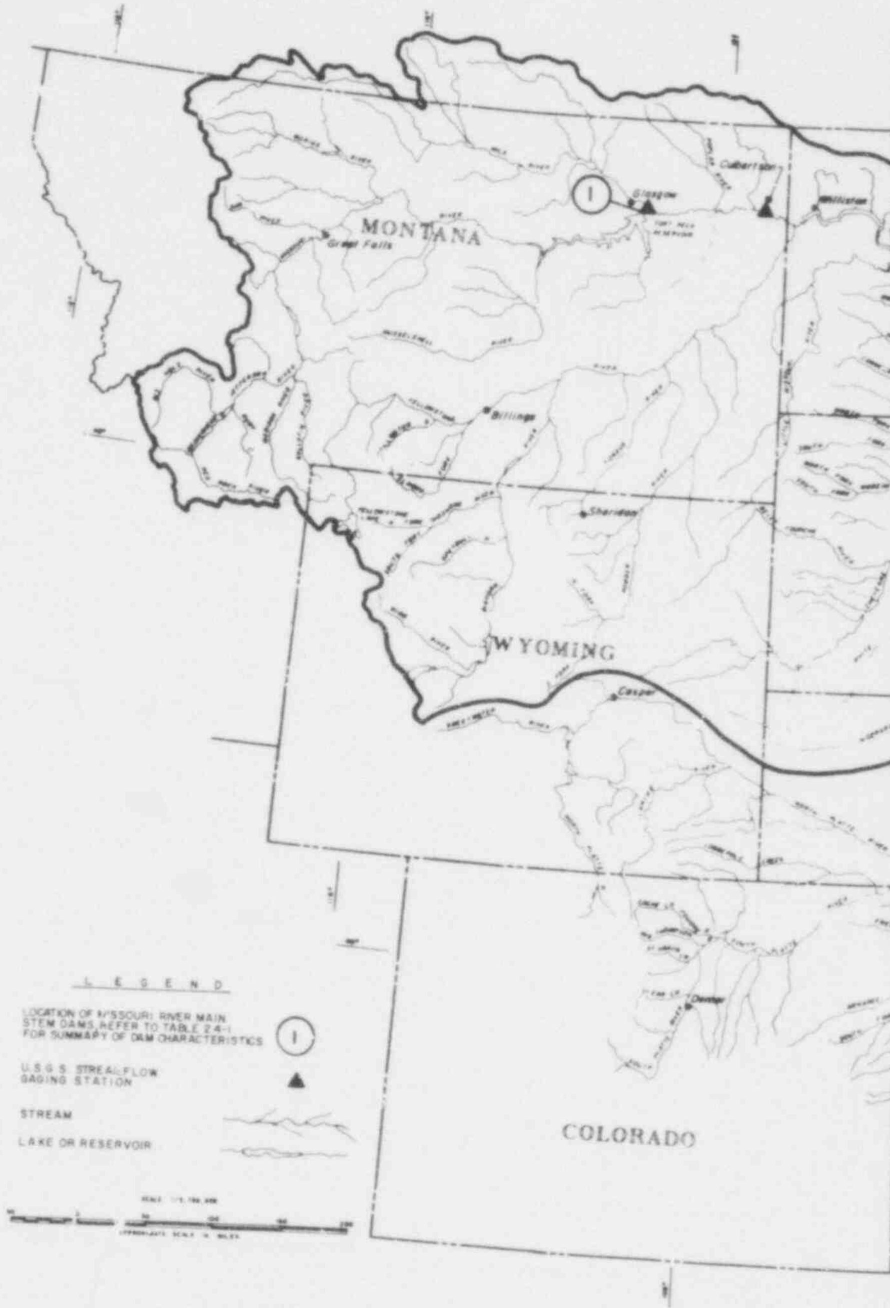
2.7.1 Surface Water Hydrology

Surface water in the vicinity of the station consists of the Missouri River and various small streams. The Missouri River drainage basin upstream from the site encompasses 321,258 square miles and conveys runoff from 7 states (Nebraska, Iowa, Minnesota, South Dakota, North Dakota, Montana, and Wyoming) and the provinces of Alberta and Saskatchewan. Along the length of the Missouri River, the U. S. Army Corps of Engineers has constructed 6 major dams, referred to as the Missouri River Main Stem Dams. These dams are used for the purpose of flood control, irrigation, generation of hydroelectric power, flow augmentation for the navigation season, and low flow augmentation for pollution control. The major tributaries to the Missouri River are identified in Table 2.7-1 and shown in Figure 2.7-1. The table summarizes the location and river miles of the major tributaries, the drainage area, average discharges, and recorded maximum and minimum flow information.

The Missouri River near the site is approximately 600 feet wide and 15 feet deep, with an average discharge of 28,850 cfs at the USGS gauging station at Omaha, Nebraska. The average slope of the river from Gavins Point Dam to Omaha is approximately 0.0002 feet per foot. The river reach from Sioux City, Iowa, to Omaha is used for navigation and is maintained in a relatively uniform condition with respect to width, depth, and alignment. Many jetties, pile dikes, and levees have been

Table 2.7-1
Flow Data, Missouri River and Tributaries

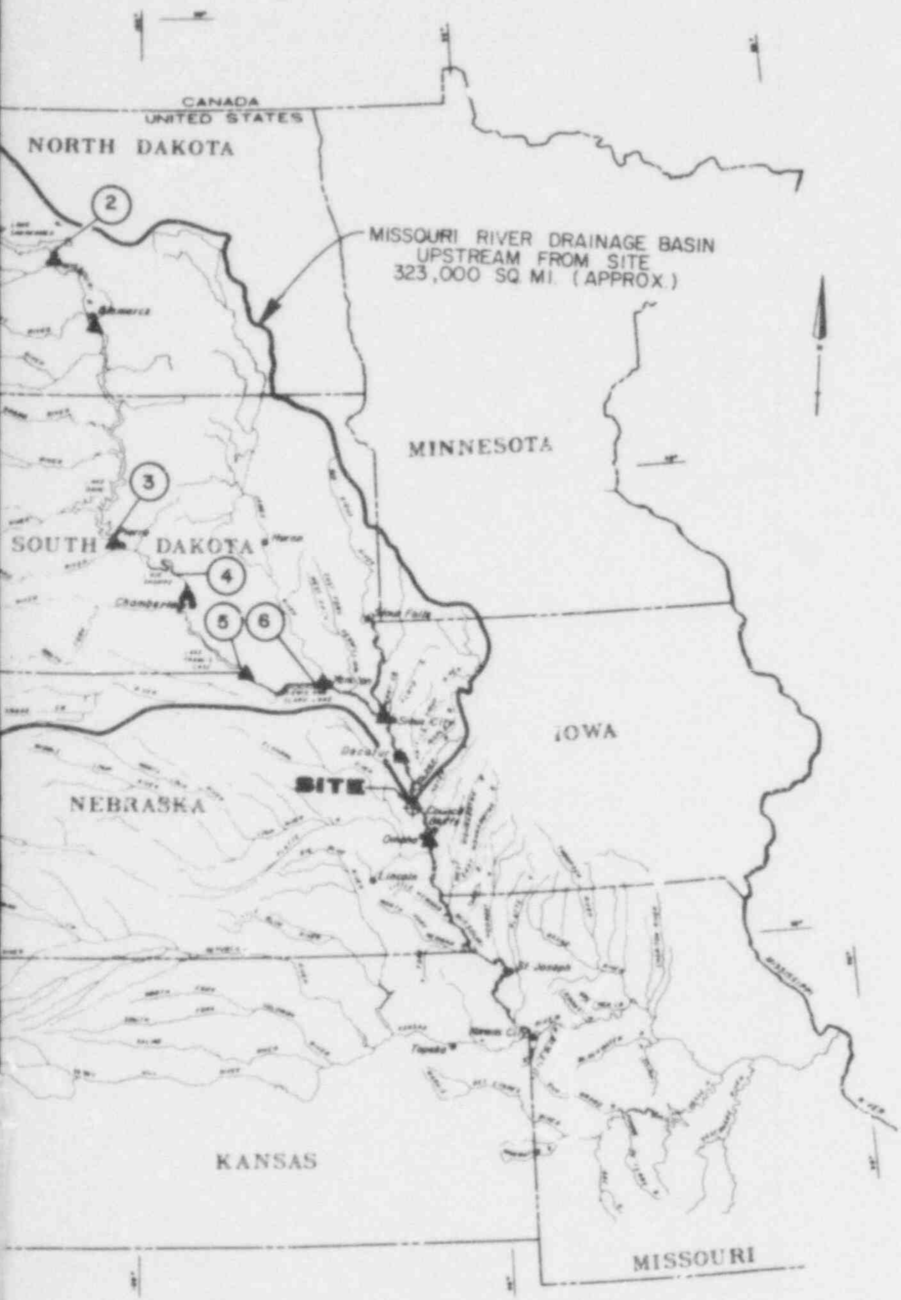
RIVER OR STREAM	MISSOURI RIVER MILE	LOCATION (CITY, STATE)	DRAINAGE AREA (SQ. MI.)	AVERAGE FLOW (cfs)	MAXIMUM FLOW (cfs)	WATER SURFACE ELEVATION AT MAXIMUM DISCHARGE (FEET M.S.L.)	DATE OF MAXIMUM FLOW	MINIMUM FLOW (cfs)	DATE OF MINIMUM FLOW
Missouri	805.8	Yankton, SD	279,500	25,520	480,000	1175.2	13 April 1952	2,700.0	15 November 1940
Monona-Harrison Ditch	670.[illegible]	Turin, IA	900	227	19,900	1043.0	19 February 1971	8.5	3 January 1959
Little Sioux	669.2	Turin, IA	4,027	1,078	30,000	1047.3	19 February 1971	22.0	10 February 1959
Soldier	663.9	Pisgah, IA	407	125	22,500	1064.7	12 June 1950	2.0	2 January 1945
Missouri	646.0	Site	321,258	28,500	396,000	1008.7	18 April 1952	2,200.0	6 January 1937
Boyer	635.2	Logan, IA	1,000	306	25,000	1032.0	19 February 1971	1.5	16 July 1936
Missouri	615.9	Omaha, NB	322,800	28,850	396,000	988.4	18 April 1952	2,200.0	6 January 1937
Elkhorn	---	Waterloo, NB	6,900	4,124	100,000	1123.3	12 June 1944	50.0	12 November 1940
Platte	---	South Bend, NB	88,800	5,399	124,000	1019.6	30 March 1960	240.0	3 September 1955



REFERENCE

THE MISSOURI RIVER BASIN COMPREHENSIVE FRAMEWORK STUDY, MISSOURI RIVER INTER-AGENCY COMMITTEE, VOLUME 6, "HYDROLOGIC ANALYSES," 1969.

497 240



OMAHA PUBLIC POWER DISTRICT FORT CALHOUN STATION	Figure 2.7-1 Missouri River Main Stem Dams and Gaging Stations

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2.7 Hydrology and Water Quality (Continued)

2.7.1 Surface Water Hydrology (Continued)

constructed by the Corps of Engineers in order to provide a uniform, relatively straight channel.

The flood plain of the Missouri River is approximately 10 miles in width near the site, narrowing to a few miles as the river flows past Omaha. A typical cross section of the river and its flood plain near the site is shown by section 32 on Figure 2.7-2. A plot of stage versus discharge at the site is presented on Figure 2.7-3. Estimated mean velocity versus mean discharge curves for the Fort Calhoun Station site are shown in Figure 2.7-4. While the mean flow velocity ranges between 3 and 5 feet per second during normal conditions, discrete flow velocities may range up to approximately 7 feet per second. The rate of flow in the river past the site is largely controlled by the releases from the Gavins Point Dam, approximately 165 river miles upstream from the site.

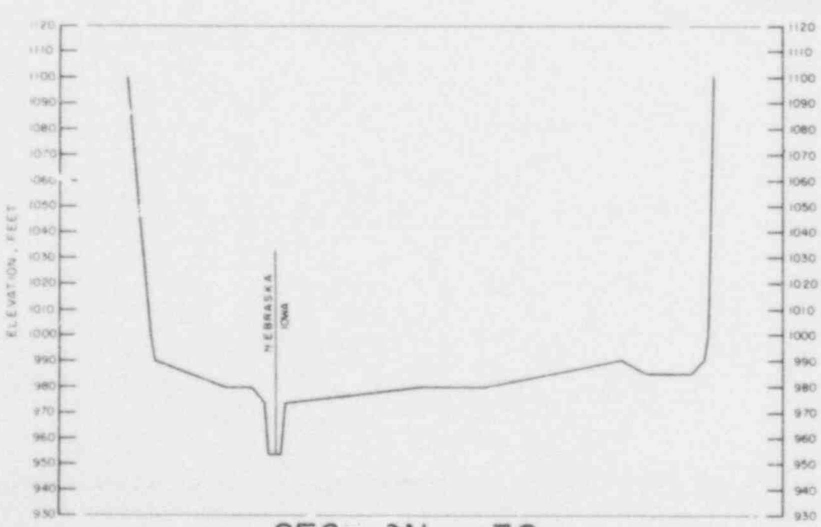
The maximum historical flow recorded for the Missouri River at Omaha, Nebraska, is 396,000 cfs on April 18, 1952. The river remains largely within its banks until a flow of approximately 100,000 cfs is exceeded, at which point flow spreads extensively onto the farm land on the flood plain. Flood frequency curves are presented in Figure 2.7-5. The 2 periods of record shown in the figure represent construction of the main stem dams.

The record minimum 1-day low flow in the Missouri River at Omaha is 2200 cfs, recorded on January 6, 1937. The 10-year recurrence interval 7-day low flow at Omaha is 3700 cfs, based upon the entire period from 1928 to 1974. For the period 1957 to 1971, the 10-year recurrence interval 7-day low flow is 4850 cfs. The first period includes the severe drought of the 1930's and the latter, subsequent to construction of the dams, reflects low flows due to filling of the ams An analysis of the period 1967 to 1974, using Hazen's method, indicates a 7 day, 10-year recurrence interval low flow of 8800 cfs. All yearly low flows have occurred during the winter months when ice jams occur.

The principal small streams occurring near the site are Fish Creek and Long Creek. The drainage basins of these creeks lie in the immediate vicinity of the site, greatly on the Missouri River flood plain. Fish Creek is dry much of the time.

SECT

SECTION 32



SECTION 36

NOTES:

1. SEC THE IOW

2. SEC IOW

3. SEC

4. CRO ON EAC

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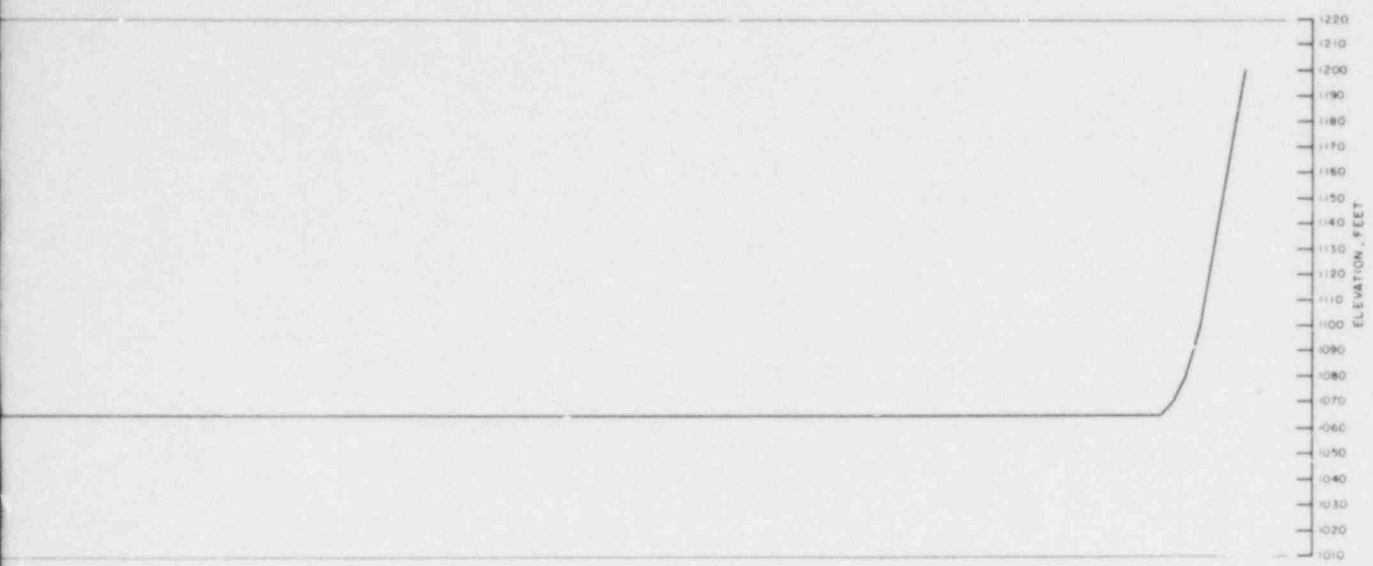

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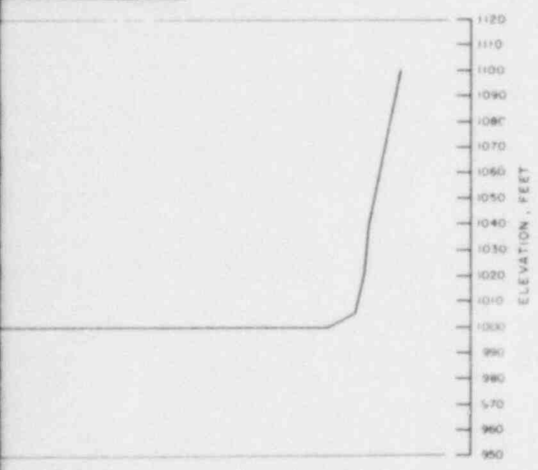

ON 21 IS TAKEN AT THE APPROXIMATE WIDEST PORTION OF
MISSOURI RIVER FLOOD PLAIN AND PASSES THROUGH HORNICK,

ON 32 PASSES THROUGH BLAIR, NEBRASKA, AND MISSOURI VALLEY,
, AND IS APPROXIMATELY 3 MILES UPSTREAM FROM THE SITE

ON 56 IS TAKEN JUST NORTH OF OMAHA, NEBRASKA

S SECTIONS LOOKING UPSTREAM THE STATE OF NEBRASKA LIES
THE LEFT OF TI.Z RIVER, THE STATE OF IOWA ON THE RIGHT FOR
SECTION

HORIZONTAL SCALE

3000 6000 9000 FEET

VERTICAL SCALE

30 60 90 FEET

OMAHA PUBLIC POWER DISTRICT FORT CALHOUN STATION	Figure 2.7-2 Missouri River Cross Sections

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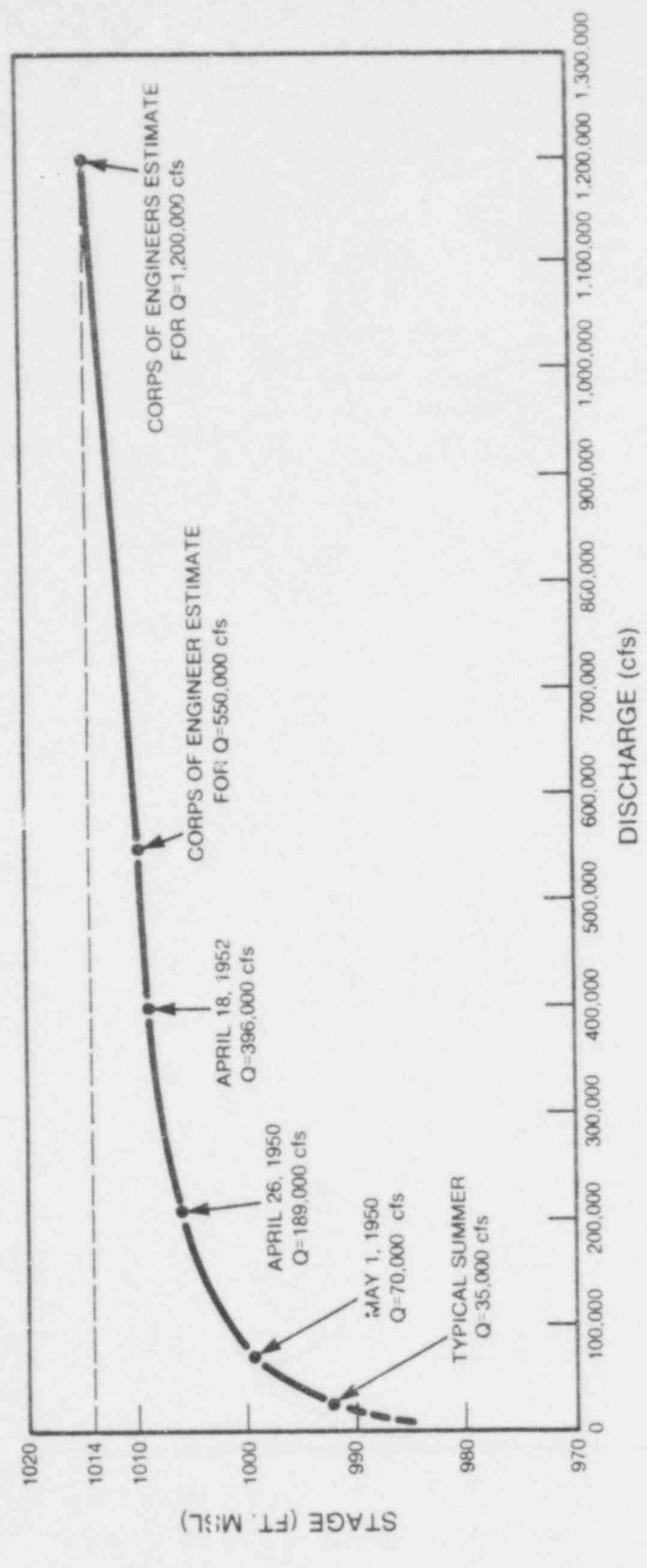
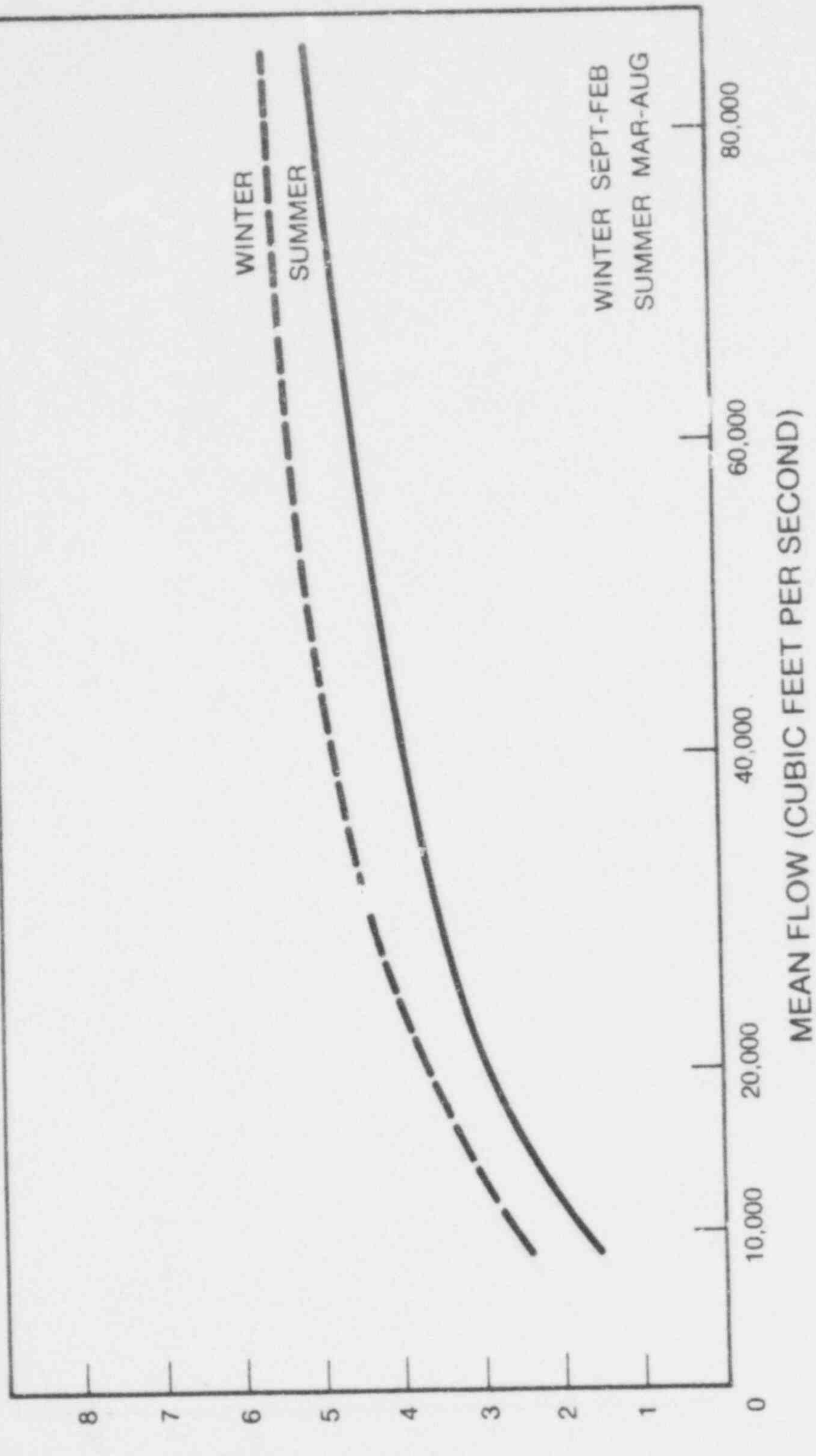


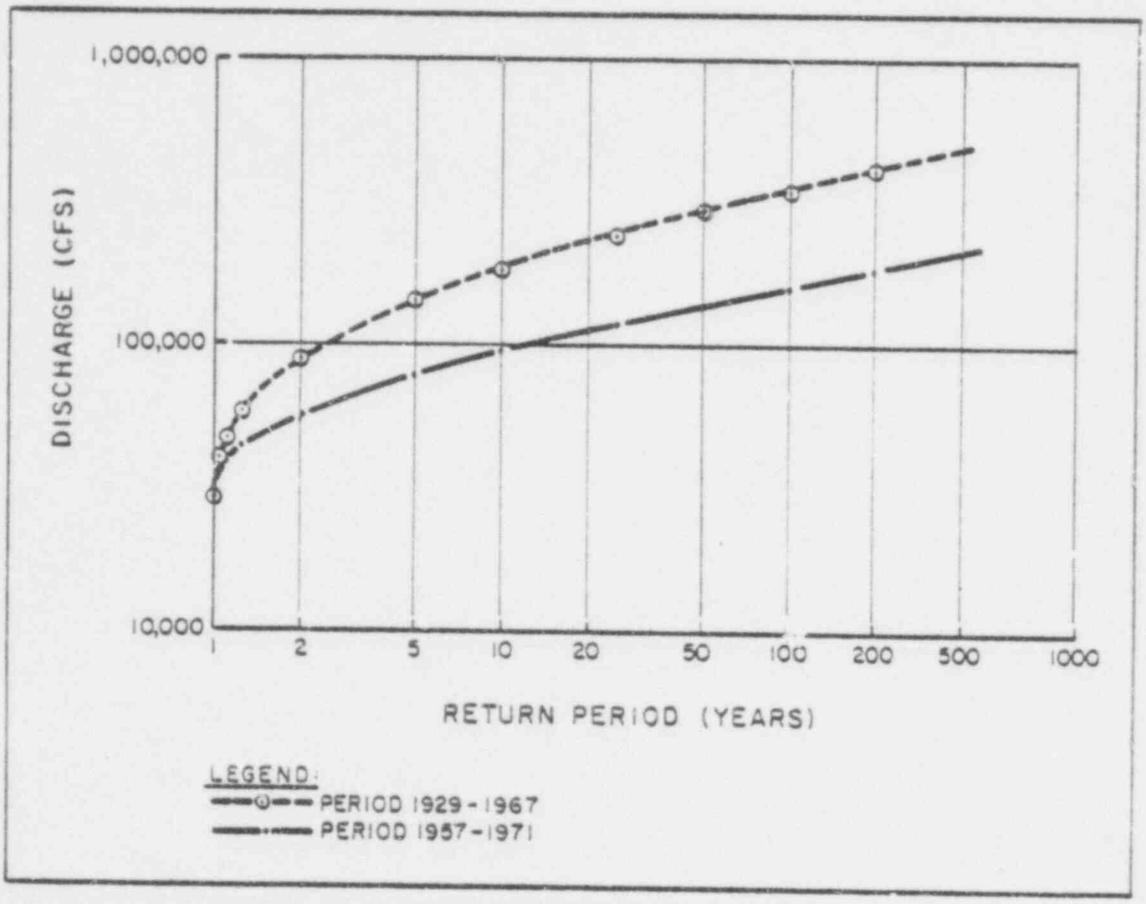
OMAHA PUBLIC POWER DISTRICT FORT CALHOUN STATION	Figure 2.7-3 Stage-Discharge at Site

497 245



OMAHA PUBLIC POWER DISTRICT FORT CALHOUN STATION	Figure 2.7-4 Estimated Mean Flow-Velocity Curves for Missouri River at Fort Calhoun Site on 1967-1975 USGS Data from Sioux City, Iowa, and Omaha, Nebraska

497 246



OMAHA PUBLIC POWER DISTRICT FORT CALHOUN STATION	Figure 2.7-5 1-Day High Discharge - Frequency Curves, Missouri River at Omaha, Nebraska

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2.7 Hydrology and Water Quality (Continued)

2.7.2 Surface Water Quality

Missouri River water quality data have been compiled from stations extending as far from the site as Decatur (45 river miles upstream) and Omaha (approximately 19 river miles downstream). The data from Decatur, Nebraska, include temperatures, turbidity, pH, dissolved oxygen, BOD, hardness and fecal coliform among other pollutants and are presented in Table 2.7-2. Data have been obtained from 2 sources in the Omaha area, the Metropolitan Utilities District (MUD) intake at Florence and USGS station 06610000 in Omaha. The MUD data are presented in Table 2.7-3 and include similar pollutants presented at Decatur, plus total dissolved and suspended solids. The MUD data, however, lack information about temperature, turbidity, and fecal coliform. The USGS data are listed in Tables 2.7-4 and 2.7-5. Table 2.7-4 presents the Missouri River average temperature at Omaha for each month based on the record period 1968 through 1975. Table 2.7-5 provides a detailed distribution of grain sizes for the suspended sediment and bed material of the Missouri River at Omaha. Additionally, radioactivity (gross alpha, beta) has been measured at MUD, commencing in 1975. Although the period of record is very limited, the readings ranged from 12 to 37 pCi/l.

2.7.3 Ground Water Hydrology

The source of ground water in the area of the site is the alluvial sands and gravels of the Pleistoiene Valley fill. The water table closely follows the level of the Missouri River and varies seasonally in a regular pattern. Gradients are relatively flat in the flood plain, but dip toward the river. These alluvial deposits in the flood plain are in direct hydraulic convection to the Missouri River. The movement of the ground water in the uplands area surrounding the Missouri River flood plain is toward the river.

Locations of all wells within a 2-mile radius of the plant are shown on Figure 2.7-6. Many of the records and entries were estimated by the drillers and owners. Where possible, the depths, sizes, and other physical parameters were measured, but generally most of the wells were not accessible. Where entries could not be reasonably estimated, they were classified as unknown.

In the eastern Nebraska region along the Missouri River valley, the ground water in storage is contained in the quaternary and tertiary sand and gravel deposits. The amount of water stored in this aquifer is extensive and has not been noticeably affected by ground water withdrawals. Average

Table 2.7-2
Surface Water Quality, Missouri River at Decatur, Nebraska

PARAMETER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
Temp (C)	0.5	1.4	3.4	9.6	16.5	20.6	26.1	23.8	17.7	13.8	6.9	[illegible]
Turbidity (JTU)	16.0	22.0	91.0	43.0	34.0	61.0	21.0	21.0	18.0	26.0	23.0	42.0
pH (units)	7.6	7.7	7.7	8.0	8.0	7.8	8.0	7.9	7.7	7.8	7.9	7.6
Dissolved Oxygen	13.2	12.5	11.4	11.0	9.1	8.1	7.8	7.6	8.9	9.7	11.2	12.2
BOD	2.1	2.6	5.9	2.1	3.1	1.9	1.9	1.8	1.5	1.4	1.2	1.8
Fecal Coliform (Coliform/100 ml)	7,227.0	4,003.0	3,475.0	1,967.0	3,517.0	8,133.0	5,850 0	6,800.0	4,953.0	7,550.0	2,550.0	4,552.0
Hardness	252.0	242.0	211.0	240.0	254.0	247.0	247.0	240.0	317.0	249.0	236.0	249.0
Specific Conductance (micromhos/cm at 25 degrees C)	720.0	724.0	649.0	707.0	726.0	737.0	747.0	762.0	740.0	743.0	707.0	741.0
Magnesium	21.0	22.0	18.0	22 0	24.0	22.0	22.0	22.0	21.0	22.0	21.0	23.0
Calcium	61.0	62.0	53.0	61.0	63.0	64.0	61.0	60.0	59.0	64.0	59.0	64.0
Chloride	11.5	11.8	9.3	12.0	10.8	10.6	10.5	11.0	14.7	10.6	10.5	11.5
Sulfate	215.0	197.0	152.0	191.0	202.0	205.0	213.0	215.0	210.0	212.0	206.0	216.0

NOTES: All units are milligrams/liter (mg/l) unless otherwise specified.
No replicates were taken.
Location of Sampling: from State Highway 175 bridge at river mile 691 in ice-free periods; from the adjacent Nebraska bank at other periods.
Methods of Collection: grap sample at surface with weighted bucket on a rope.
Methods of Analyses: standard U.S.G.S. methods (Ref. 2.4-16 and 2.4-16b).

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Table 2.7-3
Surface Water Quality for the MUD Intake on the Missouri River at Omaha, Nebraska

PARAMETER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
pH (units)	8.24	8.18	8.13	8.23	8.28	8.23	8.30	8.33	8.38	8.37	8.33	8.22
Dissolved Oxygen	12.40	12.40	11.30	10.40	8.30	7.20	6.60	7.00	7.50	8.60	10.30	12.42
BOD (5 day)	1.70	2.40	3.70	1.40	2.10	1.60	2.50	1.40	1.40	1.20	1.40	1.42
Hardness ($CaCo_3$)	260.00	233.00	231.00	261.00	246.00	242.00	241.00	239.00	238.00	241.00	245.00	262.00
Specific Conductance (micromhos/cm at 25 degrees C)	708.00	680.00	633.00	663.00	673.00	657.00	675.00	675.00	683.00	685.00	698.00	725.00
Suspended Solids	141.00	159.00	437.00	501.00	641.00	569.00	695.00	245.00	534.00	138.00	207.00	96.00
Total Dissolved Solids	593.00	563.00	531.00	579.00	558.00	556.00	548.00	567.00	568.00	565.00	578.00	604.00
Sodium	61.00	58.00	50.00	53.00	53.00	60.00	61.00	63.00	62.00	65.00	64.00	63.00
Magnesium	24.00	22.00	21.00	24.00	23.00	22.00	22.00	23.00	23.00	24.00	24.00	25.00
Calcium	65.00	60.00	59.00	65.00	61.00	61.00	60.00	58.00	57.00	58.00	59.00	64.00
Bicarbonate	215.00	207.00	198.00	213.00	198.00	193.00	186.00	187.00	191.00	207.00	204.00	219.00
Chloride	13.00	12.00	13.00	13.00	13.00	13.00	13.00	12.00	12.00	11.00	12.00	12.00
Fluoride	0.62	0.58	0.55	0.60	0.60	0.59	0.59	0.64	0.63	0.62	0.61	0.61
Sulfate	204.00	183.00	163.00	192.00	193.00	189.00	207.00	213.00	211.00	201.00	202.00	234.00
Nitrate	2.47	2.96	4.83	4.69	3.70	3.92	2.08	1.35	0.97	1.69	1.83	2.53
Phosphate	0.13	0.12	0.15	0.15	0.12	0.14	0.09	0.06	0.09	0.07	0.08	0.07

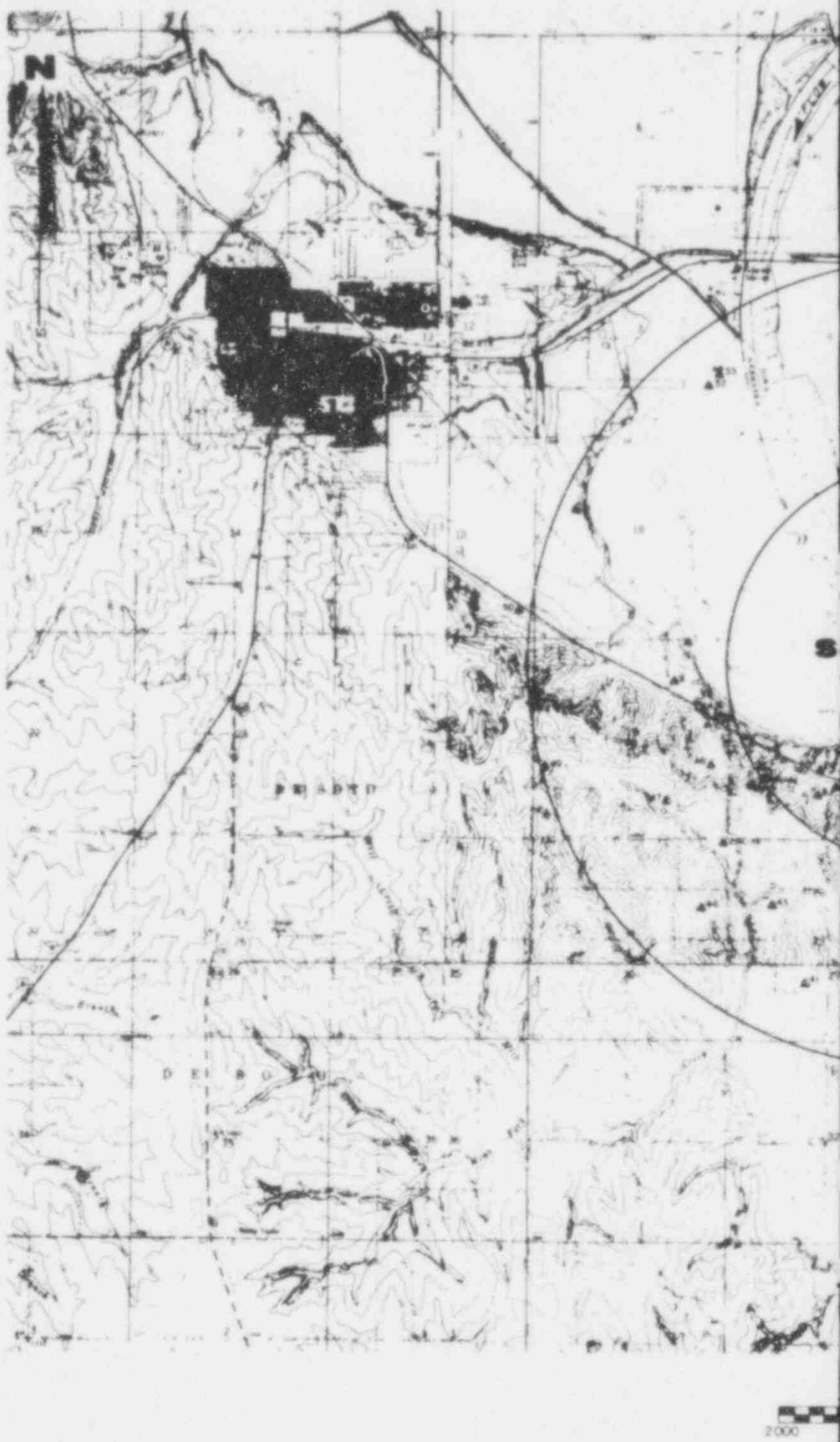
NOTES: All units are milligrams/liter (mg/l) unless otherwise specified.
Data are averages of monthly random samples.
No replicates were taken.
Time span: 1971 to 1975
Number of Measurements: 4 to 5 per month on Wednesdays.
Location of Sampling: Florence Plant intake, at river mile 626, 10 to 15 feet below surface in winter.
Methods of Sampling: grab sample from continuous flow hose taken from raw water line which comes from plant intake.
Methods of Analysis: Ref. 2.4-16c.

Table 2.7-4
Surface Water Quality Average Monthly Temperature
for the Missouri River at Omaha, Nebraska

MONTH	TEMPERATURE (C)
January	1.0
February	1.1
March	2.8
April	8.3
May	14.6
June	20.6
July	24.6
August	24.2
September	22.4
October	13.9
November	7.2
December	3.0

Table 2.7-5
Surface Water Quality Suspended Sediment Gradation, Missouri River at Omaha, Nebraska

DATE	SUSPENDED SEDIMENT (mg/l)	SUSPENDED SEDIMENT DISCHARGE (T/day)	PERCENT FINER THAN 0.062 mm	PERCENT FINER THAN 0.125 mm	PERCENT FINER THAN 0.250 mm	PERCENT FINER THAN 0.500 mm	PERCENT FINER THAN 0.062 mm	PERCENT FINER THAN 0.125 mm	PERCENT FINER THAN 0.250 mm	PERCENT FINER THAN 0.500 mm
			BED MATERIAL				SUSPENDED SEDIMENT			
1972										
June	684	92,100	-	-	-	-	33	51	100	-
July	784	95,500	-	2	74	99	25	44	99	100
August	441	59,800	-	2	67	98	40	60	100	-
September	637	84,500	-	-	-	-	19	34	99	100
October	746	104,100	0	3	76	100	19	30	95	100
November	555	84,100	0	1	60	99	43	58	96	100
December	546	31,700	0	2	84	100	33	50	100	-
1973										
January	754	56,500	1	2	74	98	58	69	97	100
February	784	60,300	0	1	85	98	36	53	100	-
March	1,440	170,000	1	2	77	100	87	91	100	-
April	1,277	109,300	0	2	54	98	65	76	99	100
May	1,046	105,500	-	-	-	-	53	67	99	100
June	776	70,800	0	2	79	99	58	72	100	-
July	757	70,500	0	4	70	100	58	66	97	100
August	579	53,400	1	2	57	96	50	70	99	100
September	704	65,200	0	2	74	100	23	34	98	100
October	753	77,200	0	2	88	99	52	66	100	-
November	468	39,500	0	1	73	100	28	50	99	100
December	434	24,[illegible]00	0	4	93	100	31	46	100	-
1974										
January	288	14,300	-	0	53	76	47	54	100	-
February	382	22,900	0	3	79	99	33	45	99	100
March	451	32,600	0	2	56	97	32	48	96	100
April	599	49,600	0	2	60	98	24	35	100	-
May	559	51,900	0	2	49	91	34	52	98	100
June	1,500	159,000	0	4	90	100	73	81	100	-
July	480	46,400	0	4	70	98	46	62	100	-
August	529	54,300	0	4	53	92	34	48	98	100
September	479	44,400	0	2	86	100	26	42	98	100



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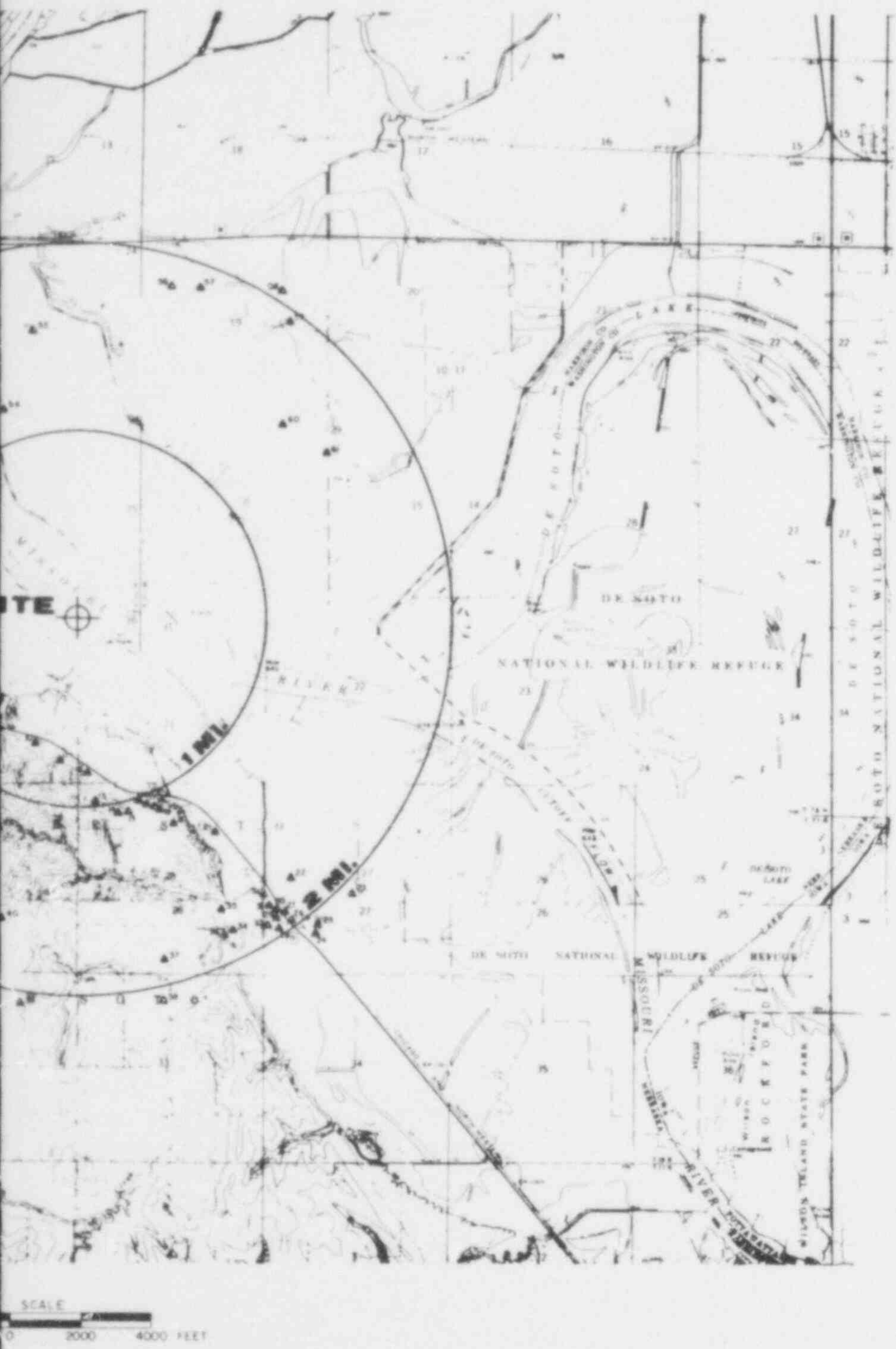


NOTE:
SEE TABLE 2.4-9 FOR DESCRIPTION OF EACH WELL SHOWN.

OMAHA PUBLIC POWER DISTRICT FORT CALHOUN STATION	Figure 2.7-6 Plan and Location of Wells Surveyed

2.7.3 Ground Water Hydrology (Continued)

annual ground water pumpage in the Missouri River flood plain is in the range of 100 to 200 acre-feet per square mile, while in the uplands bordering the river valley the pumpage is in the range of 1 to 3 acre-feet per square mile.

For the middle Missouri River region of the Missouri River basin, in which the site is located, approximately 75 percent of the land is in crops and 95 percent is in agricultural usage. Projected population growth in the area is a 20 to 25 percent increase by the year 2020, while the rural population is expected to remain constant or decrease slightly. Industrial ground water usage is expected to increase, but it is unlikely that any significant industrial development will occur upgradient from the site because of the unfavorable upland topography and distance from the river.

2.7.4 Ground Water Quality

Water samples have been obtained from the 5 piezometers located at the plant site. A chemical analysis of the samples taken from the piezometers has been performed. The results are presented in Table 2.7-6. The range of total dissolved solids is from 593 to 1230 mg/liter which is above the normal recommended limit for drinking water.

2.8 Geology and Seismology

The U1 FSAR adequately summarizes the geologic and seismic characteristics of the site (§ 2.4 and 2.6). The following conclusions are drawn from these sections:

2.8.1 The site is subject to infrequent slight ground motion from regional shocks. Conservatively, and in line with USC & GS recommendations, the plant is designed for earthquake intensities postulated on the basis of a fault system in the vicinity of the site.

2.8.2 The bedrock beneath the site provides suitable support for the plant structures. There is no geologic feature of the site or surrounding area which adversely affects the use of the site for a nuclear power plant.

Stretching the Fort Calhoun Station does not alter these conclusions.

2.9 Regional Historic Features

There are several previously discovered archaeological sites within a 10-mile radius of Fort Calhoun Station. The following is

Table 2.7-6
Chemical Analysis .. Ground Water

DETERMINATION	UNITS	B-201	B-204	B-209	B-212	B-228A
pH @ 10.0 degrees C		7.15	7.40	7.30	7.85	7.20
Specific Conductance @ 25.0 degrees C	micromhos/cm	1540.00	1070.00	1340.00	1210.00	800.00
Alkalinity	mg/l as $CaCO_3$	768.00	589.00	802.00	650.00	388.00
Total Dissolved Solids (evaporation)	mg/l	1230.00	738.00	933.00	845.00	593.00
Total Hardness	mg/l as $CaCO_3$	815.00	529.00	699.00	563.00	332.00
Sulfate	mg/l as SO_4	310.00	105.00	105.00	115.00	115.00
Chloride	mg/l as Cl	1.54	3.09	1.03	1.54	1.54
Nitrate	mg/l as NO_3-N	0.04	0.01	0.03	0.03	0.05
Total Soluble Iron	mg/l as Fe	0.54	0.26	1.09	0.12	0.10
Manganese	mg/l as Mn	2.64	1.83	2.04	1.12	0.20
Sodium	mg/l as Na	98.00	77.00	8[illegible]0	86.20	84.50
Potassium	mg/l as K	10.70	8.50	10.50	10.60	12.20
Calcium	mg/l as Ca	316.00	156.00	204.00	170.00	100.00
Silica	mg/l as SiO_2	11.50	11.50	9.30	13.70	15.60

2.9 Regional Historic Features (Continued)

a listing of sites published by the Nebraska State Historical Society:

2.9.1 Site 25 WN6 is a burial site 1 to 2 miles southwest of Fort Calhoun Station.

2.9.2 Site 25 WN7 is a burial site to which no cultural affiliation has been assigned. The site is 5.5 miles west-southwest of Fort Calhoun Station.

2.9.3 The Renne Site is a Nebraska Culture earthlodge village site located about 8.1 miles southwest of Fort Calhoun Station.

2.9.4 The O'Hanlan Site has shell beads on a hilltop burial site which suggests a Woodland occupation. This site is about 1.8 miles west of Fort Calhoun Station.

2.9.5 The Peterson Site is a Nebraska Culture earthlodge village located 7.5 miles south-southwest of Fort Calhoun Station.

2.9.6 The Nelson Site is a location from which a stone axe has been collected. The site is located 7.6 miles south-southwest of Fort Calhoun Station.

2.9.7 The Dawson Site has a Clovis point reported from it, giving an approximate date of 10,000 B.C. and is located 7.8 miles south-southwest of Fort Calhoun Station.

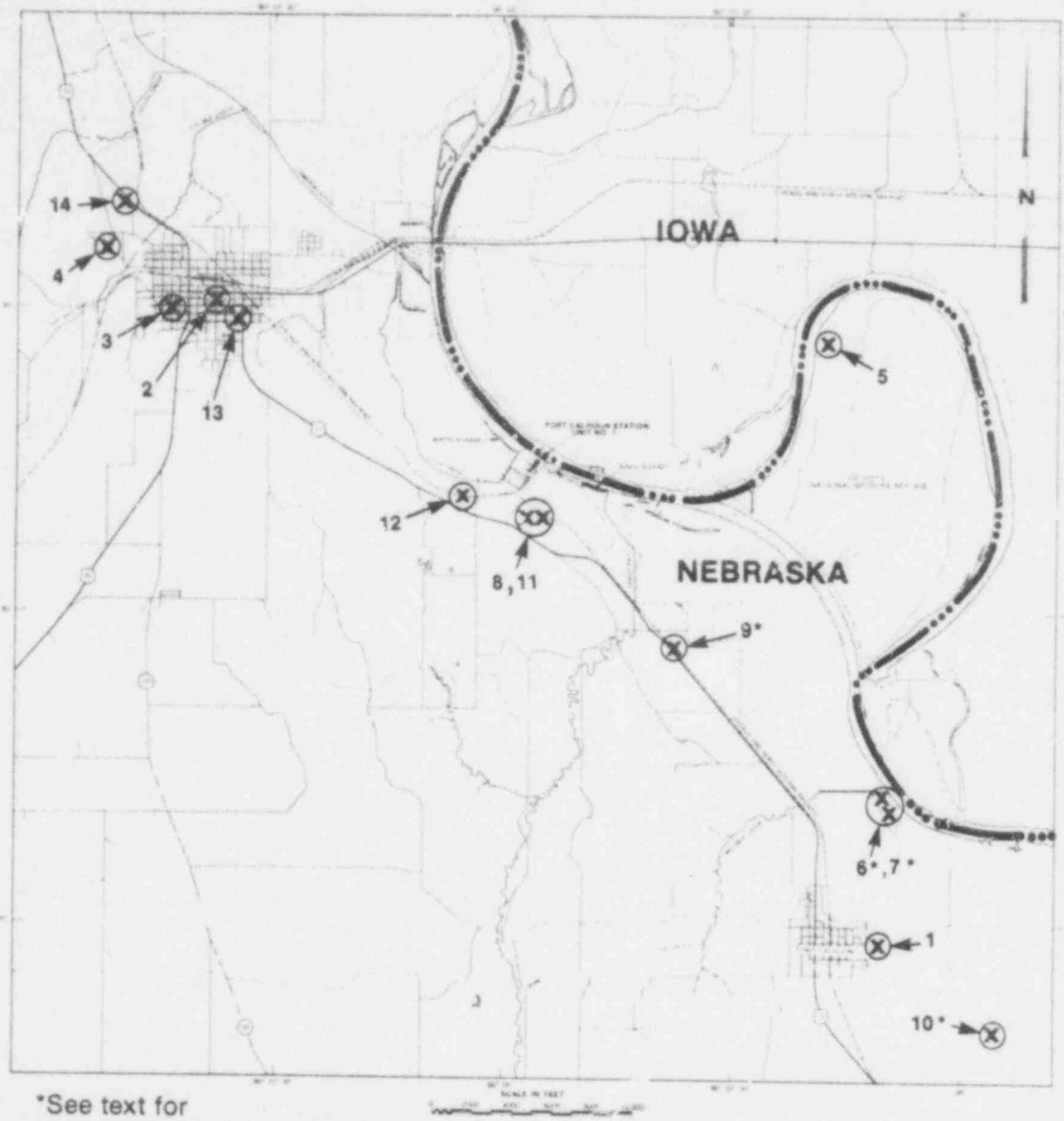
2.9.8 The James Site, a Nebraska Culture earthlodge village site, is located 9.1 miles southwest of Fort Calhoun Station.

2.9.9 The Frank Parker Site, located about 11 miles southeast of Fort Calhoun Station, is a Nebraska Culture earthlodge village site.

2.9.10 The Kelly Site, located on a ridge about 9.2 miles southeast of Fort Calhoun Station, is a burial site excavated in 1938.

There are also several historical sites within 10 miles of the station. The site numbers and distances from the station given in the following descriptions are shown in Figure 2.9-1.

Fort Atkinson (No. 1) was the second fortified position built by Colonel Harry Atkinson in the area. The post was the largest military post in the United States during the period 1820 to 1827. The fortification consisted of a rectangular arrangement of 1-story barracks fashioned of horizontal logs and is believed to have been



*See text for discussion of location.

LEGEND

1. FORT ATKINSON
2. CONGREGATIONAL CHURCH
3. CROWELL HOUSE
4. OLD MAIN
5. THE BERTRAND STEAMBOAT
6. CANTONMENT MISSOURI
7. FORT ATKINSON CEMETERY
8. DESOTO TOWNSITE
9. SUMMER QUARTERS
10. ENGINEERS CANTONMENT
11. THE OLD DESOTO
12. ANDERSON STEAMBOAT
13. COUNTY COURTHOUSE
14. CUMING CITY

OMAHA PUBLIC POWER DISTRICT FORT CALHOUN STATION	Figure 2.9-1 Location of Historic Sites Within 10-Mile Radius of Fort Calhoun Station

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2.9 Regional Historic Features (Continued)

built on the site of the Lewis and Clark Indian Council. This site is a National Historic Landmark and appears in the National Register of Historic Places. Fort Atkinson is located 5.8 miles southeast of Fort Calhoun Station.

The Congregational Church (No. 2) in Blair, Nebraska, was erected in 1874 in the Gothic Revival style. The interior has been altered, but the exterior has not. The church is 3.4 miles northwest from Fort Calhoun Station.

The Crowell House (No. 3) in Blair was a 3-story frame structure erected at a cost of $85,000 in 1884 by Christopher C. Crowell. This High Victorian mansion was by far the most elaborate house in Blair. A historical marker now marks the previous location of the Crowell House and is located 3.7 miles northwest of Fort Calhoun Station.

The Old Main (No. 4) Dana College, Blair, was constructed when the college was founded in 1884. It was first designed to house 40 students, the president's family, classrooms, and administrative offices. The house is 4.5 miles northwest of Fort Calhoun Station.

The Bertrand (No. 5) is the wreck of a Missouri River steamer which sank in DeSoto Bend in April, 1865, while on her maiden voyage upstream with cargo for the Montana goldfields. Excavation of her cargo has proven to be an important time capsule for artifacts revealing articles needed in western gold mine towns in the 1860's. The Bertrand is listed in the National Register of Historic Places, and is located 3 miles east of the Fort Calhoun Station in DeSoto National Wildlife Refuge.

The Fort Atkinson Cemetery (No. 7) served the fort as post cemetery from 1820 to 1827. It is probably located approximately 4 to 5 miles southeast of Fort Calhoun Station.

The DeSoto Site (No. 8) is the site of the historic town of DeSoto which served as river port and ferry town from 1854 to the mid-1860's. Nothing remains of this old steamboat town that once flourished on the Omaha to Decatur road, but the platted city limits are only a few yards southeast of the substation at Fort Calhoun Station. The Nebraska State Historical Society has erected a marker just off U. S. Highway 73 at the entrance to Fort Calhoun Station, to indicate the significance of DeSoto.

The Summer Quarters (No. 9) were farmed by the Mormons to supply their immigrant trains heading west to Utah until 1847 or 1848. It was probably located approximately 2 to 3 miles south-southeast from Fort Calhoun Station near Fort Calhoun, Nebraska.

2.9 Regional Historic Features (Continued)

The Engineers Cantonment (No. 10) was the wintering place for Major Stephen H. Long's Expedition in 1819 and 1820. Major Long, geologists, zoologists, and an artist were sent by the Federal Government to explore the Platte River and the mountain region beyond. The cantonment is located approximately 10 to 11 miles southeast of Fort Calhoun Station, along the Missouri River.

The Old DeSoto (No. 11) is located on the upper edge of the Fort Calhoun Station Unit No. 1 borrow pit about 0.6 miles south of the reactor containment structure. This is the site of a historic house yielding artifacts of the mid-19th Century and Fort Atkinson brick. The original plat maps suggest that this building was located in DeSoto's central business district.

The Anderson Steamboat Site (No. 12) is the suspected location of a sunken steamboat. Three (3) boats are known to have sunk in the area and private attempts are being made to locate these sites. The possible site in question is about 1 mile west of Fort Calhoun Station.

The County Courthouse (No. 13) is a 19th Century masonry courthouse erected in 1889 to 1891 at a cost of $36,000. The courthouse is presently in use and is located 3.2 miles west-northwest of Fort Calhoun Station.

Cuming City (No. 14) is an abandoned townsite located about 5 miles northwest of Fort Calhoun Station.

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SECTION 3 - PLANT DESCRIPTION

3.1 External Appearance

No change in plant appearance will result from operation at stretch power.

3.2 Reactor and Steam-Electric System

Operation at stretch power will not require design modifications to the reactor and steam-electric system. Therefore, the system description provided in section 3.3 of the U1 ER is unchanged, with the exception of the following operating parameters:

Thermal power level - increased from 1420 MWt to 1500 MWt.

Secondary steam pressure - increased from 770 psia to approximately 820 psia.

Saturated steam flow (full load) - increased from 6.2 x 10^6 lb/hr to 6.6 x 10^6 lb/hr.

As shown in the U1 FSAR, the reactor and steam systems are currently designed to support operation at 1500 MWt.

3.3 Plant Water Use - Heat Dissipation Systems

No significant change in plant water use will result from operation at stretch power. Maximum circulating water and raw water flows remain the same, and water inventories within the plant are unchanged. A general description of water usage for heat dissipation is provided in section 3.4 of the U1 ER. Expected effluent temperatures and resultant environmental impact are addressed in section 4 of this application.

3.4 Radwaste Systems

Operation of the unit at stretch power is not expected to increase radwaste volumes or significantly increase radwaste releases from the plant. A description of certain radwaste systems at the plant is provided in section 3.5 of the U1 ER and section 11 of the U1 FSAR. All systems are designed to accommodate reactor operation at 1500 MWt and have been evaluated at the stretch rating in the U1 FSAR.

In addition, the radwaste system has been evaluated to demonstrate compliance with 10 CFR 50, Appendix I, at a power level of 1500 MWt. This evaluation has been submitted to the Commission for review in the following documents:

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3.4 Radwaste Systems (Continued)

Letter, dated June 2, 1976, from T. E. Short to G. E. Lear, and enclosed report entitled "Evaluation of Fort Calhoun Station Unit No. 1 in Accordance with 10 CFR Part 50, Appendix I".

Application for Amendment of Facility Operating License, dated March 21, 1979.

3.5 Chemical and Sanitary Wastes

No increases in the amount of chemical or sanitary wastes will result from stretching the Fort Calhoun Station.

3.6 Transmission

No additional transmission lines are necessary due to the increase in power level.

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SECTION 4 - ENVIRONMENTAL EFFECTS OF PLANT OPERATION

4.1 Non-Radiological Effects

Omaha Public Power District is currently operating the Fort Calhoun Station Unit No. 1 within temperature limits, as specified in Appendix B of Operating License No. DPR-40. One effect of stretch power at the station will be the increase in steam flow and resultant BTU's discharged through the condenser cooling water system. As a result of the fact that there will be no change in the amount of circulating water flow in the condenser cooling system, the ΔT across the plant will increase. An analysis of the additional steam flow, resulting from stretch power, has enabled the District to calculate an increase in the current 20°F ΔT of 5°F up to 1560* thermal megawatt stretch power conditions. The calculated increase in ΔT of 5°F would cause changes in the current Appendix B Technical Specifications. The changes necessary for 1560 thermal megawatt stretch power conditions are as follows:

The condenser cooling water discharge temperature shall not exceed 110°F.

The difference ΔT between the ambient temperature of the Missouri River, as measured just upstream from the cooling water intake structure, and the temperature of the cooling water at the discharge shall not exceed 25°F when the river temperature is > 55°F.

The change necessary in the maximum discharge temperature from 105°F to 110°F was determined by the evaluation of ambient river temperature data from two sources. The frequency of occurrence of ambient temperatures > 80°F at the Fort Calhoun Station was recorded for the 6 year period, 1973-1978. Under 1560 thermal megawatt conditions and with a ΔT of 25°F, the maximum discharge temperature during the 6 year period would have been 109°F. This temperature would have persisted for 35 total hours in the 6 year period. A one time occurrence of 85°F was recorded in 1969 (data from 1955 to 1972*) at the North Omaha Station water inlet. Based upon this occurrence and a 25°F ΔT, as a result of a thermal increase due to stretch power, a 110°F maximum discharge temperature, which will be required, is calculated. This temperature will occur quite infrequently in the future under similar Missouri River flow conditions.

The once through condenser cooling system, as designed, increases the temperature of the ambient river water pumped through the condenser cooling system during full load operation by 20°F. Once discharged, the added heat rapidly mixes with the ambient Missouri River water and produces a thermal plume, which hugs the Nebraska bank downstream of the cooling water discharge.

The District has studied the effects of station operation on thermal plume dimensions in excess of 5 years, in accordance with Technical Specification 2.1 of Operating License No. DPR-40. A 5 year report, consisting of a thermal plume summary, was submitted to the Commission in July, 1978.

*Data from the Metropolitan Utilities District water inlet (approximately R.M. 627) and the North Omaha Station.

4.1 Non-Radiological Effects (Continued)

Thermal plume dimensions are presented in the Five Year Report (Tables 4.1-1 and 4.1-2). Maximum lengths and widths of plume isotherms measured are presented on these tables. Under average river flow conditions (35,000 cfs to 40,100 cfs), the average length of the 5°F isotherm downstream of the station's discharge was 985 feet. The width of the 5°F isotherm under the average flow conditions was 101 feet from the shoreline. During conditions of low river flow (16,800 cfs to 22,400 cfs), the average length of the 5°F isotherm was approximately 4450 feet downstream of the discharge, but the maximum width of approximately 100 feet for the 5°F isotherm remained similar to river width under the average flow conditions.

These data indicate that the average 5°F ΔT thermal plume dimensions, under average summer river flow conditions, when the highest discharge temperatures are realized, are less than 50% of the predicted (AEC, 1972) width of 250 feet and length of 2000 feet, as in the Fort Calhoun Final Environmental Assessment. Based on our preliminary estimations, the additional 5°F ΔT, resulting from 1560 thermal megawatt stretch power conditions, will result in plume dimensions that are expected to fall within the 1972 projections.

The Fort Calhoun Station is not currently operating under any limits or constraints, with respect to thermal plume dimensions. Under federal regulations (40 CFR Part 423), Fort Calhoun is classified as an "old unit" and is not prohibited from the discharge of heat. Fort Calhoun's thermal discharge to the Missouri River operates on National Pollutant Discharge Elimination System Permit No. NE 0000418 and has its only temperature requirement a thermal maximum of 105°F. In order to operate under stretch power conditions, an NPDES permit change will be pursued with the State of Nebraska Department of Environmental Control (D.E.C.). The thermal maximum must be changed to 110°F, which could be reached with a 25°F ΔT and a river temperature of 85°F. The D.E.C. has been contacted with respect to our intent to pursue this change. The District's permit application requirements are not known at this time, but should be known soon.

Organisms subjected to the effects of ΔT are those which are components of the condenser cooling water, which is used to cool turbine exhaust steam. Organisms mixed with the thermal discharge at the river interface experience the full ΔT and thermal maximum for only a very short period of time. River flow (average approximately 5 feet per second) rapidly moves the discharged water and entrained organisms downstream to areas of reduced thermal load. Sessile organisms, attached to rock and pile substrates downstream of the plant, are exposed to the plant's thermal discharge. Due to the rapid mixing characteristics of the Missouri River, organisms exposed to the highest temperatures are in a small zone near the plant (< 500 feet). Fishes in the area may also encounter the thermal plume. The plume at no time blocks the river and allows the fish to seek preferred temperatures in it or avoid it completely.

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SECTION 4 - ENVIRONMENTAL EFFECTS OF PLANT OPERATION (Continued)

4.1 Non-Radiological Effects (Continued)

During the first 5 years of station operation, studies were conducted on the thermal and/or mechanical effects on the biotic communities entrained in the Fort Calhoun condenser cooling system. The entrainment of zooplankton, phytoplankton, and macroinvertebrates was determined to have minimal effects. Phytoplankton productivity indices (carbon fixation per unit chlorophyll a) 7 hours after collection indicated slight mean inhibition in the summer (9%) (Kline, 1977). The total Missouri River effect, however, was < 0.5% for all collection periods 7 through 72 hours following collection (Kline, 1977). When high absolute discharge temperatures ($\geq$ 35C) were observed at the Fort Calhoun Station, entrainment losses for total zooplankton ranged from 5.5% to 21.6%. Impact based on delayed effects ranged from < 0.1% to 0.6% losses of the total zooplankton assemblage passing the plant (Rodgers, 1978). During periods of high absolute temperatures of 32 to 37C, entrainment losses for macroinvertebrates averaged 10.0% (Carter, 1978). Apparently, most of the entrained biotic organisms are able to withstand higher absolute temperatures, otherwise much higher mortality rates would have been detected. An assessment of maximum entrainment losses at the Fort Calhoun Station on the assemblage of zooplankton, phytoplankton, and macroinvertebrates drifting past the plant was determined to be < 0.6%, < 0.5%, and approximately 0.2%, respectively (Rodgers, 1978), (Kline, 1977), and (Carter, 1978). Due to this small percentage of effect, a Facility License Change was approved by the Commission in 1978 to eliminate these studies from the original Technical Specification requirements.

It is expected that the increased ΔT (25°F) and thermal maximum temperature (110°F) will not kill all the entrained zooplankton, phytoplankton, and macroinvertebrates, due primarily to the short term of exposure (approximately 2 to 3 minutes). The worst case can be discussed, however, if 100% mortality is assumed. In the summer, when the highest absolute temperatures are reached, river flows average approximately 33,500 cfs. Under these conditions, the maximum withdrawal for condenser cooling will be 802 cfs. Assuming complete homogeneity of organisms in the Missouri River, the maximum worst case total river mortality for each of the 3 drift components is calculated to be 2.4%. We do not believe this minor reduction in population size will endanger the balanced indigenous population of fish and fauna in the vicinity of the station.

A fourth component of the entrainment studies involved the determination of the effects of station operation on the ichthyoplankton community. Larval fish studies also included analysis of species composition, abundance, and distribution. The impact of entrainment on game fish (including sauger-walleye and white bass) and commercial fish (including carp, channel catfish, and flathead catfish) was low because larvae of these species generally made up a very low percentage of the entrained ichthyoplankton. Annually, freshwater drum accounted for approximately 75% of the larvae that

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4.1 Non-Radiological Effects (Continued)

were entrained. Entrainment of ichthyoplankton during peak larval fish periods always occurred when there was heat transfer. This prevented the separation of mechanical from thermal effects. Survival following condenser passage was nearly 30% in 1977 when discharge temperatures ranged from 29 to 37°C (84.2 to 98.6°F). Survival of larvae at temperatures above 30°C (86°F) was attributed to the short duration of exposure to absolute discharge temperatures (approximately 2 to 3 minutes).

A station operational effect of 5.3% on the larval assemblage passing the plant has been calculated assuming 100% mortality as a result of larval fish entrainment. Due to the fact that the circulating water volume used will not change and no increase in the number of larvae entrained will be experienced, the worst case (100% mortality) estimate for increased temperature, as a result of stretch power, will not differ from the 5.3% calculated for current conditions.

As [illegible] result of the larval fish studies conducted at the Fort [illegible] ation and a demonstration of the maximum effect of the [illegible] 5.3%, the Nebraska State Department of Environmental Con- [illegible] has allowed continued operation of the Fort Calhoun Station [illegible]ce through cooling system. In this document, the worst case assumption of 100% mortality was used to calculate the effect on the drift population passing the plant of 5.3%. This level of effect was determined to be acceptable and we believe should continue to be acceptable under stretch power conditions.

Other entrainment studies conducted at the Fort Calhoun Station, as stated earlier, have resulted in minimal effects on the availability and composition of the phytoplankton, zooplankton, and macroinvertebrates in the drift of the Missouri River. These major food items utilized by the adult fish have apparently been available in sufficient quantities and no alteration in feeding habits (Bliss, 1978) has been noticed in fish stomach analysis conducted since 1973. Additional reductions due to stretch power are not expected to modify this situation.

Other research conducted has used species composition and relative abundance data to evaluate the status of the adult fishery. On the basis of data collected from 1973 through 1977, it appears that station operation has had minimal effects on the distribution and relative abundance of fish populations. Other physical aspects of the habitat and seasonal and yearly changes in flow characteristics probably have greater influence on the adult fishes than the heated effluent. The catch per unit effort data indicate that certain species may be attracted to the heated effluent, while others may avoid it. Since the stretch power thermal plume, as discussed earlier, is only slightly larger than the plume studied since 1973, we believe that the adult fish population will not be adversely affected.

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4.1 Non-Radiological Effects (Continued)

In addition to the entrainment and fish population studies, periphyton and macroinvertebrate monitoring studies were also conducted at the Fort Calhoun Station. Glass slide and rock basket techniques were utilized with 3 week exposures to obtain samples from thermally affected and unaffected zones. Results of these studies indicate that the station's thermal discharge influenced the assemblages of these organisms only in the immediate vicinity of the station's discharge. These effects were localized and rarely statistically significant.

Biochemical reaction rates are normally accelerated by increases in temperature. This was verified by higher productivity (based upon chlorophyll a values of periphyton and biomass of macroinvertebrates) in the immediate area of the thermal discharge. Comparisons of productivity levels further downstream of the thermal discharge were comparable to upstream or unaffected river conditions indicating that the increased productivity was very localized in the immediate discharge area.

Biomass analysis from macroinvertebrates samples was normally greater at the most thermally affected zone, except on certain occasions, which normally occurred during the hot summer months when temperatures were greater than 30°C (86°F). During these periods, the locations upstream from the thermal discharge and downstream of the discharge generally exhibited higher biomass than the location nearest to the immediate discharge.

Being the highest temperatures (> 7°F) will still be located in the area of the immediate discharge when ΔT is increased, the area where biomass may be reduced will be small. The reduction in biomass is not believed to be of any significance due to recovery when temperatures are reduced, annual repopulation from the river and the fact that adult fishes food habits have not been documented to have been affected under the current conditions.

Based upon this evaluation, it is the District's belief that an increase ΔT of approximately 5°F will not cause any major alteration in the Missouri River biota. The total impact from an increase in temperature as a result of stretch power will be minimal due to the mixing characteristics of the submerged discharge, rapid dissipation of heat, short exposure to plume temperatures greater than 5°F ΔT, and the low percentage of river water used for cooling.

*NOTE: All of the above analyses and conclusions conservatively apply to a thermal power of 1500 MWth.

4.2 Radiological Effects

No adverse radiological environmental impact will result from operation at stretch power. All releases are intended to be made in accordance with 10 CFR Part 50, Appendix I, dose design objectives. No significant increase in the amount of radioactivity released to the environs is anticipated.

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Table 4.1-1
Length of Isotherms in Feet Downstream
of the Immediate Thermal Discharge

OPPD Surface Thermal Plumes

Date	% Power	River Flow cfs	7°F	5°F	4°F	3°F	2°F	1°F
High River Flow Conditions								
7-25-75	80	60,500	250	300	310	560	810	>5500
8-21-75	86	64,000	310	400	500	570	1430	>5500
9-5-75	86	67,000	300	375	440	720	2560	>5500
10-16-75	86	64,000	375	470	810	940	2870	>5500
11-4-75	87	6[illegible]00	310	560	670	1250	2560	>5500
12-3-75	87	5[illegible],000	220	375	625	1300	3250	>5500
Average	85.3	63,167	294	413	559	890	2247	>5500
Low River Flow Conditions								
12-2-74	80	18,500	2400	5000	>5500	>5500	>5500	>5500
2-28-77	96	16,800	4700	>5500	>5500	>5500	>5500	>5500
3-16-77	96	22,400	870	3900	5200	>5500	>5500	>5500
Average	90.7	19,233	2657	>4450	>5400	>5500	>5500	>5500
Average River Flow Conditions								
7-26-74	77.5	37,000	650	1300	None	>5500	>5500	>5500
8-8-74	79	36,000	280	440	720	3970	>5500	>5500
9-6-74	79	35,000	300	630	1260	3875	>5500	>5500
10-18-74	80	36,000	400	1688	3040	4750	>5500	>5500
9-3-76	76	40,100	250	525	600	1350	5310	>5500
4-15-76	96	35,000	375	620	1250	1750	4870	>5500
5-6-76	95	39,000	430	1690	2950	4800	>5500	>5500
Average	83.21	36,870	384	985	1637	>3714	>5383	>5500

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Table 4.1-2
Width of Isotherms in Feet Across
River from Nebraska River Bank

OPPD Surface Thermal Plumes

Date	% Power	River Flow cfs	7°F	5°F	4°F	3°F	2°F	1°F
High River Flow Conditions								
7-25-75	80	60,500	65	75	86	100	106	136
8-21-75	86	64,000	65	75	99	110	125	200
9-5-75	86	67,000	38	63	78	90	130	175
10-16-75	86	64,000	34	73	88	100	112	56
11-4-75	87	64,500	52	74	88	108	138	162
12-3-75	87	59,000	27	37	49	68	92	125
Average	85.3	63,167	47	66	81	96	117	142
Low River Flow Conditions								
12-2-74	80	18,500	38	62	75	87	100	132
2-28-77	96	16,800	63	82	95	112	125	145
3-16-77	96	22,400	165	175	183	187	193	212
Average	90.7	19,233	89	106	118	129	139	163
Average River Flow Conditions								
7-26-74	77.5	37,000	125	161	None	200	222	235
8-8-74	79	36,000	75	102	130	170	200	237
9-6-74	79	35,000	60	73	84	104	147	172
10-18-74	80	36,000	31	87	100	125	137	148
9-3-76	76	40,100	65	108	118	129	137	150
4-15-76	96	35,000	78	100	106	118	122	140
5-6-76	95	39,000	71	76	81	84	130	137
Average	83.21	36,870	72	101	103	133	156	174

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SECTION 5 - EFFLUENT ENVIRONMENTAL MEASUREMENT AND MONITORING PROGRAMS

5.1 Non-Radiological Programs

Various non-radiological monitoring programs have been conducted by OPPD and environmental consultants to OPPD. These programs have monitored various media, including surface waters, ground water, air, and land, as described in the following subsections.

5.1.1 Surface Water Monitoring Programs

Surface water programs have included measurement of both physical and chemical parameters and ecological parameters. Table 5.1-1 provides a listing by month from January, 1974, through December, 1975, of the monitoring programs used for measuring physical and chemical parameters of surface waters on or near the site, as well as relevant studies away from the site. Studies in progress or completed prior to January, 1974, are also indicated. The following list describes some of the more important programs used for measuring physical and chemical parameters of surface waters.

Physical Parameter Monitoring

1. Fort Calhoun Continuous Temperature Measurements in the Missouri River (OPPD)

   Upstream river ambient and discharge temperatures at Fort Calhoun Station Unit No. 1 were continuously monitored and recorded prior to 1974 and have been continued through the present. Measurements are currently made from permanently emplaced thermistors upstream out of the influence of the Unit No. 1 intake structure and within the outfall tunnel prior to any mixing with river water. This program is part of the operational monitoring program for the Fort Calhoun Station.

2. Fort Calhoun Surface Thermal Plume Measurement in the Missouri River (OPPD)

   Temperatures within the top 6 inches of river water have been monitored monthly over the entire extent of the station plume from 1973 to present. Measurements are made on a standard grid, and locations in the river were established using optical range finders and river mile markers along the banks. This program is part of the operational monitoring program for the station. Its continuation is not deemed necessary due to the extensive data base generated during the past years. See Section 4 for thermal impact assessment of stretch power.

3. Fort Calhoun Monthly Triple-Depth Temperature Measurements in the Missouri River (OPPD)

   Temperatures are measured at the surface, at half the total depth, and near the river bottom, on a standard

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Table 5.1-1
Physical and Chemical Parameters Measured in the Missouri River and Adjacent Bodies of Water

	PRIOR TO JAN 1974	JAN 1974	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN 1975	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
. Calhoun Continuous Temperature Measurements (OPPD)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Fort Calhoun Thermal Plume Measurements (OPPD)	x		x	x	x	x	x	x	x	x	x	x	x			x	x	x	r	x	x	x	x	x	-
Fort Calhoun Monthly Triple Depth Measurements (OPPD)				x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x
Fort Calhoun Radioactive Waste Disposal System & Steam Generator Blowdown Chemical Discharge (OPPD)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Fort Calhoun Missouri River Water Quality Sampling (OPPD)	x			x	x	x	x	x	x	x	x					x	x	x	x	x	x	x	x		
Fort Calhoun River Water Chemical Analysis taken Upstream & Downstream of Lagoon & Sanitary Waste Discharges (OPPD)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Fort Calhoun Aerial Infrared Surface Scans (OPPD/TI)														x	x										
Fort Calhoun Thermal & Flow Measurements (GHDR)												x						x		x					
Fort Calhoun Comparative Water Quality Studies in the Missouri River, Lateral Slough, & Long Creek (GHDR)															x		x			x			x		
Fort Calhoun Water Quality Measurements in Lateral Slough & Long Creek (GHDR)																	x	x	x	x	x	x	x	x	
George Neal Station Water Quality & Thermal Plume Measurements (Hey & Baldwin)	x																								
Fort Calhoun & Cooper Station Preoperational Water Chemistry & Temperature Measurements (Dept. of Env. Control, State of Nebraska)	x																								
DeSoto Lake Temperature & Water Chemistry Measurements (Huggins)	x																								
Missouri River Water Quality (EPA)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Missouri River, Snyder Bend Lake & DeSoto Lake Water Chemistry (Dillon & Hansen)	x																								
Cooper Station Temperature & Water Chemistry Measurements (Bio-Test)	x			x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x

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SECTION 5 - EFFLUENT ENVIRONMENTAL MEASUREMENT AND MONITORING PROGRAMS (Continued)

5.1 Non-Radiological Programs (Continued)

5.1.1 Surface Water Monitoring Programs (Continued)

3. Fort Calhoun Monthly Triple-Depth Temperature Measurements in the Missouri River (OPPD) (Continued)

grid. Locations were established using an optical range finder and river mile markers. This program is part of the operational monitoring program at the station and is not expected to continue due to the adequate data base already established.

4. Fort Calhoun Radioactive Waste Disposal System and Steam Generator Blowdown Chemical Discharge Monitoring (OPPD)

All radioactive batch discharges and 3 steam generator blowdown samples per week are chemically analyzed. Analyses are used in conjunction with steam generator blowdown rates, monitor tank release rates, and circulating water flows to calculate concentrations of chemical constituents in the circulating water discharge. Analyses for iron, copper, nickel, and chromium were performed according to Technical Specification requirements This program is part of the operational monitoring program for the station.

5. Fort Calhoun Missouri River Water Quality Sampling (OPPD)

Samples for water quality were pumped from the Missouri River into glass carboys by integrated sampling at each of the sites designated in Figure 5.1-1. This water is thoroughly mixed and 2 1-liter aliquots removed for physical and chemical analyses. Such sampling proceeded on a bi-weekly basis in 1972 (June through October) and 1973 (March through October). Sampling frequency increased to weekly in 1974 (March through October) and continued April, 1975, through 1977. The following parameters were measured: water temperature, dissolved oxygen, biochemical oxygen demand, turbidity, ammonia nitrogen, nitrite nitrogen, nitrate nitrogen, organic phosphate, and inorganic phosphate. This program was part of the operational monitoring program for Unit No. 1.

6. Fort Calhoun River Water Chemical Analyses Taken Upstream and Downstream of the Lagoon and Sanitary Waste Discharges in the Missouri River (OPPD)

River water samples were collected and chemically analyzed once per week, upstream of the cooling water

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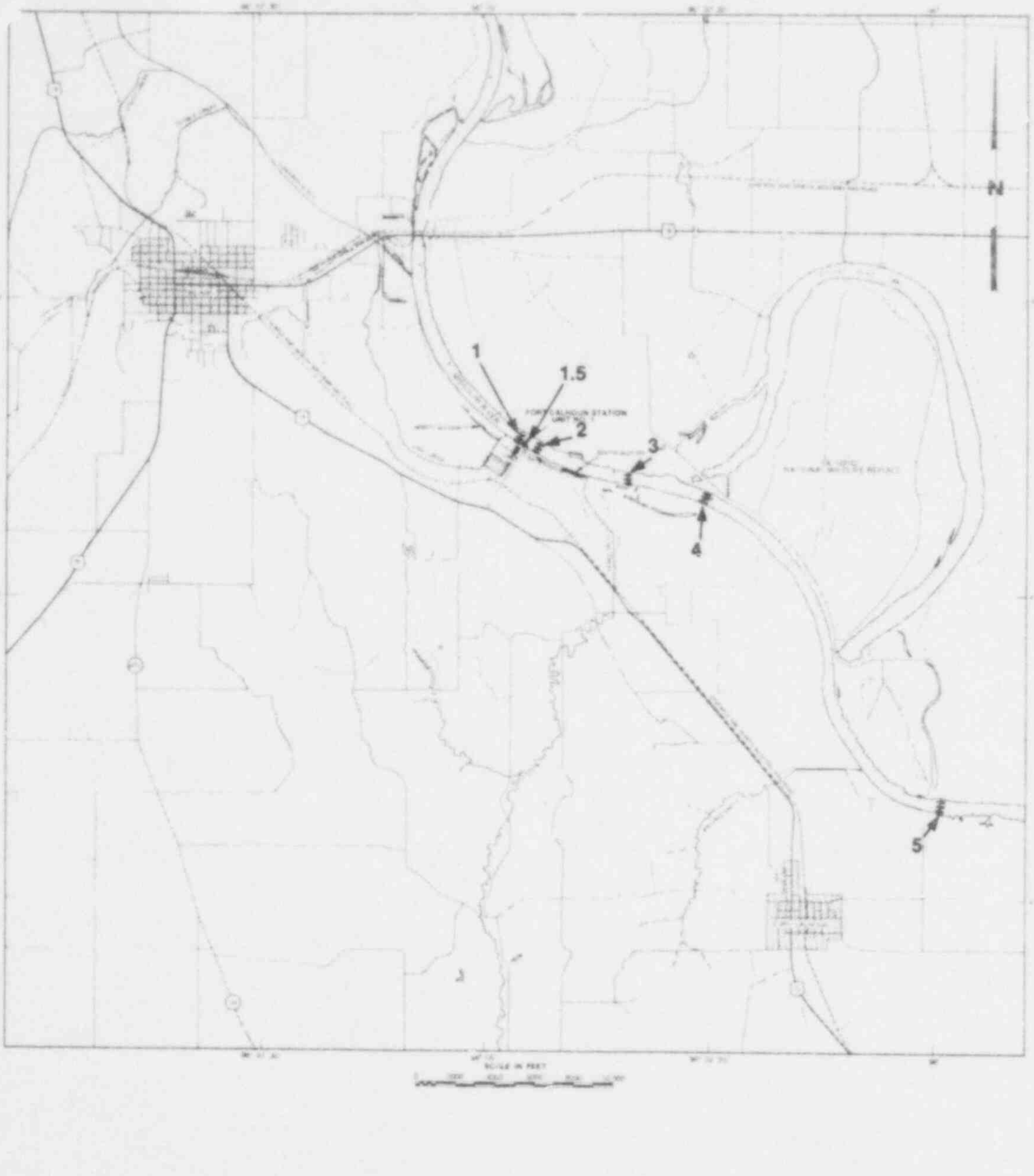

OMAHA PUBLIC POWER DISTRICT FORT CALHOUN STATION	Figure 5.1-1 Pumped Water and Rock Basket Sampling Stations on the Missouri River in the Vicinity of Fort Calhoun Station

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5.1 Non-Radiological Programs (Continued)

5.1.1 Surface Water Monitoring Programs (Continued)

6. Fort Calhoun River Water Chemical Analyses Taken Upstream and Downstream of the Lagoon and Sanitary Waste Discharges in the Missouri River (OPPD)

intake and 75 feet downstream of the lagoon and sanitary waste discharge. This analysis includes pH, alkalinity, methyl orange alkalinity with phenolpthalein, turbidity (Klett Units), oil, total dissolved solids, dissolved oxygen, biochemical oxygen demand, and total coliform bacteria. This program was part of the operational monitoring program for the station, but was suspended, for the sanitary lagoons, when permanent zero discharge retention basins were installed. The program was suspended for chemical lagoons pursuant to a Technical Specification change in January, 1978.

7. Fort Calhoun Aerial Infrared Surface Scans of the Missouri River (OPPD/TI)

Two aerial infrared scans were made in January and February, 1975, by Texas Instruments to characterize the surface thermal plume at times when ice on the river prevented access by boats. This program is part of the operational monitoring program for the station and will continue as needed.

8. Fort Calhoun Thermal and Flow Measurement in the Missouri River (GHDR)

In order to obtain river velocity and temperature within the plume, 2 sampling programs were conducted to examine the flow field on the Fort Calhoun Station discharge. In 1 program, recordings were made at 1 foot intervals to a depth of 10 feet on a grid pattern. In the other program, measurements were made at 2 depths, 2 feet from the surface and 2 feet from the bottom, on a grid pattern more extensive than that used for the 1974 measurements.

9. Fort Calhoun Comparative Water Quality Studies in the Missouri River, Lateral Sloughs, and Long Creek (GHDR)

Water samples were collected in 1975 from the river, between the thermal discharge and the chemical lagoon outfall on February [illegible] and from the Long Creek and the south slough on May 5. These samples were

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5.1 Non-Radiological Programs (Continued)

5.1.1 Surface Water Monitoring Programs (Continued)

9. Fort Calhoun Comparative Water Quality Studies in the Missouri River, Lateral Sloughs, and Long Creek (GHDR) (Continued)

analyzed by Nebraska Testing Labs for the following constituents: carbonate alkalinity, ammonia nitrogen, nitrite nitrogen, nitrate nitrogen, chloride, sulfate, hardness, suspended solids, dissolved solids, phosphate as P, biochemical oxygen demand, sodium, mercury, total coliform bacteria, fecal coliform bacteria, and pH. Samples were also taken at all 3 locations in July and October, 1975.

10. Fort Calhoun Water Quality Measurements in Lateral Sloughs and Long Creek (GHDR)

Measurements of temperature, pH, dissolved oxygen (DO), and conductivity were made at 350 and 1000 feet from the mouth of Long Creek and in the sloughs upstream and downstream from the existing plant. Water quality measurements were taken concurrently with the biological sampling beginning in April, 1975, (except DO which was begun in June, 1975). The measurement program with monthly samples in the slough and biweekly samples in Long Creek were continued through November, 1975.

11. Fort Calhoun and Cooper Station Preoperational Water Chemistry and Temperature Measurements in the Missouri River (Department of Environmental Control, State of Nebraska)

Temperature measurements were taken at 6 points on transects across the Missouri River in July, September, and November, 1970, and April, 1971. The stations were located at the following river mile locations:

Station	Fort Calhoun	Cooper
1	645.9	532.6
2	645.55	532.1
3	640.0	528.6
4	641.4	527.0
5	637.0	523.2
6	633.7	519.7

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5.1 Non-Radiological Programs (Continued)

5.1.1 Surface Water Monitoring Programs (Continued)

11. Fort Calhoun and Cooper Station Preoperational Water Chemistry and Temperature Measurements in the Missouri River (Department of Environmental Control, State of Nebraska) (Continued)

Station 1, at Fort Calhoun Station, was located immediately upstream from the power plant effluent, and at Cooper Station, was located at the north boundary of the plant. Recordings were made at the surface and at 5-foot depth intervals.

Water analyses were made at Fort Calhoun Station and Cooper Station in July, September, and November, 1970, and April, 1971. Dissolved oxygen was measured at all locations where temperature was measured. The other analyses were made of samples taken at Stations 1, 2, 4, and 6 for Fort Calhoun Station and Stations 1, 2, 3, and 6 for Cooper Station. The parameters analyzed were calcium carbonate, hardness, calcium, magnesium, sodium, conductivity, total dissolved solids, sodium absorption ratio, potassium, sulfate, turbidity, carbonate alkalinity, pH, chloride, nitrate nitrogen, and total phosphate.

Ecological Parameter Monitoring

Table 5.1-2 provides a listing of ecological monitoring programs of surface waters conducted through 1975. The following list summarizes important programs.

1. Fort Calhoun Fish Impingement Monitoring Program (OPPD)

Impingement studies have been conducted at Fort Calhoun Station from May, 1973, to the present. Samples were taken daily at noon and midnight, plus or minus 2 hours, from May through October and at noon, plus or minus 2 hours, during November through April. Only 1 of the 6 screens was sampled during each sampling period, but all are sampled on a rotational basis. For the first 20 minutes, the screen being sampled was cleaned. All impinged organisms were then collected for the next 60 minutes and identified, measured for length, and recorded as alive or dead.

Table 5.1-2
Aquatic Ecological Background Field Studies

Ecological parameters	PRIOR TO JAN 1974	JAN 1974	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN 1975	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	CONTINUED MONITORING
FISH																										
Fort Calhoun fish impingement Monitoring Program (OPPD)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Fort Calhoun fish impingement study (GHDR)										x		x		x	x		x	x	x	x	x	x	x	x		
Fort Calhoun Missouri River Reactor Shutdown Monitoring (OPPD)	x					x	x	x	x	x	x	x						x	x	x	x	x	x	x		x
Fort Calhoun Missouri River Monitoring Program (Bio-Test)															x											
Fort Calhoun Long Creek and slough populations (GHDR)																	x	x	x	x	x	x	x	x		
Fort Calhoun and Cooper Nuclear Missouri River (NG&P)	x	x	x	x	x	x	x	x	x	x	x	x			x	x	x	x	x	x	x	x	x	x		x
Missouri River commercial fisheries report (NG&P)	x																									x
Missouri River creel census (Groen)	x																									
Missouri River environmental inventory (Gould & Schmulbach)	x																									
Missouri River catfish (Longemeier; Holz; Morris, et al)	x																									
Lower Missouri River fisheries study (Berner)	x																									
George Neal Station Missouri River study (Hey & Baldwin)	x																									
Cooper Station Missouri River study (Bio-Test)	x					x	x	x	x	x	x	x						x	x	x	x	x	x	x		x
Missouri tributaries basin stream study (NG&P)	x																									
DeSoto Lake study (ICC)																										
FISH LARVAE																										
Fort Calhoun Missouri River monitoring (Bio-Test)	x				x	x	x	x									x	x	x	x						x
Fort Calhoun Missouri River monitoring (OPPD)						x	x	x	x									x	x	x	x					
Fort Calhoun Missouri River monitoring (Hergenrader)					x	x	x	x									x	x	x	x						x
Fort Calhoun creek and slough sampling (GHDR)																			x	x						
Cooper Station Missouri River sampling (Bio-Test)	x					x	x	x										x	x	x						x
MACROINVERTEBRATES																										
DRIFT MACROINVERTEBRATES																										
Fort Calhoun Missouri River Monitoring (Bio-Test)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Fort Calhoun Long Creek and slough sampling (GHDR)																		x	x	x	x	x	x	x		
Middle Missouri River sampling (Morris, et al)	x																									
Middle Missouri River sampling (Holz)	x																									
Middle Missouri River sampling (Langemeier)	x																									
Lower Missouri River sampling (Berner)	x																									
AUFWUCHS																										
Fort Calhoun physiological studies (OPPD)	x			x	x	x	x	x	x	x	x					x	x	x	x	x	x	x	x			x
Fort Calhoun taxonomic studies (NG&P)	x																									
Middle Missouri River sampling (Holz)	x																									
Cooper Station Missouri River sampling (Bio-Test)	x						x	x	x	x	x	x														x
George Neal Station Missouri River sampling (Hey & Baldwin)	x																									
BENTHOS																										
Fort Calhoun Long Creek and slough sampling (GHDR)																	x	x	x	x	x	x	x	x		
Middle Missouri River sampling (Morris, et al)	x																									
Middle Missouri River sampling (Langemeier)	x																									
Lower Missouri River sampling (Berner)	x																									
Cooper Station Missouri River sampling (Bio-Test)	x				x	x		x		x																x
Callaway Plant Missouri River sampling (USNRC)	x		x			x				x																
DeSoto Lake sampling (Huggins)	x																									
ZOOPLANKTON																										
Fort Calhoun Missouri River monitoring (Bio-Test)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Fort Calhoun Long Creek and slough monitoring (GHDR)																		x	x	x	x	x	x	x		
Fort Calhoun Missouri River transects (OPPD)	x			x	x	x	x	x	x	x	x					x	x	x	x	x	x	x	x			x
Missouri River environmental inventory (Dillon & Hansen)	x																									
Lower Missouri River sampling (Berner)	x																									
Cooper Station and North Omaha Station (Bio-Test)	x					x	x	x	x	x	x	x														x
Callaway sampling (USNRC)	x		x			x				x																
George Neal Station Missouri River sampling (Hey & Baldwin)	x																									
DeSoto Lake study (Huggins)	x																									
PERIPHYTON																										
Fort Calhoun Missouri River sampling (OPPD)	x					x	x	x	x	x	x	x						x	x	x	x	x	x	x		x
Fort Calhoun sampling (OPPD)									x	x	x	x														
Fort Calhoun Missouri River sampling (NG&P)	x																									
Cooper Station Missouri River sampling (Bio-Test)	x							x	x	x	x	x														
PHYTOPLANKTON																										
Fort Calhoun Missouri River studies (Bio-Test)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Fort Calhoun Missouri River transects (OPPD)	x			x	x	x	x	x	x	x	x					x	x	x	x	x	x	x	x			x
Fort Calhoun Long Creek and slough sampling (GHDR)																		x	x	x	x	x	x	x		
Missouri River Environmental Inventory (Dillon & Hansen)	x																									
Lower Missouri River studies (Berner)	x																									
Cooper Station and North Omaha Station studies (Bio-Test)	x					x	x	x	x	x	x	x														x
Callaway studies (USNRC)	x		x			x				x																
George Neal Station studies (Hey & Baldwin)	x																									
DeSoto Lake study (Huggins)	x																									

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5.1 Non-Radiological Programs (Continued)

5.1.1 Surface Water Monitoring Programs (Continued)

2. Fort Calhoun Fish Impingement Study (GHDR)

Beginning in September, 1974, an impingement study was begun to assess the diurnal variability in fish impingement rate. Sampling was conducted once in September and 3 times in November, 1974. Sampling in 1975 was conducted once in January, February, and April and twice monthly in May and June. Samples were taken twice monthly July through December. The procedure used was to collect all the organisms impinged on each of the 6 screens every time the screens moved over a 24-hour period. All the organisms collected were identified, weighed, and measured. During all or part of the sampling periods in January, February, May, and December, the screens were running continuously and sampling was conducted for 15-minute intervals every 45 or 75 minutes.

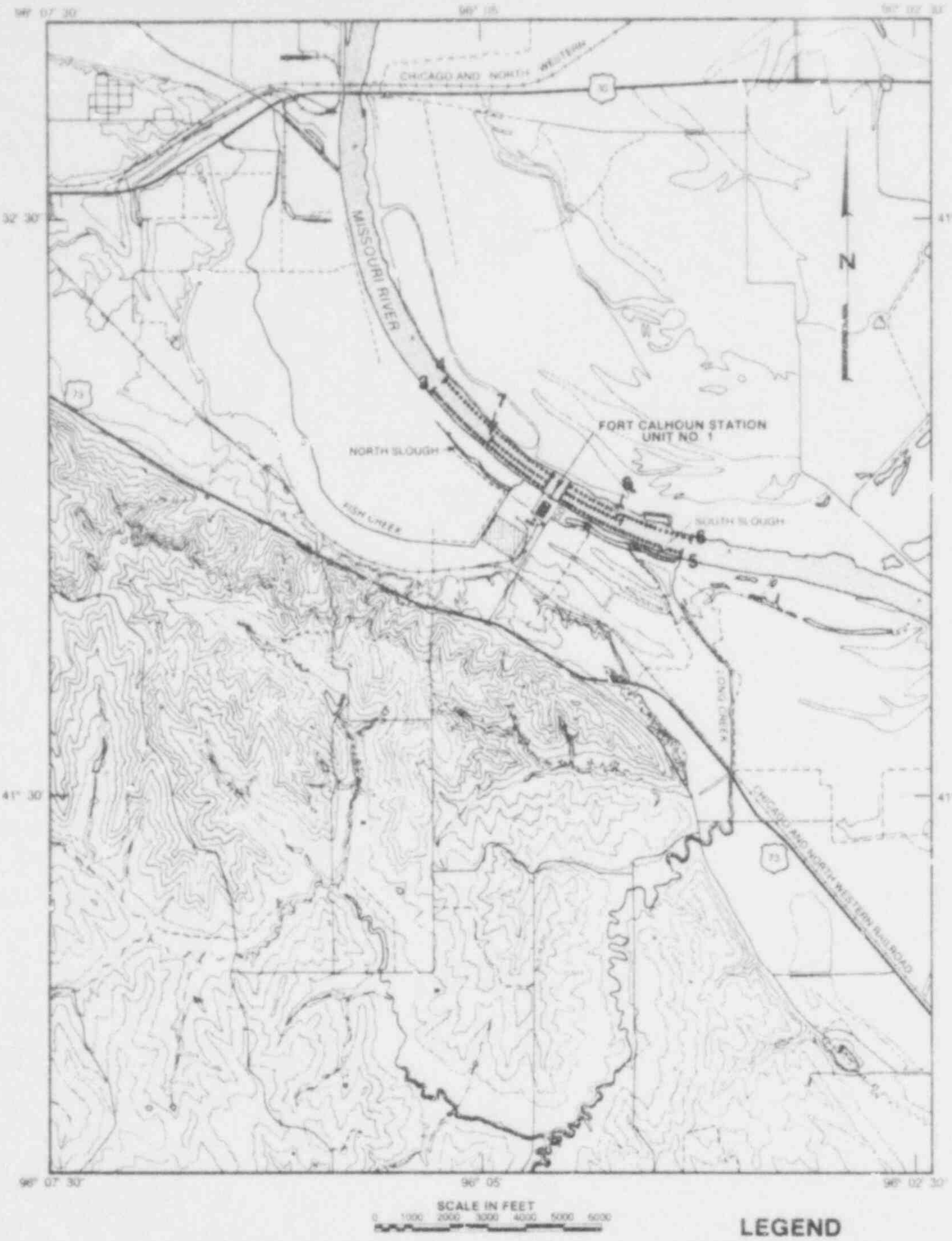
The plant was not generating power from February through April and 2 of the screens were not operating due to maintenance work on them during the February and April sampling periods.

3. Fort Calhoun Missouri River Reactor Shutdown Monitoring (OPPD)

On February 7, 1975, the Fort Calhoun Station was taken out of service until May 9, 1975. The plant was operating at 75 percent power and decreased power by 7 percent per hour during shutdown. The discharge area was visually monitored for aquatic organisms at 255, 285, and 330 feet downstream from the screenhouse by OPPD personnel for 1 hour at the beginning of shutdown and then for 1/2-hour intervals each hour until shutdown was completed.

4. Fort Calhoun Missouri River Monitoring Program (Bio-Test)

Sampling of adult fish at Fort Calhoun Station began in 1973 (October and November) and is continuing with samples taken once monthly May through November by means of electroshocking. Sampling locations are transects parallel to the bank, 1 on each side of the river and 1 in the main channel, above and below the plant for a total of 6 stations (see Figure 5.1-2). The electroshocking catch is summed along the whole transect for each sample.



LEGEND

ADULT FISH SAMPLING LOCATION

OMAHA PUBLIC POWER DISTRICT FORT CALHOUN STATION	Figure 5.1-2 Sampling Locations for Bio-Test Fish Population Study at Fort Calhoun Station in 1973 and 1974

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5.1 Non-Radiological Programs (Continued)

5.1.1 Surface Water Monitoring Programs (Continued)

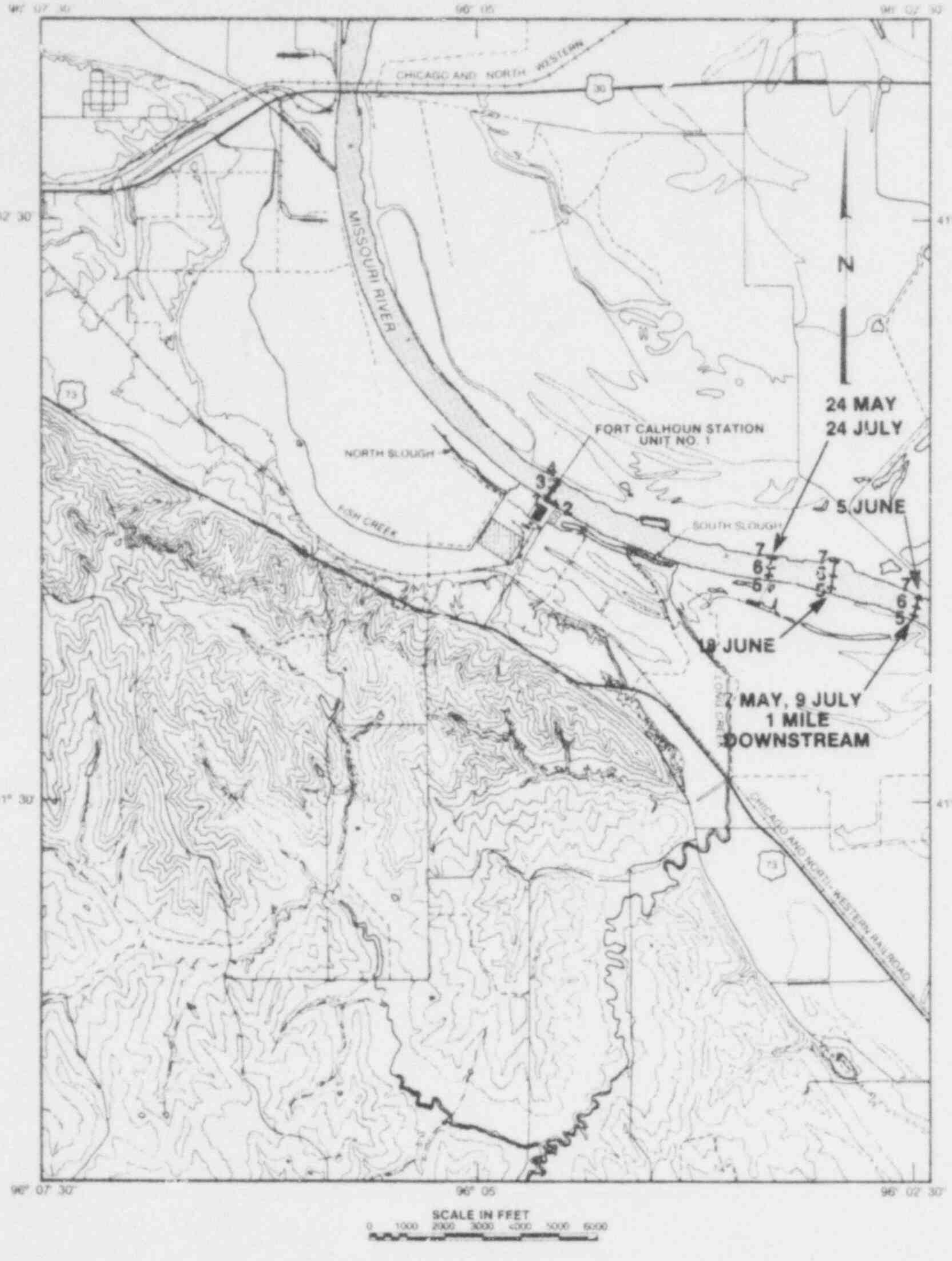
4. Fort Calhoun Missouri River Monitoring Program (Bio-Test) (Continued)

Fish larvae collections were made in the river twice monthly in the spring and summer of 1974 (April through July) by Bio-Test. Duplicate samples were taken at 7 locations in the river in May and June: near the intake, at mid-river, and at the Iowa side at the level of the intake, at the discharge outfall, and at 3 locations on a transect across the river from 0.5 to 3.0 miles downstream from the discharge where the 1 degree C isotherm was measured (see Figure 5.1-3). Larval collections were discontinued at the downstream mid-river location in July. Samples were placed in 5 gallon containers and immediately returned to the laboratory at the site for separation into live-dead fractions.

In 1975 through the present, sampling for fish larvae was conducted during the period of larval drift (May through July). Sampling locations, methods, and statistical analyses were the same as in the 1974 study, with few exceptions.

Duplicate samples of drifting macroinvertebrates were collected beginning with 1 collection in October, 1973, and continuing twice monthly from November, 1973, on for the operational monitoring. These collections are made adjacent to the intake and discharge of the station (see Figure 5.1-4) using a flow-metered conical plankton net. Sample volumes average 1900 cubic feet. Immediately after collection, live and dead organisms are separated and preserved for later identification and enumeration. Percent differential mortality was determined. This program was part of the station's operational monitoring program and was terminated in January, 1978, pursuant to a Technical Specification change.

Duplicate zooplankton samples (not simultaneous) were collected with an Icanberry filter pump system at the intake and discharge of Fort Calhoun Station year-round, monthly sampling beginning in October, 1973. Samples, averaging 10.6 cubic feet, were filtered through a screen and live samples, maintained at upstream ambient water temperature, were examined 0.3, 4, and 24 hours after collection for evidence of motility.



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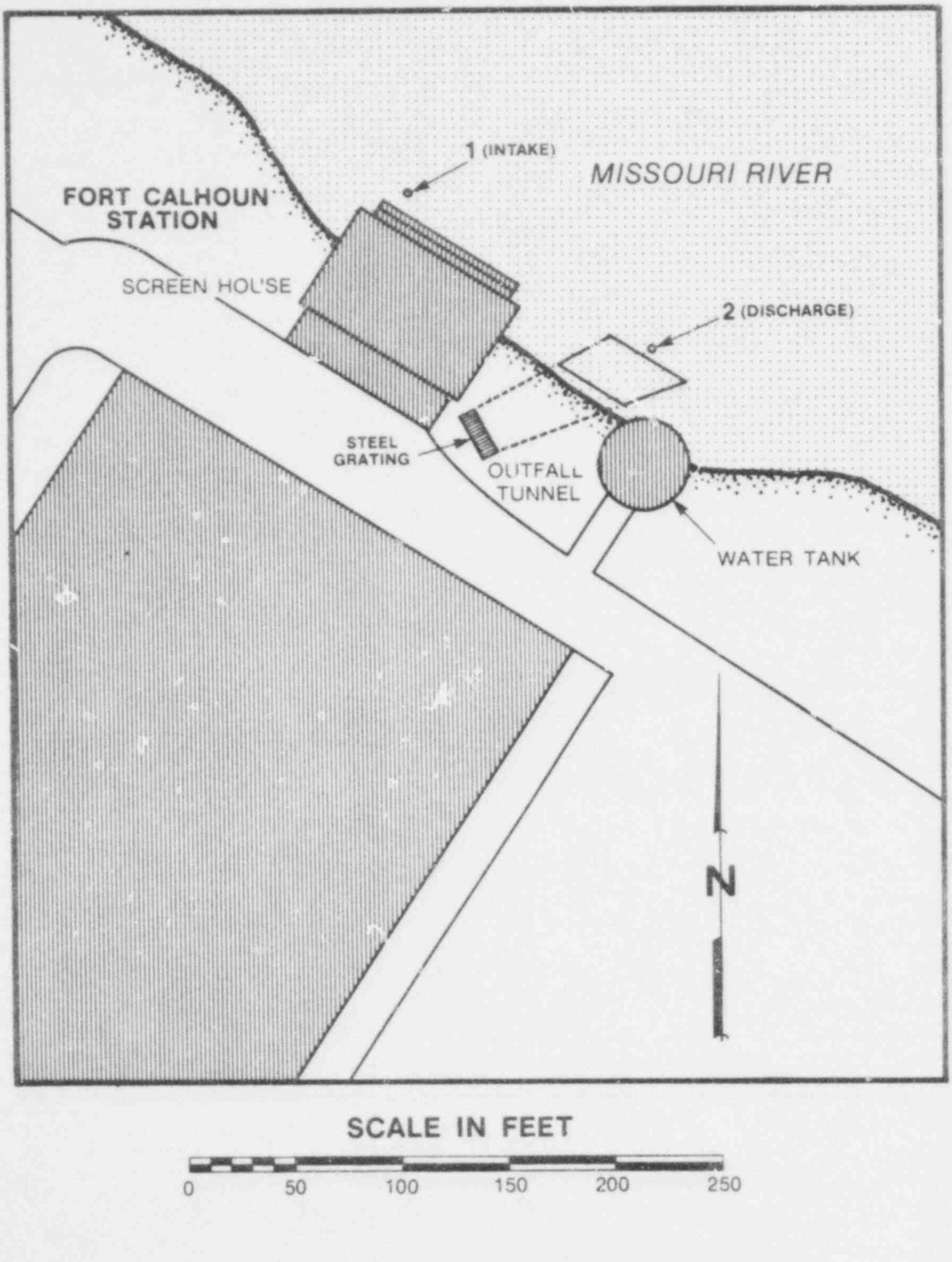
OMAHA PUBLIC POWER DISTRICT FORT CALHOUN STATION	Figure 5.1-3 Sampling Locations for Fish Larvae Entrainment Study at Fort Calhoun Station, 1974



OMAHA PUBLIC POWER DISTRICT FORT CALHOUN STATION	Figure 5.1-4 Drift Macroinvertebrate, Zooplankton, Phytoplankton Entrainment Sampling Locations Fort Calhoun Station, 10/73 Through 12/74

5.1 Non-Radiological Programs (Continued)

5.1.1 Surface Water Monitoring Programs (Continued)

4. Fort Calhoun Missouri River Monitoring Program (Bio-Test) (Continued)

Percent differential immotility and mortality were determined. Zooplankton were preserved at the conclusion of each survival analysis for later identification and counting. This program was part of the station operational monitoring program and continued until January, 1978, when it was terminated pursuant to a Technical Specification change.

Phytoplankton samples were collected by Bio-Test twice monthly year-round beginning in October, 1973, at the intake and discharge of Fort Calhoun Station. Duplicate composite water samples, 6.3 gallons each, were sampled from each location using a 1.6-gallon Kemmerer bottle. Each composite sample was maintained at ambient river temperature in translucent carboys during incubation in diurnally controlled light-dark growth chambers. Carbon fixation rates, chlorophyll a, and ATP concentrations were measured at 7, 24, 48, and 72 hours after sample collection from the intake and discharge. Phytoplankton abundance and species composition were determined for the incubated samples at 7 and 72 hours after collection. Samples were collected during station operation with no temperature differential to determine mechanical effects. This was part of the Unit No. 1 operational monitoring program and was terminated pursuant to a Technical Specification change in January, 1978.

5. Fort Calhoun Long Creek and Slough Populations (GHDR)

Fish were gill-netted in Long Creek once in April and twice monthly in May and June, 1975, and once in the north and south sloughs in June, 1975. Sampling was done twice monthly in Long Creek and monthly in the sloughs from July through November.

Fish were seined in Long Creek at the Chicago and Northwestern Railroad crossing in May and June, 1975, and adjacent to the bluffs in June, 1975. This program was continued monthly at both locations from July through November, 1975.

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5.1 Non-Radiological Programs (Continued)

5.1.1 Surface Water Monitoring Programs (Continued)

5. Fort Calhoun Long Creek and Slough Populations (GHDR) (Continued)

Fish were seined near the mouth of Long Creek in April and in the sloughs from April through June, 1975. Three hauls were made in the creek and 1 to 3 hauls in each of the sloughs. Seining was continued in the sloughs from July through November, 1975.

Fish larvae were collected at Fort Calhoun Station once in May and twice in June and July, 1975. Duplicate night tows were taken once monthly in the mouth of Long Creek in May and June and 1000 feet from the creek mouth in July. Qualitative ichthyoplankton samples were also collected from the north slough, the south slough, and near the mouth of Long Creek once in May and twice monthly in June and July by dip netting. All organisms were preserved for taxonomic enumeration.

Drifting macroinvertebrates were sampled monthly at Fort Calhoun Station in the sloughs and in Long Creek from May through November, 1975. The locations were the same as for GHDR fish larvae samples (Figure 5.1-5).

In order to sample benthos, duplicate Ponar dredge samples of 36 square inches were collected monthly from April through November, 1975, in the north slough, the south slough, and in Long Creek and 9000 feet from the mouth. The samples were sieved through a standard window screen and all the organisms were preserved for identification and enumeration.

Zooplankton samples were collected in the 2 sloughs and Long Creek near Fort Calhoun Station monthly from May through November, 1975. Qualitative samples were collected at night in the mouth of Long Creek in May and June. From July through November, the sampling location was 1000 feet up from the creek mouth during high water. In addition, qualitative samples were collected in the north and south sloughs. Organisms were preserved for identification and enumeration.

Phytoplankton were collected monthly from Long Creek and the north and south sloughs in surface water samples from April through November, 1975. Samples taken were preserved for identification and enumeration.

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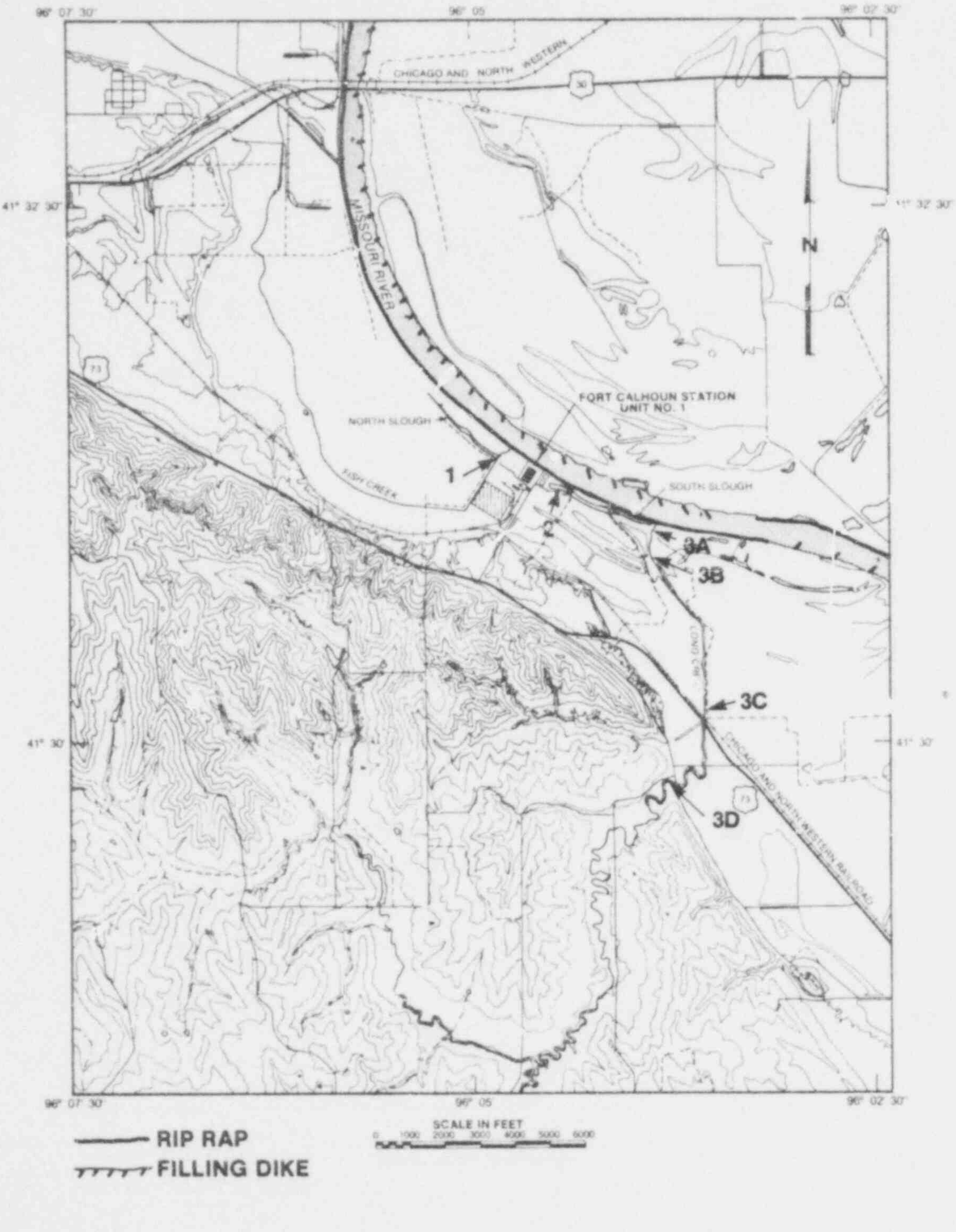

OMAHA PUBLIC POWER DISTRICT FORT CALHOUN STATION	Figure 5.1-5 Aquatic Sampling Stations in Long Creek and the Sloughs Near Fort Calhoun Station

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5.1 Non-Radiological Programs (Continued)

5.1.1 Surface Water Monitoring Programs (Continued)

6. Fort Calhoun Missouri River Monitoring (OPPD)

Fish larvae were collected in the Missouri River on 27 sampling dates between May 8 and August 23, 1974. Four stations at 35, 150, 300, and 450 feet from the Nebraska bank were sampled on a transect across the river at river mile 646 (0.2 mile upstream of Fort Calhoun Station). Subsurface samples were collected using a 30-inch diameter net 70 inches long with 526-micron aperture mesh net. The net was connected to an 11-inch diameter 5-gallon plastic bucket and had a flowmeter mounted in the mouth.

Larval fish and eggs were collected in June, 1975, from the discharge of Fort Calhoun Station Unit No. 1, using the same net described immediately above. The net anchored by a 10-pound weight tied to the bridle, was lowered into the discharge area on approximately 10 feet of line. The sampling duration varied with larval densities, but was approximately 3 minutes. Larvae and eggs were separated from detritus and divided into live, dead, and viable categories. Specimens were then watched for 2 hours, and the normal eggs and living larvae were placed into 1 gallon jars with an air pump to aerate and circulate the water and eggs. Fish were kept in the gallon jars and fed a commercial fish fry food. After the first group of fish eggs died from fungus, a drop of methylene blue was added to later collection jars to inhibit such infestations. Fish and hatching eggs were kept in the 1 gallon jars for 2 weeks, after which they were transferred to a 20-gallon community aquarium and fed a combination of zooplankton and commercial brine shrimp.

Periphyton were collected from the rock baskets. The organisms retained by the 0.45-micron sieve were weighed and tested for caloric content, protein content, respiration, and photosynthetic activity. In addition, the samples were analyzed for chlorophyll a and b. Representative samples were preserved and stored. This program was terminated pursuant to a Technical Specification change.

The thermal plume produced by the Fort Calhoun Nuclear Power Plant influences the periphyton population downstream from the discharge. Pigment analyses were performed on populations obtained from unaffected

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5.1 Non-Radiological Programs (Continued)

5.1.1 Surface Water Monitoring Programs (Continued)

6. Fort Calhoun Missouri River Monitoring (OPPD) (Continued)

and thermally exposed artificial substrates to determine total amounts and proportions of chlorophylls a, b, c, phaeophytin a, and carotenoids. This study was undertaken to test the feasibility of using pigment analysis as an indicator of thermal impact on periphyton populations.

7. Fort Calhoun Missouri River Monitoring (Hergenrader)

Larval fish were sampled in the Missouri River near Fort Calhoun Station April through July, 1974, and 1975 and 1976. Simultaneous duplicate samples were collected both day and night at bi-weekly intervals using 1.6-foot diameter flow metered nets towed 3 feet below the water surface. Stations sampled were the same as those in the Bio-Test fish larvae entrainment sampling program conducted at Fort Calhoun Station. In the 1975 samples, larvae were separated into live and dead fractions, and live larvae were held at ambient river temperature to be observed for delayed effects. The 1976 samples received the same treatment. Specimens were preserved for taxonomic identification and enumeration.

8. Fort Calhoun Physiological Studies (OPPD)

Aufwuchs samples have been collected at Fort Calhoun since 1972 utilizing rock basket samplers, each containing several concrete bricks with a surface area of 326 plus or minus 16 square inches. The baskets were placed at 5 shore stations on both sides of the river located at river miles 646.0, 645.6, 644.8, 641.4, and 640.2 (see Figure 5.1-6). They were sampled every 2 to 4 weeks from March through October of each year. The rock surfaces were picked and scraped for organisms. Each sample was washed with filtered river water and then filtered through 965, 165, and 0.45-micron mesh aperture sieves. Biomass, respiration, caloric measurements were performed on aliquots of those organisms retained by each sieve. Representative specimens and aliquots were preserved for future reference. This program was part of the station operational monitoring program and was terminated pursuant to a Technical Specification change in January, 1978.

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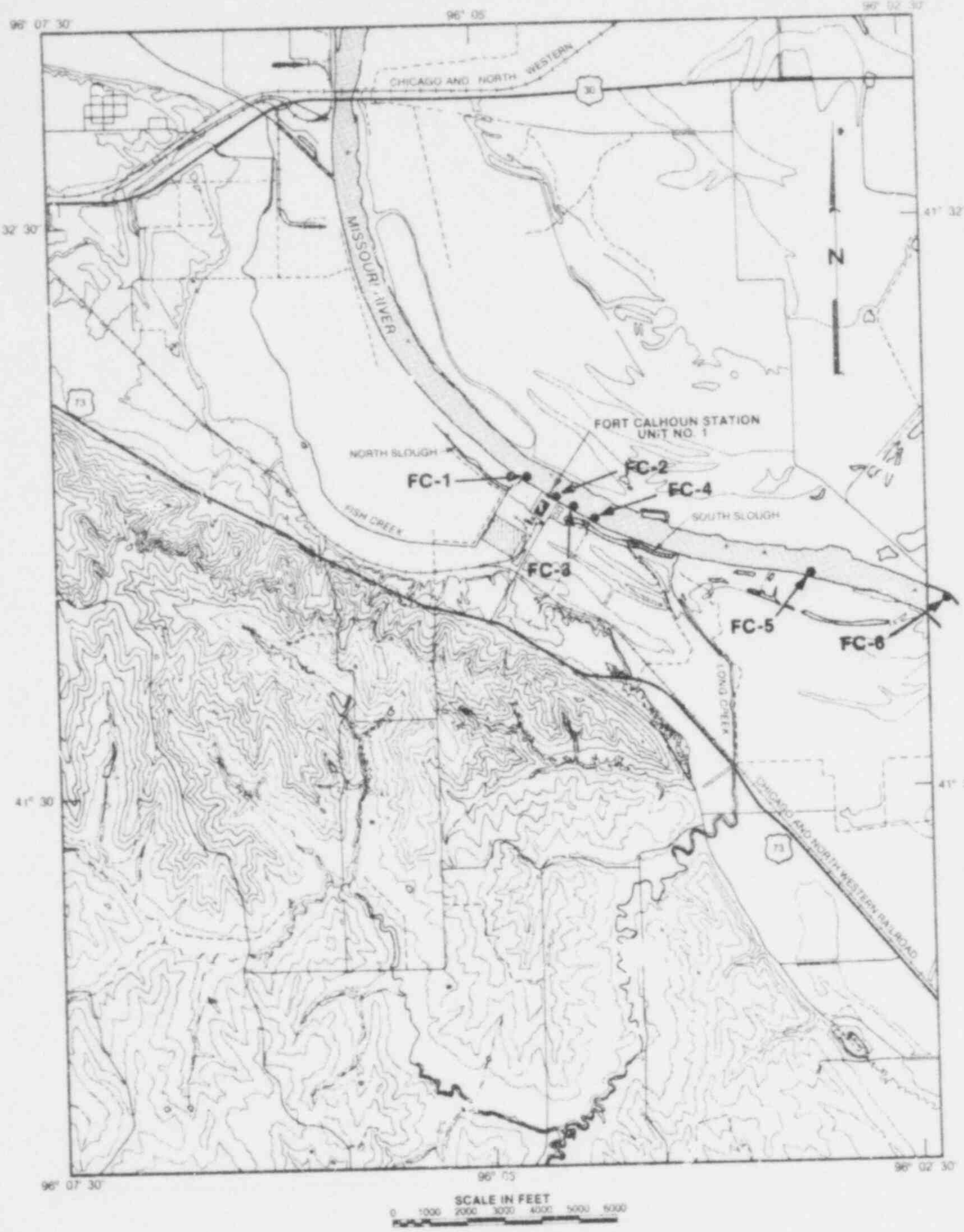

OMAHA PUBLIC POWER DISTRICT FORT CALHOUN STATION	Figure 5.1-6 Sampling Stations Near Fort Calhoun Station Unit No. 1 on the Missouri River for Aufwuchs & Periphyton in 1971

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5.1 Non-Radiological Programs (Continued)

5.1.1 Surface Water Monitoring Programs (Continued)

9. Fort Calhoun Taxonomic Studies (NG&P)

Preoperational rock basket aufwuchs samples were collected at 6 stations near Fort Calhoun Station in 1970 and 1971. Five stations were on the Nebraska side of the river and 1 on the Iowa side (see Figure 5.1-6) at river miles 646.1, 645.9, 645.8, 645.6, 644.4, and 643.8. Rock baskets of crushed limestone were suspended at a depth of 4 feet from the downstream side of pilings for approximately 21 days for each sampling period (May, July, September, and October). The rocks were then cleaned of all organisms, and the washed material was poured through a U. S. Standard #40 mesh screen sieve. The organisms retained were preserved for identification, counting, and determination of wet and dry weight.

10. Fort Calhoun Missouri River Transects (OPPD)

Zooplankton were sampled by pumped water samples collected weekly from March through October since 1972 from 3 points on transects across the river near Fort Calhoun Station (see Figure 5.1-1) at the same river mile locations used for rock baskets. A 1-gallon depth-integrated whole water sample was taken at each of the 3 transect stations and the samples filtered through 965, 164, and 0.45-micron sieves. Biomass, respiratory, and caloric measurements were determined for subsamples of the 3 filtrate fractions. Subsamples were preserved for future reference. Samples were collected and processed on the same schedule for an additional 5 years.

Phytoplankton were collected in a similar manner to the OPPD zooplankton sampling methods. Phytoplankton ranging in size from 165 to 0.45 microns were weighed and tested for caloric content, respiration, and photosynthetic activity. In addition, the samples were analyzed for chlorophyll a and b and protein content. Representative aliquots were preserved and stored (catalogued). Samples were collected and processed as in 1975 for an additional 5 years.

11. Fort Calhoun Missouri River Sampling (NG&P)

Periphyton samples were collected in the Missouri River from June to July, August to September, and in November, 1970, and in May, July, September, and November, 1971, near Fort Calhoun. Duplicate glass slides were

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5.1 Non-Radiological Programs (Continued)

5.1.1 Surface Water Monitoring Programs (Continued)

11. Fort Calhoun Missouri River Sampling (NG&P) (Continued)

suspended 3 inches under the water surface by bouyant slide holders attached to the downstream side of pilings at 6 stations (see Figure 5.1-6). One series of the duplicate slides was analyzed for chlorophyll pigments and the other preserved for identification and enumeration.

12. Larval Fish Recruitment Study (OPPD)

The origins of larvae found in the drift had not been documented, and information showing larvae spawned at locations other than upstream of the Fort Calhoun Station was not available before commencement of the recruitment study. Calculations of the percent of the larvae in the drift removed by the plant could be partially mitigated by demonstrating that larvae are recruited to the drift downstream of the Fort Calhoun Station. In 1978, 4 utilities, sampling a 400 mile stretch of the Missouri River (river mile 808 to river mile 411) both upstream and downstream of the Fort Calhoun Station on 7 transects, determined larval fish concentrations. Boat towed .75 meter diameter plankton nets were used to sample the drift. Calculations of the number of larvae passing each transect were subjected to statistical evaluation. Increases in the number from 1 transect to the next would demonstrate recruitment to the drift. This study will continue in 1979.

13. Backwater Larval Fish Collection Program (OPPD)

Larval fish spawned and raised in local backwater areas (adjacent areas connected to the river, but not receiving full river flow) may be in part responsible for supporting the standing crop of adult fishes in the vicinity of Fort Calhoun Station. Investigations into the production of backwater zones were conducted in 1977 and 1978. Various larval fish collection techniques were utilized to sample the backwater habitats during the spawning season (April-August). Similar studies will take place in 1979.

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5.1 Non-Radiological Programs (Continued)

5.1.2 Ground Water Monitoring Programs

Ground water contours were determined as discussed in Section 2.7. This program is not on-going.

5.1.3 Meteorological Monitoring Programs

The meteorological on-site data acquisition program was begun in June, 1967, by Omaha Public Power District at the Fort Calhoun Station site. Initially, a climatological station was instrumented with standard-type Weather Bureau quality instruments for recording temperature (thermograph), relative humidity (hygrothermograph), precipitation (rain gauge), barometric pressure (barograph), and wind. The wind system, a Meteorology Research, Inc. (MRI) mechanical weather station (MWS), was installed atop a 40-foot fold-over tower at a location adjacent to the Missouri River and slightly south-southeast of the reactor centerline. This tower was operable, producing valid data, until June, 1977. In addition, a hilltop station for recording temperature was instrumented during September, 1968. The hilltop thermograph was the same model as that installed at the climatological station and was located on a 310-foot hill about 1 mile southwest of the reactor. The 310-foot elevation difference between the 2 temperature sensors provided interim vertical temperature gradient measurements. The technique of selection of the temperature differences (delta T) which are representative of the various Pasquill-Turner Stability Classes was based on the various temperature gradient parameters developed at NRTS. Table 5.1-3 presents a list of the above instruments including the description, specifications, and installation levels of each sensor.

During 1970, a Rohn 160-foot guyed weather tower was installed on the Fort Calhoun Station plant site which operated, producing valid data, until June, 1977. The weather tower was located more than 1/2-mile northwest of the reactor building. It was located upwind of the prevailing winds over the reactor in order to more accurately measure the winds prior to their passage over the reactor complex towards the greatest concentrations of population in the area. The weather tower was originally instrumented with 3 aspirated temperature sensors: 1 at an elevation of approximately 32.8 feet above the plant ventilation discharge duct at 117 feet above ground level (AGL), 1 at approximately 32.8 feet below the duct outlet, and the third at approximately 6.6 feet AGL. An MRI "vectorvane" wind system was mounted near 115 feet AGL, the above-duct outlet elevation. See Table 5.1-4 for a list of the above sensors which includes the description, specifications, and installation levels of each. The meteorological sensors listed in Table 5.1-3 were continued for backup.

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Table 5.1-3
Fort Calhoun On-Site Meteorological Measurement Program
(Initial Instrumentation and Recording System)

CLIMATOLOGICAL STATION - FOLD-OVER 40-FOOT TOWER AND HILLTOP STATION				
METEOROLOGICAL INSTRUMENT	MANUFACTURER	INSTRUMENT MODEL	SENSOR LEVEL-(feet)[1]	SENSOR SPECIFICATIONS
Wind direction, speed and temperature (Mechanical weather station)	Meteorology Research, Inc.	MWS 1071	[illegible].6	Direction Starting threshold: <0.75 mph Delay distance: 4 feet (50 percent recovery) Damping ratio: 0.5-0.6 Range: 0 degrees -360 degrees ± 1 percent of full scale (accuracy) Speed Starting threshold: <0.75 mph Response distance: 18 feet (63 percent recovery) Flow coefficient: 7.9 ft/rev. Accuracy: ± 2 percent Temperature: ± 3 degrees F
Temperature (Thermograph)	Bendix Corporation	W-6	5.7	Bimetal strip, accuracy: ± 2 degrees F Calibrated range: -35 to +110 degrees F
			5.7 Hilltop 310.0	Bimetal strip, accuracy: ± 2 degrees F Calibrated range: -35 to +110 degrees F
Relative Humidity (Hygrothermograph)	Belfort Instrument Company	5-594	5.7	Banjo spread human hair, accuracy: ± 4 percent Calibrated range: 0-100 percent Bimetal strip, accuracy: + 2 degrees F Calibrated range: 0-110 degrees F
Precipitation (Rain gauge)	Belfort Instrument Company	5-780	3.3	Weighing gauge, accuracy: ± 1 percent Calibrated range: 0-12 in. water
Barometric Pressure (Barometer)	Belfort Instrument Company	5-800A	4.7	Bellows, accuracy: ± 0.3 millibars Calibrated range: 28.5 - 31.0 in. mercury

[1]All levels are elevations above ground level (AGL).

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Table 5.1-4
Fort Calhoun On-Site Meteorological Measurement Program
(Instrumentation and Recording System)

ROHN GUYED 160-FOOT WEATHER TOWER				
METEOROLOGICAL INSTRUMENT	MANUFACTURER	INSTRUMENT MODEL	SENSOR LEVEL-(feet)[1]	SENSOR SPECIFICATIONS
Wind speed and direction horizontal and vertical (WSI, Al & SDE & SDA, respectively)	Meteorology Research, Inc.	1053 Mark III "Vectorvane"	115	Direction Starting threshold: 0.75 mph Delay distance: 3 feet (50 percent recovery) Damping ratio: [illegible] Range: azimuth 0-540 degrees ± 1 percent (accuracy) elevation -60 degrees to +60 degrees ± 2 percent (accuracy) Speed Starting threshold: 0.75 mph Response distance: 3 feet (63 percent recovery) Range: 0-100 mph ± 0.2 mph or 1 percent (whichever is greater)
Temperature	Meteorology Research, Inc.	YSI Thermilinear No. 44203	84.2	Thermistor accuracy: ± 0.15 degrees C Calibrated range: -30 to 50 degrees C Beckman Whitley Aspirated Shield
Delta Temperature (T1 & T3)	Meteorology Research, Inc.	YSI Thermilinear No. 1001	6.56 147.5	Thermistor accuracy: ± 0.15 degrees C Calibrated range: -30 to 50 degrees C Beckman Whitley Aspirated Shield Copper/constantan, accuracy ± 0.1 degrees C Threshold 0.1 percent range: 0-100 MV Calibrated range: -1.5 to 3.5 degrees F
Recorders	Leeds & Northrup	610XL Multipoint	Reactor Bldg.	

[1]All levels are elevations above ground level (AGL).

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5.1 Non-Radiological Programs (Continued)

5.1.3 Meteorological Monitoring Program (Continued)

Due to the limited amount of data which was being recovered, Omaha Public Power District began an update and an improvement program of the instrumentation system on the Rohn 160-foot weather tower in late 1973. In January, 1974, the updated system became operational and in full compliance with the Regulatory Guide 1.23. In Table 5.1-5 is shown the updated weather tower system with instruments and sensors listed with specifications and mounted elevations of each. The meteorological parameters sensed on the 160-foot Rohn tower were transmitted to a remote recording system which has hard copy strip charts and is located in the control room. In addition, all parameters from the weather tower were stored digitally through a data logger on discs for computer processing to hourly average values which, in turn, were hard copied to hourly data logs.

In 1976, a 110 meter weather tower was installed and became operable. The tower is currently equipped with wind direction, wind speed, ambient temperature, delta temperature, and sigma azimuth meteorological instrumentation located at various levels. Table 5.1-6 provides a listing of meteorological instruments located on the 110 meter tower giving manufacturer, model number, sensor elevation, quantity, and important sensor specifications. Figure 5.1-7 shows the location of the tower, along with former locations of the mechanical tower and Rohn tower discussed above.

5.1.4 Land Monitoring Programs

Non-radiological land monitoring programs consist primarily of Fort Calhoun Station Unit No. 1 and No. 2 preoperational surveys of geological characteristics of the site, seismological investigations, land use and demographic surveys, and surveys of terrestrial ecology. The results of these programs are discussed in Section 2. With the exception of some population surveys required to implement 10 CFR 50, Appendix I, these programs are not on-going.

5.2 Radiological Monitoring Programs

Radiological environmental monitoring programs are designed to provide data concerning the types and amount of radioactivity present in the environment of the Fort Calhoun Station before and during operation. The preoperational program was designed to assess environmental conditions before arrival of fuel and is described in Section 2.10.2 of the Unit No. 1 FSAR. The operational monitoring program is intended to monitor any changes in environmental conditions due to plant operation. It is not expected that any change in the

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Table 5.1-5
Fort Calhoun On-Site Meteorological Measurement Program
(Update Instrumentation and Recording Systems)

ROHN GUYED 150-FOOT WEATHER TOWER				
METEOROLOGICAL INSTRUMENT	MANUFACTURER	INSTRUMENT MODEL	SENSOR LEVEL-(feet)[1]	SENSOR SPECIFICATIONS
Wind direction and speed (WDRT1 & WSRT1) (WDRT2 & WSRT2)	Meteorology Research, Inc.	1074 wind system	36.3 117.8	Direction Starting threshold: 0.75 mph Delay distance: 4 feet (50 percent recovery) Damping ratio: 0.5-0.6 Range: 0 degrees -540 degrees ± 1 percent (accuracy) Speed Starting threshold: 0.75 mph Response distance: 18 feet (63 percent recovery) Flow coefficient: 7.9 ft/rev. Range: 0-80 mph Accuracy: ± 0.4 mph
Temperature	Meteorology Research, Inc	YSI Thermilinear No. 44203	32.1 5.7	Thermistor, accuracy: 0.15 degrees C Calibrated range: -30 to 50 degrees C Beckman Whitley Aspirated Shield
Delta Temperature (DTRT)	Meteorology Research, Inc.	YSI Thermilinear No. 1001	32.3 147.5	Thermistors, accuracy, ± 0.15 degrees C Calibrated range: -5.4 to 5.4 degrees F Beckman Whitley Aspirated Shield
Recorders	Leeds & Northrup	AZAR "Speedomax-H", Multipoint	Reactor Bldg.	Copper/constantan, accuracy ± 0.1 degrees C Threshold 0.1 percent Calibrated range: -1.5 to 3.5 degrees F

CLIMATOLOGICAL STATION - FOLD-OVER 40-FOOT TOWER				
METEOROLOGICAL INSTRUMENT	MANUFACTURER	INSTRUMENT MODEL	SENSOR LEVEL-(feet)[1]	SENSOR SPECIFICATIONS
Wind direction, speed and temperature (WSMT & WDMT)	Meteorology Research, Inc.	MWS 1071	43.6	Direction Starting threshold: <0.75 mph Delay distance: 4 feet (50 percent recovery) Damping ratio: 0.5-0.6 Range: 0 degrees -360 degrees ± 1 percent of full scale (accuracy) Speed Starting threshold: <0.75 mph Response distance: 18 feet (63 percent recovery) Flow coefficient: 7.9 ft/rev. Accuracy: ± 2 percent Temperature: ± 3 degrees F
Temperature	Bendix Corporation	W-6	5.7	Bimetal strip, accuracy: ± 2 degrees F Calibrated range: -35 to +110 degrees F
			5.7 Hilltop 310	Bimetal strip, accuracy: ± 2 degrees F Calibrated range: -35 to +110 degrees F
Relative Humidity	Belfort Instrument Company	5-594	5.7	Banjo spread human hair, accuracy: ± 4 percent Calibrated range: 0-100 percent Bimetal strip, accuracy: ± 2 degrees F Calibrated range: 0-100 degrees F
Precipitation	Belfort Instrument Company	5.780	3.3	Weighing gauge, accuracy: ± 1 percent Calibrated range: 0-12 in. water
Barometric Pressure	Belfort Instrument Company	5-800A	4.7	Bellows, accuracy: ± 0.3 millibars Calibrated range: 28.5-31.0 in. mercury

[1]All levels are elevations above ground level (AGL).

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Table 5.1-6
Fort Calhoun 110 Meter Tower Instruments

Meteorological Instrument	Manufacturer	Instrument Model	Sensor Elevation (ft)	Instrument Quantity	Sensor Specifications
Wind Direction	Climatronics	F460	1365.9 (at 110M) 1152.6 (at 45M) 1037.8 (at 10M)	1 1 2	Azimuth 0-540° Starting Threshold 0.9 mph Accuracy ± 5° Damping Ratio 0.6 Delay Distance 4 ft
Wind Speed	Climatronics	F460	1365.9 (at 110M) 1152.6 (at 45M) 1037.8 (at 10M)	1 1 2	Speed Range 0-100 mph Starting Threshold 0.9 mph Accuracy ± 0.5 mph Response Distance 8 ft
Ambient Temperature	Climatronics	TS-10	1037.8 (at 10M)	3	Range -50°C to +50°F Accuracy ± 0.10°C
Delta Temperature	Climatronics	YSI-703	1037.8 - 1365.9 (at 110M - 10M)	3	Range -5°C to +15°C Accuracy ± 0.1°C
Sigma Azimuth	Climatronics	Special	1365.9 (at 110M) 1037.8 (at 10M)	1 2	Azimuth 0-540° Starting Threshold 0.9 mph Accuracy ± 5° Damping Ratio 0.6 Delay Distance 4 ft

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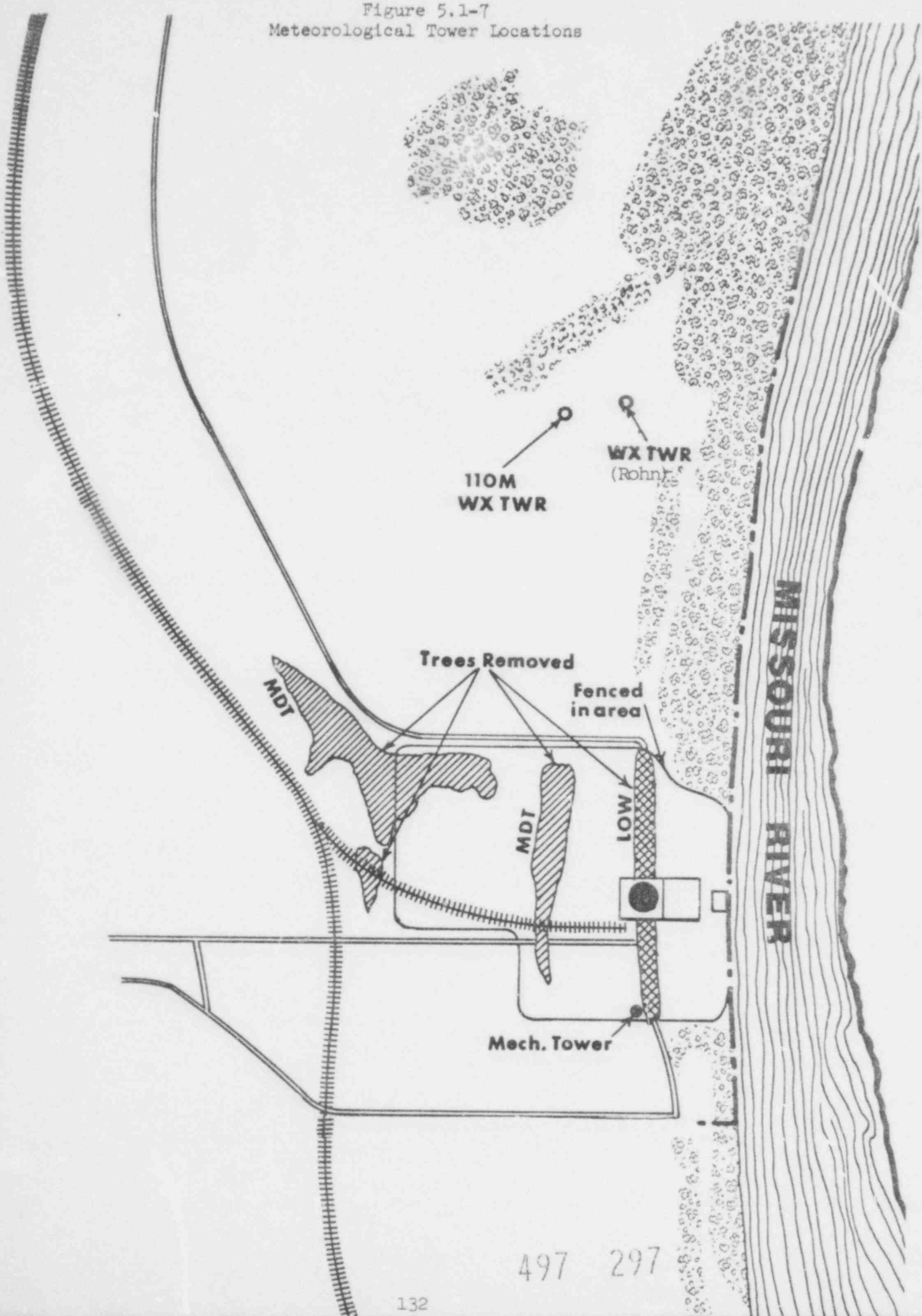
Figure 5.1-7
Meteorological Tower Locations



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5.2 Radiological Monitoring Programs (Continued)

environmental operational monitoring program will be required as a result of stretching power at the station.

Section 3.11 of the Fort Calhoun Station Technical Specifications provides a schedule of environmental samples routinely taken and evaluated for radioactivity content. This schedule provides sample type, collection frequency, analysis frequency, and number of samples. Sensitivity requirements and sensitivity of the analysis is provided by Tables 3-10 and 3-11, respectively, of the Technical Specifications. Figure 2.10-1 of the Unit No. 1 FSAR depicts locations from which samples are taken.

In addition to environmental monitoring, all liquid and gaseous discharges are analyzed prior to release and are continuously monitored during release. The amount of radioactivity released is documented as a standard plant operating procedure and is reported routinely in the Fort Calhoun Station Semi-Annual Report. In-plant radiological monitoring and radwaste handling is currently being evaluated by the Commission in connection with assessment of station compliance with 10 CFR 50, Appendix I.

SECTION 6 - ENVIRONMENTAL EFFECTS OF ACCIDENTS

6.1 Radiological Consequences Study of a Fuel Handling Accident in the Spent Fuel Pool

6.1.1 Physical Model

The possibility of a fuel handling accident is remote because of the many administrative controls and physical limitations imposed on the fuel handling operations.

Should a fuel assembly be dropped or otherwise damaged during handling, radioactive release could occur in either the containemnt or the auxiliary building. The ventilation exhaust air from both of these areas is monitored before release to the atmosphere.

The potential radiological consequences resulting from the occurrence of a postulated fuel handling accident in the spent fuel pool have been analyzed using assumptions and parameters that are consistent with Regulatory Guide 1.25 recommendations. A description of the mathematical model utilized in the dose calculations is included.

6.1.2 Assumptions and Conditions

The calculational methods and assumptions described in Regulatory Guide 1.25 were assumed as: (1) the values for maximum fuel rod pressurization, (2) peak linear power density for the highest power assembly discharged, (3) maximum centerline operating fuel temperature for the assembly in item (2) above, and (4) average burnup for the peak assembly above are assumed less than the corresponding values in Regulatory Guide 1.25.

An evaluation of the failure of all fuel rods in a fuel rod assembly (176 fuel rods) was not performed since this evaluation is performed only to demonstrate the capabilities of the fuel handling building ventilation system.

6.1.3 Mathematical Models Used

1. Inhalation Thyroid Dose

The inhalation dose to the thyroid due to iodine can be determined by use of the following equation in accordance with Regulatory Guide 1.25:

$$D = \frac{F_g I F P B \, (X/Q)(DCF)}{(DF_p)\,(DF_f)}$$

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Table 6.1-1
Parameters Used in Evaluating the Radiological Consequences of a Fuel Handling Accident

Parameter	Assumptions	Reference
Source Data:		
Power level, Mwt	1500	FSAR
Radial peaking factor	1.65	FSAR
Burnup	15-15-18 month cycle reload scheme at full power	
Decay time, h	72	FSAR
Number of failed rods	56	
Fraction of fission product gases contained in the gap region of the fuel rods, %		Regulatory Guide 1.25
Kr-85	30	
Other Noble Gases	10	
Iodine	10	
Activity Release Data		Regulatory Guide 1.25
Fraction of gap activity released to pool, %	100	
Minimum water depth above damaged rods, ft	23	
Pool decontamination factor for noble gases	1	

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Table 6.1-1
(Continued)
Parameters Used in Evaluating the Radiological Consequences of a Fuel Handling Accident

Parameter	Assumptions	Reference
Effective iodine decontamination factor for pool water	100	Regulatory Guide 1.25
Iodine chemical form released to fuel building		Regulatory Guide 1.25
Elemental iodine, %	75	
Organic iodine, %	25	
Charcoal filter availability	Assumed not available	
Activity released to fuel pool, Ci		
Isotope		
I-131	6.14×10^3	(a)
Xe-131m	5.00×10^1	
Xe-133	1.24×10^4	
Kr-85	2.41×10^2	
Dispersion Data		
Distance to exclusion area boundary, m	910	

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Table 6.1-1
(Continued)
Parameters Used in Evaluating the Radiological Consequences of a Fuel Handling Accident

Parameter	Assumptions	Reference
Distance to LPZ outer boundary, m	4828	
Atmospheric dispersion factors, sec/m^3		
EAB	4.4×10^{-4}	
LPZ (0-8 Hrs)	1.57×10^{-5}	

(a) Determined from Regulatory Guide 1.25 assumptions and core inventories based on plant operation at full power with burnup at 15-15-18 month cycle reload scheme.

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TABLE 6.1-2

Dose Factors

ISOTOPIC PARAMETERS

Isotope	Half-Life	MeV/Disintegration (gamma)	Average MeV/Disintegration (beta)
I-131	8.06 D	0.381	0.194
I-132	2.28 H	2.333	0.519
I-133	21 H	0.608	0.403
I-134	52 M	2.529	0.[illegible]
I-135	6.7 H	1.635	0.4[illegible]5
Kr-83m	1.86 H	0.002	0.037
Kr-85m	4.48 H	0.159	0.253
Kr-85	10.73 Y	0.002	0.251
Kr-87	76.31 M	0.793	1.324
Kr-88	2.80 H	1.950	0.375
Xe-131m	11.9 D	0.20	0.143
Xe-133m	2.25 D	0.0416	0.190
Xe-133	5.29 D	0.0454	0.135
Xe-135m	15.65 M	0.432	0.095
Xe-135	9.15 H	0.247	0.316
Xe-138	14.17 M	1.183	0.606
H-3	12.3 Y	None	0.006

IODINE DOSE CONVERSION FACTORS

Isotope	Rem-thyroid/Curie Inhaled
I-131	1.48×10^{6}
I-132	5.35×10^{4}
I-133	4.00×10^{5}
I-134	2.50×10^{4}
I-135	1.25×10^{5}

BREATHING RATES

Time after Accident	m^3/s
0 to 8 hours	3.47×10^{-4}
8 to 24 hours	1.75×10^{-4}
1 to 30 days	2.32×10^{-4}

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6.1 Radiological Consequences Study of a Fuel Handling Accident in the Spent Fuel Pool (Continued)

Where:

D is the thyroid dose (rems)
Fg is the fraction of fuel rod iodine inventory in fuel rod void space (0.1)
I is the core iodine inventory at time of accident (curies)
F is the fraction of core damaged so as to release void space iodine
P is the fuel peaking factor
B is the breathing rate (cubic meter per second)
DF_p is the effective iodine decontamination factor for pool water
DF_f is the effective iodine decontamination factor for filters
χ/Q is the atmospheric dispersion factor at receptor location (second per cubic meter)
DCF is the adult thyroid dose conversion factor for the iodine isotope of interest (rems per curie inhaled)

2. Whole Body Doses

The external whole body doses are calculated using semi-infinite cloud assumption. The beta skin dose rate equation is:

$$D = 0.23\ \overline{E}_\beta \chi$$

The gamma whole body dose rate equation is:

$$D = 0.25\ \overline{E}_\gamma \chi$$

Where:

D = dose rate from semi-infinite cloud (rads/hour)
$\overline{E}_\beta$ = average beta energy per disintegration
$\overline{E}_\gamma$ = average gamma energy per disintegration
χ = concentration of beta or gamma emitting isotope in the cloud (curie/m^3)

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Table 6.1-3
Radiological Consequences of a Postulated Fuel Handling Accident in the Fuel Building

Result	Value (56 fuel rods)
Exclusion Area Boundary Dose (0-2h), rem	
Thyroid	3.74×10^{1}
Beta-skin	1.76×10^{-1}
Total body gamma	6.35×10^{-2}
LPZ Outer Boundary Dose (duration), rem:*	
Thyroid	1.34
Beta-skin	6.29×10^{-3}
Total body gamma	2.27×10^{-3}

Results:

As these values for thyroid and whole body gamma dose show the dose calculated using these conservative assumptions are well within the limits of 10CFR100.

*For conservatism, the LPZ dose calculations are based on a dispersion factor for 0-8 hours.

6.1 Radiological Consequence Study of a Fuel Handling Accident in the Spent Fuel Pool (Continued)

6.1.4 Uncertainties and Conservatisms

The uncertainties and conservatisms in the assumptions used to evaluate the radiological consequences of the fuel handling accident in the spent fuel pool are as follows:

1. The gas gap activity inventory is conservatively calculated based upon plant operation at full power with burnup at 15-15-18 month cycle reload scheme.

2. The number of fuel rods that are assumed to fail in the assembly is a conservative number for the design case.

3. No credit is taken for iodine decontamination factor for the filtration system in the spent fuel pool area.

6.2 Radiological Consequences Study of a Fuel Handling Accident in Containment

6.2.1 Physical Model

The potential radiological consequences resulting from the occurrence of a postulated fuel handling accident inside the containment building have been analyzed using assumptions and models presented in Table 6.2-1.

The analysis investigated the possibility of activity release through the containment purge system and found that no release via the purge exhaust system is expected. The automatic closure of the containment isolation dampers, due to increased activity level, preclude any radiological releases.

6.2.2 Assumptions and Conditions

As a very conservative accident estimate, the following assumptions will be made:

1. All fuel rods in the dropped assembly fail (176 fuel rods).

2. No credit for containment isolation.

3. No credit for iodine filtration (except pool decontamination) or mixing within the containment.

4. Radioactivity released, instantaneously reaches the dose evaluation point (EAB), that is, no credit taken for decay.

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Table 6.2-1
Parameters Used in Evaluating the Radiological Consequences of a Fuel Handling Accident in Containment

Parameter	Assumptions	Reference
Source Data:		
Power Level, Mwt	1500	
Radial Peaking Factor	1.65	
Burnup	15-15-18 month cycle reload scheme at full power	
Decay Time, hr	72	
Number of Failed Rods	176	
Activity Release Data:		
Fraction of gap activity released to pool	100	Reg.Guide 1.25
Pool Decontamination Factor for Noble Gases	1	Reg.Guide 1.25
Factor for Iodine		
Inorganic	133	Reg.Guide 1.25
Organic	1	Reg.Guide 1.25
Iodine Chemical Form Released to Containment Building		
Elemental, %	75	Reg.Guide 1.25
Organic, %	25	Reg.Guide 1.25
Activity Released to Containment Pool, Ci:		
Kr-85	7.5×10^{2}	(a)
Xe-131m	1.57×10^{2}	
Xe-133	3.89×10^{4}	
I-131	1.93×10^{4}	
Dispersion Data:		
Distance to Exclusion Area Boundary, EAB, m	910	
Atmospheric Dispersion Factor, χ/Q, sec/m^3	4.4×10^{-4}	
Containment Building Design Parameters:		
Containment Isolation Iodine Removal Efficiency	None	
Release Location	Radioactivity released instantaneously reaches the dose evaluation point (EAB)	

(a) Determined from Regulatory Guide 1.25 assumptions and core inventories based on plant operation at full power (1% failed fuel) with burnup at 15-15-18 month cycle reload scheme.

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Table 6.2-2
Radiological Consequences of a Postulated Fuel Handling Accident in the Containment Building

Result	Value (175 fuel rods)
Exclusion Area Boundary Dose (0 to 2 hr), rem	
Thyroid	3.74×10^{1}
Total body gamma	2.06×10^{-1}

Results.

As these values for thyroid and whole body gamma dose show, even without a containment building, the dose calculated using these conservative assumptions are well within the limits of 10CFR100.

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6.2 Radiological Consequences Study of a Fuel Handling Accident in Containment (Continued)

6.2.2 Assumptions and Conditions (Continued)

It is assumed that the activity released from a dropped assembly is equal to the maximum gas gap activity of the assembly. This activity, except for those iodines filtered out by the pool, is assumed to be released to the EAB instantaneously.

The major assumptions and parameters assumed in the analysis are itemized in Table 6.2-1.

6.2.3 Mathematical Models Used

Mathematical models used in the analysis are described in the following sections:

1. The atmospheric dispersion factors used in the analysis are based on meteorological conditions assumed present during the course of the accident.

2. The potential thyroid inhalation dose and total-body gamma immersion dose to an individual exposed at the exclusion area boundary are analyzed using the model described in subsection 6.1.3 and results are listed in Table 6.2-2.

6.2.4 Uncertainties and Conservatisms

The uncertainties and conservatisms in the assumptions used to evaluate the radiological consequences of the fuel handling accident in containment are as follows:

1. The radioactivity releases as a result of the fuel handling accident, instantaneously reached the dose evaluation point.

2. No credit is taken for containment isolation.

3. No credit for iodine filtration (except pool decontamination) or mixing within the containment.

4. All fuel rods in the assembly are assumed to fail (176 fuel rods).

5. The gas gap inventory is conservatively calculated based upon plant operation at full power with burnup at 15-15-18 month cycle reload scheme.

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6.3 Radiological Consequences of a Gas Decay Tank Rupture

6.3.1 Physical Model

The most limiting waste gas accident is defined as an unexpected and uncontrolled release to the atmosphere of the radioactive Xenon and Krypton fission gases and Iodines that are stored in one waste gas decay tank.

This accident is considered a limiting fault, and a rupture of a waste gas decay tank is analyzed to define the worst consequences of a gaseous release that could result from any malfunction in the gaseous radwaste system.

6.3.2 Assumptions and Conditions

The major assumptions and parameters assumed in the analysis are itemized in Table 6.3-1

It is assumed that the plant has been operating at 1500 Mwt with 1% failed fuel for an extended period, sufficient to achieve equilibrium radioactive concentrations in the reactor coolant. The maximum gas activity would occur after shutdown and coolant degasification.

It is also assumed that the activity released from a gas decay tank rupture is the maximum quantity that can be contained within the tank at its maximum operating pressure of 100 psig (when the core is operating at 1% failed fuel).

The tank is assumed to rupture and all of the noble gases and iodines assumed to be released to the atmosphere in a 2-hour period, consistent with Regulatory Guide 1.24.

Table 6.3-1 lists the conservative assumptions for waste gas decay tank rupture and waste gas decay tank inventory prior to release.

6.3.3 Mathematical Models Used

1. Inhalation Thyroid Dose

The inhalation dose to the thyroid due to iodine can be determined from the following equation:

$$D = Q \cdot B \cdot t \; (^{X}/Q) \; (DCF)$$

Where:

D is the thyroid dose (rems)
Q is the average iodine release rate (curies/second)
B is the breathing rate ($meter^3$/second)

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Table 6.3-1
Assumptions for Waste Gas Decay
Tank Release Accident

Parameter	Assumption	Reference
A. Source Data		
1. Power Level, Mwt	1500	FSAR
2. RCS Radioactive Concentrations	Maximum Values based on 1% failed fuel	FSAR Regulatory Guide 1.24
3. Decay Time, hrs.	0	FSAR
	All gases stripped from processing the entire RCS volume are immediately passed to gas decay tank which fails. Accident occurs immediately following a cold shutdown releasing entire tank inventory.	Regulatory Guide 1.24
4. Gas Decay Tank (i) volume, scf (ii) pressure, psig	 2875 100	FSAR
5. Tank Activity, Ci		
Isotope		(a)
I-131	2.631×10^{-2}	
I-132	4.209×10^{-3}	
I-133	2.762×10^{-2}	
I-134	1.973×10^{-3}	
I-135	9.734×10^{-3}	
Kr-85m	$8.024 \times 10^{+2}$	
Kr-85	$5.261 \times 10^{+2}$	
Kr-87	$4.341 \times 10^{+2}$	
Kr-88	$1.447 \times 10^{+3}$	
Xe-131m	$5.656 \times 10^{+2}$	
Xe-133	$9.602 \times 10^{+4}$	
Xe-135	$3.025 \times 10^{+3}$	
Xe-138	1.973×10^{2}	

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Table 6.3-1
Assumptions for Waste Gas Decay
Tank Release Accident

Parameter	Assumption	Reference
B. Activity Release:	All gases released from tank leak from auxiliary building at ground level within 2 hour period	FSAR Regulatory Guide 1.24
C. Dispersion Data, X/Q (i) EAB (ii) LPZ (0-8 hrs)	 4.4×10^{-4} sec/m^3 1.57×10^{-5} sec/m^3	

(a) Determined from a 23,720 ft^3 volumetric gas flow and conservative influent specific activities when the core is operating a 1% failed fuel, into a 2875 scf gas decay tank.

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Table 6.3-2
Radiological Consequences of a Postulated
Gas Decay Tank Rupture

Radiological Exposures (rem)	EAB	LPZ*
Thyroid	7.86×10^{-3}	2.8×10^{-4}
Whole Body Gamma	9.61×10^{-1}	3.48×10^{-2}
Beta Skin	1.57	5.61×10^{-2}

Results:

As these values for thyroid and whole body gamma dose show the dose calculated using these conservative assumptions are well within the limits of 10CFR100.

*For conservatism, the LPZ dose calculations are based on a dispersion factor for 0-8 hours.

6.3.3 Mathematical Models Used (continued)

t is the exposure time (seconds)
X/Q is the dispersion factor at the receptor location (seconds/meter^3)
DCF is the adult thyroid dose conversion factor for the iodine isotope of interest (rems/curie inhaled)

2. Whole Body Doses

The external whole body doses are calculated using semi-infinite cloud assumption. The beta skin dose rate equation is:

$$D = 0.23\ \overline{E}_\beta \chi$$

The gamma whole body dose rate equation is:

$$D = 0.25\ \overline{E}_\gamma \chi$$

Where:

D = dose rate from semi-infinite cloud (rads/hour

$\overline{E}_\beta$ = average beta energy per disentegration

$\overline{E}$ = average gamma energy per disentegration

χ = concentration of beta or gamma emitting isotope in the cloud (curie/m^3)

6.3.4 Uncertainties and Conservatisms

The uncertainties and conservatisms in the assumptions used to evaluate the radiological consequences of the gas decay tank rupture are as follows:

1. No credit is taken for radioactive decay during transit from RCS to the gaseous waste management system or for holdup in the gas decay tank.

2. The auxiliary building leak rate is assumed to be equal to tank leak rate.

3. The gas decay tank inventory is conservatively calculated based upon plant operation with 1% failed fuel.

4. No credit is taken for filtration in the auxiliary building.

6.4 Radiological Consequences Study of a Control Element Assembly Ejection Accident

6.4.1 Physical Model

The evaluation of the radiological consequences of a postulated control element assembly (CEA) ejection accident assumes a coincident loss of offsite power at the time of turbine trip. Thus, activity is released via 2 pathways:

1. From the reactor coolant, through the ruptured CEA drive mechanism pressure housing, to the containment, and to the environment via containment leakage.

2. From the reactor coolant to the steam generator secondary side (primary-to-secondary leakage), and to the environment via mass release from secondary relief and dump valves operated during initial cooldown.

Previous analysis of this accident revealed no fuel rod cladding damage which results in additional fission products discharged into the coolant. This is again assumed to hold true.

6.4.2 Assumptions and Conditions

The major assumptions and parameters assumed in the analysis are itemized in Table 6.4-1.

Reactor coolant activity levels are calculated assuming that, prior to the accident, the plant operated with simultaneous 1% failed fuel and a 1 gal/min primary-to-secondary leak. For conservatism, the secondary system is assumed to contain activity levels of 0.1 μCi/gm I-131 DEC.

1. Activity Release from Containment

The activity available for leakage from containment is based on the equilibrium reactor coolant activity. The nuclide activity instantaneously available for release from containment is 100% of the noble gases and 25% of the iodines.

The activity available for leakage from containment is assumed to be instantaneously mixed in the containment free volume. Activity is assumed to leak out at the limit (0.2 vol. %/day) for the first day and at half this rate for the duration of the accident (1-30 days).

Table 6.4-1
Parameters Used in Evaluating Radiological Consequences
of a CEA Ejection Accident

Parameter	Assumptions	Reference
Power Level (Mwt)	1500	FSAR
Percent Fuel Experiencing Clad Failure	0	FSAR
Primary Coolant Liquid Volume (ft^3)	6616	FSAR
Primary Coolant Liquid Mass (lbm)	412,8[illegible]0	FSAR
Steam Generator Liquid Mass (lbm)	79,530	
Steam Generator Steam Mass (lbm)	4,986	
Purification Flowrate	36 gpm (=1800 lb/hr)	FSAR
Reactor Coolant Specific Activity, before accident (μCi/gm)	Table 6.4-2	(a)
Secondary System Spec. Activity, before accident (μCi/gm)	0.1μCi/gm DEC I-131	

Notes:

(a) RCS specific activities estimated per ANSI N237 Standard Methods, with following assumptions employed to yield conservative values:

1. Adjustment factor of "8" introduced to obtain results for operation with 1% failed fuel
2. Noble Gases: Reactor coolant removal rate conservatively assumed to be zero.
3. Iodines: Reactor coolant removal rate conservatively taken as 0.039 hr^{-1}

Table 6.4-1
(Continued)
Parameters Used in Evaluating Radiological Consequences
of a CEA Ejection Accident

Parameter	Assumptions	Reference
Containment Volume (ft^3)	$1.05x10^6$	FSAR
Containment Leak Rate (1) 0-24 hr, vol%/day	0.2	FSAR
(2) 1-30 day, vol%/day	0.1	Reg. Guide 1.4
Percent Coolant Fission Products Assumed released to Containment	100%(noble) 25%(iodines)	Reg.Guide 1.77
Iodine Removal System Parameters	Not utilized	
Credit for Radioactive Decay		
(1) Holdup in containment	yes	Reg.Guide 1.77
(2) In transit to Dose Point	no	Reg.Guide 1.77
Activity Available for Release from Containment @ t=0	Table 6.4-4	(b)
Activity Release from Containment	Table 6.4-5	(c)
Primary to Secondary Leak Rate	8640 lb/day	
Secondary Mass Release to Atmosphere (rate)		
(1) Safety Valves, lbm/hr	5.16×10^4	(d)
(2) Dump Valves, lbm/hr	$2.27x10^5$	
(averaged over t=3.08 hours)		
Steam Generator Decontamination Factor (water to steam)	10	
Activity Release from Secondary System	Table 6.4-3	
Atmosphere Dispersion Factors, (sec/m^3)		
EAB	4.4×10^{-4}	
LPZ (0-8 hours)	1.57×10^{-5}	

Notes:

(b) Determined from Regulatory Guide 1.4 and 1.77 assumptions and core inventories based on ANSI N237 standard

(c) Determined from previous item of the table with credit taken for the removal mechanisms of decay, iodine removal system and containment leakage. Values represent the activity available for leakage from the containment 40 days following the accident.

(d) For conservatism, mass release rate (average) based on calculated steam releases (secondary) for postulated CEA ejection accident at Millstone II power plant.

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6.4 Radiological Consequences Study of a Control Element Assembly Ejection Accident (Continued)

6.4.2 Assumptions and Conditions (Continued)

No credit for iodine removal system operation is taken. The activity in containment is assumed to decay due to holdup. After leaking from containment, no radioactive decay or ground deposition is assumed during transit to the dose point.

2. Activity Release from Secondary System

The activity released from the secondary system is the activity released to the atmosphere from the main steam safety (relief) valves and atmospheric dump valves during the cooldown phase until the shutdown cooling system is placed in operation. Primary-to-secondary leakage continues at 1 gpm until shutdown cooling is initiated.

The duration of the mass release will be assumed to be 11,092 seconds (3.08 hours) until shutdown cooling is placed in operation. The mass release of 2.8 x 10^5 lbm (total) is assumed to take place at a constraint rate over the 3.08 hour period. Since this results in rapid turnover of the S/G steam volume, decay is not taken into account.

6.4.3 Mathematical Models Used

Mathematical models used in the analysis are described in the following sections:

1. The atmospheric dispersion factors used in the analysis are based on meteorological conditions assumed present during the course of the accident.

2. The potential thyroid inhalation dose and total-body gamma immersion dose to an individual exposed at the exclusion area boundary or outer boundary of the low population zone (LPZ) are analyzed using the models described in Subsection 6.3.3 and results are listed in Table 6.4-6

Table 6.4-2
RCS Specific Activity

Nuclide	Specific Activity (μCi/gm)
Kr-83m	9.9 (-2)
-85m	5.2 (-1)
-85	8.7 (+1)
-87	2.8 (-1)
-88	9.5 (-1)
Xe-131m	7.1 (-1)
-133m	1.1 (0)
-133	9.9 (+1)
-135m	6.1 (-2)
-135	1.7 (0)
-138	2.1 (-1)
I-131	2.6 (0)
-132	6.5 (-1)
-133	2.5 (0)
-134	3.1 (-1)
-135	1.4 (0)

Table 6.4-3
Activities Released (Secondary System)

Nuclide	Activity Released (Ci)
Kr-83m	5.0 (-2)
-85m	2.6 (-1)
-85	4.[illegible] (+1)
-87	1.4 (-1)
-88	4.8 (-1)
Xe-131m	3.6 (-1)
-133m	5.5 (-1)
-133	5.0 (+1)
-135m	3.1 (-2)
-135	8.5 (-1)
-138	1.1 (-1)
I-131	2.9 (0)
-132	2.2 (-1)
-133	1.3 (0)
-134	3.7 (-2)
-135	4.9 (-1)

6.4 Radiological Consequences Study of a Control Element Assembly Ejection Accident (Continued)

6.4.3 Mathematical Models Used (Continued)

3. Release Rate

A. Containment Release

The average release of a specific isotope which is released from the containment during a time interval assuming a constant leak rate, removal of iodine by the containment iodine removal system and radioactive decay until release is given by:

$$Qi = F_p \cdot F_b \, (q_s/P_o)_i \, \frac{\lambda_1}{\lambda_1 + \lambda_2} \left(1 - e^{-(\lambda_1 + \lambda_2)\, t} \right) P_o$$

where Q_i is the average release of the ith isotope, (Curies)

F_p is the fraction of the isotope released from the reactor to the containment building (0.5 for iodine)

F_b is the fraction of the isotope which remains airborne and available for release from the containment to the atmosphere, (0.5 for iodine)

$(q_s/P_o)_i$ is the saturation inventory of the ith isotope contained by the reactor per unit reactor power, (Curies/Mwt)

λ_1 is the containment leak rate to the atmosphere, (hours $^{-1}$)

λ_2 is the radiological decay constant for the ith isotope (hours $^{-1}$)

t is the time interval since the start of release during which exposure is assumed to take place, (seconds)

P_o is the rated reactor power level (1500 Mwt)

6.4 Radiological Consequences Study of a Control Element Assembly Ejection Accident (Continued)

6.4.3 Mathematical Models Used (Continued)

3. Release Rate (Continued)

B. Secondary Releases

(1) All noble gases entering the secondary system via the primary-to-secondary leak mechanism are assumed discharged to the atmosphere for the 3.08 hour period following the accident.

(2) The iodine activity released from the secondary system is given by:

$$Q = A_o + A_{p/s} - A_f$$

where Q = activity released (CE)
A_o = initial activity in S/G (liquid), Ci
$A_{p/s}$ = activity leaked into S/G (secondary) from the RCS during the 3.08 hour time period following the accident, Ci
A_f = final activity in S/G (liquid) at t = 3.08 hour (in Ci)

6.4.4 Uncertainties and Conservatisms

1. Reactor coolant equilibrium activities prior to the accident are based on 1% failed fuel, which is a factor of 2 to 8 greater than that normally observed in past PWR operation.

2. Steam generator equilibrium activity for both steam generators is assumed to be equal to the Technical Specification limit. The Technical Specification limits are conservatively derived based on acceptable offsite doses from accidents such as the CEA ejection accident.

3. Loss of offsite power is a conservative assumption.

4. The containment leakage rate is taken to be the leakage rate at maximum peak pressure for the first 24 hours and 50% of this value thereafter.

5. No credit for the iodine removal system was assumed. The operator could "initiate" containment recirculation at a nominal time of 1800 seconds after the accident to mitigate the consequences of the accident. 497 321

Table 6.4-4
Activity Available for Release from Containment
at Time "0"

Nuclide	Activity (Ci)
Kr-83m	1.9 (+1)
-85m	9.8 (+1)
-85	1.6 (+4)
-87	5.3 (+1)
-88	1.8 (+2)
Xe-131m	1.3 (+2)
-133m	2.1 (+2)
-133	1.9 (+4)
-135m	1.2 (+1)
-135	3.2 (+2)
-138	3.9 (+1)
I-131	1.2 (+2)
-132	3.0 (+1)
-133	1.2 (+2)
-134	1.5 (+1)
-135	6.6 (+1)

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6.4 Radiological Consequences Study of a Control Element Assembly Ejection Accident (Continued)

6.4.4 Uncertainties and Conservatisms (Continued)

6. The secondary system mass release was maximized by assuming:

A. All heat must be removed through the steam generators, and

B. A full year beginning-of-cycle case. This is conservative as (1) mass (and heat) removal actually occurs due to coolant flow through the break to containment and (2) because the full power beginning-of-cycle case results in the worse power transient with regard to secondary system releases.

Additionally, mass releases are based on analysis of CEAEA for Millstone II, a 2570 Mwt plant. Secondary releases from Fort Calhoun would be less.

7. Reactor coolant activities based on extended operation at 1500 Mwt.

6.5 Radiological Consequences Study of a Loss of Coolant Accident (Including Containment Purge for Hydrogen Control)

6.5.1 Physical Model

1. Containment Leakage Contribution

Following a postulated double-ended rupture of a reactor coolant pipe with subsequent blowdown, the ECCS limits the clad temperature to well below the melting point and ensures that the reactor core remains intact and in a coolable geometry, minimizing the release of fission products to the containment. However, to demonstrate that the operation of this nuclear power plant does not represent any undue radiological hazard to the general public, a hypothetical accident involving a significant release of fission products to the containment is evaluated.

It is assumed that 100% of the noble gas and 50% of the iodine equilibrium core saturation fission product inventory is immediately released to the containment atmosphere. Of the iodine released to the containment, 50% is assumed to plate out onto the internal surfaces of the containment or adhere to internal components. The remaining iodine and the noble gas activity is assumed to be immediately available for leakage from the containment.

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Table 6.4-5
Activity Release from Containment

Nuclide	Activity Release 0-2 hrs (Ci)	Activity Release 0-30 day (Ci)
Kr-83m	2.23 (-3)	2.23 (-3)
-85m	1.40 (-2)	1.46 (-2)
-85	2.66 (0)	4.57 (+2)
-87	5.37 (-3)	5.37 (-3)
-88	2.36 (-2)	2.37 (-2)
Xe-131m	2.16 (-2)	1.72 (0)
-133m	3.46 (-2)	5.34 (-[illegible])
-133	3.15 (0)	1.26 (+2)
-135m	3.75 (-4)	3.75 (-4)
-135	4.95 (-2)	7.80 (-2)
-138	1.11 (-3)	1.11 (-3)
I-131	1.99 (-2)	1.18 (0)
-132	3.75 (-3)	3.76 (-3)
-133	1.94 (-2)	8.75 (-2)
-134	1.25 (-3)	1.25 (-3)
-135	9.93 (-3)	1.21 (-2)

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Table 6.4-6
Radiological Consequences of a Postulated Control Element Assembly Ejection Accident

Dose Type	Dose from Containment Leakage and Secondary Releases (Rem)	
	EAB (0-2 Hr)	LPZ (0-30 days)*
Thyroid	7.54 (-1)	3.36 (-2)
Whole Body Gamma	8.19 (-4)	5.69 (-5)
Beta-Skin	2.26 (-3)	5.11 (-4)

* For conservatism, the LPZ dose calculations are based on a dispersion factor for 0-8 hours.

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6.5 Radiological Consequences Study of a Loss of Coolant Accident (Continued)

6.5.1 Physical Model (Continued)

1. Containment Leakage Contribution (Continued)

Once the gaseous fission product activity is released to the containment atmosphere, it is subject to various mechanisms of removal which operate simultaneously to reduce the amount of activity in the containment. The removal mechanisms include radioactive decay, containment iodine removal system, and containment leakage. For the noble gas fission products, the only removal processes considered in the containment are radioactive decay and containment leakage.

A. Radioactive Decay - Credit for radioactive decay for fission product concentrations located within the containment is assumed throughout the course of the accident. Once the activity is released to the environment, no credit for radioactive decay or deposition is taken.

B. Containment Iodine Removal System - Credit for the removal of iodine from the containment building atmosphere is assumed during the course of the accident resulting from filtration in the iodine removal system. The system consists of 4 air handling units; 2 having filtering capacity and the other 2 having no filtering capacity. In the calculation of the radiological consequences an absorption efficiency of 0.9 and operation of only 1 of the 2 containment filtering units is assumed. The filtration capacity of this unit is conservatively assumed to be 100,000 CFM.

C. Containment Leakage - The containment leak rate is 0.2 percent of the free volume per day for the first 24 hours, and at 50% of this leakage rate for the remaining duration of the accident. The contribution to the potential integrated thyroid, beta-skin, and total-body gamma doses is the result of direct leakage from the containment to the environment. The resultant activity release to the environment is assumed to be released at ground level. The activity released to the environment is treated as a semi-infinite cloud, i.e., a cloud containing radioactive material that is infinite in all directions above the ground. The concentration of radioactive material within

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1. Containment Leakage Contribution (Continued)

C. Containment Leakage (Continued)

the cloud is assumed uniform and equal to the maximum centerline ground-level concentration that would exist in the cloud at the point of immersion of an individual located at the exclusion area boundary or the outer boundary of the low population zone (LPZ).

2. Hydrogen Purge Contribution

The OPPD FSAR describes the design and operation of the hydrogen purge system. The hydrogen purge system is placed in operation 40 days after a LOCA to prevent the hydrogen concentration from exceeding 4.0 vol%. The hydrogen purge system performs a 5.0 standard ft^3/min bleed and feed operation on the containment atmosphere. The LOCA source term available for purging is presented in Table 6.5-1. These source terms are based on the same Regulatory Guide 1.4 assumptions used in the containment leakage contribution with credit taken for 40 days of radioactive decay, containment iodine removal system and leakage.

Hydrogen purge system filter efficiencies for iodines are presented in Table 6.5-1. Activity release models and dose models are similar to those used in the containment leakage model. The radiological consequences at the LPZ are presented in Table 6.5-2.

3. Leakage from Engineered Safety Features (ESF) Components Outside Containment

Subsequent to the injection phase of ESF system operation, the water in the containment recirculation sumps is recirculated by the HPSI pumps and the containment spray pumps. Because the LOCA will cause the sump water to contain much of the radioiodine, the potential offsite exposures due to operation of this external recirculation path with leakage are evaluated. The dose calculations are based on 50% of the core iodine inventory being immediately released. The iodine is assumed to be homogeneously mixed with the water in the reactor coolant system and in the containment at the beginning of recirculation. Since the minimum

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Table 6.5-1
Parameters Used in Evaluating the Radiological Consequences of a Loss of Coolant Accident

Parameter	Assumptions	Reference
A. Source Data		
1. Power level, Mwt	1500	FSAR
2. Fraction of core activity initially airborne in the containment, %		Regulatory Guide 1.4
a) Noble Gas	100	
b) Iodine	25	
B. Activity Release Data		
1. Containment Leakage Rate, Vol %/d		
a) 0 to 24 hours	0.2	FSAR
b) 1 to 30 days	0.1	Regulatory Guide 1.4
2. Fraction of containment leakage that is unfiltered,%	100	FSAR
3. Credit for containment iodine absorption system		
a) Iodine Removal Constants, hr^{-1}		FSAR
(1) Elemental	5.14	
(2) Organic	5.14	
(3) Particulate	5.14	
b) Decontamination Factor		
(1) Elemental	10	
(2) Organic	10	
(3) Particulate	10	

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Table 6.5-1
(Continued)
Parameters Used in Evaluating the Radiological
Consequences of a Loss of Coolant Accident

Parameters	Assumptions	Reference
c. Fraction not effected by the filters		
(1) Elemental	0	
(2) Organic	50	
(3) Particulate	0	
4. Activity initially airborne in the containment building, Ci		
Isotope		
I-131	1.04 (+7)	
I-132	1.53 (+7)	(a)
I-133	2.11 (+7)	
I-134	2.28 (+7)	
I-135	1.96 (+7)	
Xe-131m	2.94 (+5)	
Xe-133	8.46 (+7)	
Xe-135m	1.71 (+7)	
Xe-135	1.51 (+7)	
Xe-138	6.75 (+7)	
Kr-85m	1.05 (+7)	
Kr-85	3.34 (+5)	
Kr-87	1.93 (+7)	
Kr-88	2.76 (+7)	
5. Initiation of Containment purge for hydrogen reduction, days following event	40	FSAR
6. Duration of hydrogen purge, days	4000	
7. Containment airborne activity at time of hydrogen purge initiation, curie		
Isotope		
I-131	4.87 (+3)	(b)
I-132	0.0	
I-133	0.0	
I-134	0.0	
I-135	0.0	
Xe-131m	2.14 (+4)	
Xe-133	3.22 (+5)	
Xe-135m	0.0	
Xe-135	0.0	
Xe-138	0.0	

Table 6.5-1
(Continued)
Parameters Used in Evaluating the Radiological Consequences of a Loss of Coolant Accident

Parameters	Assumptions	Reference
7. (cont'd)		
Kr-85m	0.0	
Kr-85	2.43 (+5)	
Kr-87	0.0	
Kr-88	0.0	
8. Containment Hydrogen Purge Rate, SCFM	5	FSAR
9. Hydrogen Purge System Filter Iodine Decontamination Factors		FSAR
(1) Elemental	10	
(2) Organic	10	
(3) Particulate	10	
C. Dispersion Data, X/Q (sec/m^3)		
(1) Exclusion Area Boundary	4.4×10^{-4}	
(2) Low Population Zone (0-8 hours)	1.57×10^{-5}	

(a) Determined from Regulatory Guide 1.4 assumptions and core inventories based on plant operations at full power with burnup at 15-15-18 month cycle reload scheme.
(b) Determined from Item (4) of the table with credit taken for the removal mechanisms of decay, iodine removal system and containment leakage. Values represent the activity available for leakage from the containment 40 days following the accident.

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6.5 Radiological Consequences Study of a Loss of Coolant Accident (Continued)

6.5.1 Physical Model (Continued)

3. Leakage from Engineered Safety Features (ESF) Components Outside Containment (Continued)

time interval between the initiation of the injection and recirculation phases of ESF system operation is 27.4 minutes, the iodine decay is calculated for this amount of time in order to obtain the correct activity at the time recirculation is initiated. The dissolved noble gas activity in the recirculation loop is negligible since noble gases are not readily entrained in water and are assumed for accident analysis to be in the containment atmosphere. Table 6.5-3 defines the iodine inventory in the sump water at the beginning of recirculation.

Leakage rate was obtained by dividing the leakage from ESF systems (2486 cc/hr) by the total volume of the recirculation water 1.67×10^9 cc. Thus, a leakage rate of 1.49×10^{-6} hr^{-1} is used. Both ESF trains are assumed to operate at 100% capacity for the 30 days following the accident.

The offsite thyroid doses resulting from this leakage were obtained using the atmospheric dilution factors of OPPD. As iodine-water partition factor of 0.1% is used to calculate the amount of iodine which is available for release from the pump rooms. Activity was assumed to be dispersed instantaneously from the pump rooms to the atmosphere with no further nuclide holdup or decay. Further, only the thyroid dose was calculated, since the iodine contribution to the total-body dose, compared with other nuclides, is negligible.

The resulting thyroid dose in the first 2-hour period at the exclusion area boundary and the thyroid doses at the LPZ outer boundary as a function of time are given in Table 6.5-3. The doses resulting from this source are small compared to those resulting from the activity released due to containment leakage.

6.5.2 Assumptions and Conditions

The major assumptions and parameters assumed in the analysis are itemized in Table 6.5-1.

In the evaluation of a LOCA, the fission product release assumptions of Regulatory Guide 1.4 were followed. The following specific assumptions were used in the analysis:

Table 6.5-2
Radiological Consequences of a Postulated
Loss of Coolant Accident

Result	Value
Exclusion area boundary dose (0 to 2 hours), rem	
Thyroid:	
Due to containment leakage	8.68×10^{1}
Due to recirculation leakage	2.4×10^{-2}
Beta-skin:	
Due to containment leakage	8.08×10^{-1}
Total body gamma:	
Due to containment leakage	1.64
LPZ outer boundary dose (0 to 30 days)*, rem	
Thyroid:	
Due to containment leakage	1.61×10^{1}
Due to recirculation leakage	4.63×10^{-2}
Due to hydrogen purge	1.68×10^{-3}
Beta-skin:	
Due to containment leakage	3.81×10^{-1}
Due to hydrogen purge	1.35×10^{-1}
Total body gamma:	
Due to containment leakage	2.58×10^{-1}
Due to hydrogen purge	4.74×10^{-3}

Results:

As these values for thyroid and whole body gamma dose show the dose calculated using these conservative assumptions are well within the limits of 10CFR100.

* For conservatism, the LPZ dose calculations are based on a dispersion factor for 0-8 hours.

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6.5 Radiolcgical Consequences Study of a Loss of Coolant Accident (Continued)

6.5.2 Assumptions and Conditions (Continued)

1. The reactor core equilibrium noble gas and iodine inventories are based on long-term operation at 100% of the ultimate core power level of 1500 Mwt.

2. One hundred percent of the core equilibrium radioactive noble gas inventory is immediately available for leakage from the containment.

3. Twenty-five percent of the core equilibrium radioactive iodine inventory is immediately available for leakage from containment.

4. Of the iodine fission product inventory released to the containment, 91% is in the form of elemental iodine, 5% is in the form of particulate iodine, and 4% is in the form of organic iodine.

5. Credit for iodine removal by the containment iodine removal system is taken starting at 0.02 hours following the accident. Credit for organic iodine removal is taken until a reduction of 50% is achieved. Credit for elemental and particulate iodine removal is taken for the course of the accident.

6. The following iodine removal constants for the containment spray system are assumed in the analysis:

Elemental Iodine - 5.14 hr^{-1}
Organic Iodine - 5.14 hr^{-1}
Particulate Iodine - 5.14 hr^{-1}

7. The containment is assumed to leak at 0.2 vol%/d during the first 24 hours immediately following the accident and 0.1 vol%/d thereafter.

6.5.3 Mathematical Models Used

Mathematical models used in the analysis are described in the following sections:

1. The atmospheric dispersion factors used in the analysis are based on meteorological conditions assumed present during the course of the accident.

6.5.3 Mathematical Models Used (Continued)

2. The potential thyroid inhalation dose and total-body gamma immersion dose to an individual exposed at the exclusion area boundary or outer boundary of the low population zone (LPZ) are analyzed using the models described in Subsection 6.3.3 and results are listed in Table 6.5-3.

3. Release Rate - Containment

The average release of a specific isotope which is released from the containment during a time interval assuming a constant leak rate, removal of iodine by the containment iodine removal system and radioactive decay until release is given by:

$$Q_i = F_p \cdot F_b \, (q_s/P_o) \, \frac{\lambda_1}{\lambda_1+\lambda_2+\lambda_3} \left(1-e^{-(\lambda_1+\lambda_2+\lambda_3)\,t}\right) P_o$$

where Q_i is the average release of the ith isotope, (Curies)

F_p is the fraction of the isotope released from the reactor to the containment building (0.5 for iodine)

F_b is the fraction of the isotope which remains airborne and available for release from the containment to the atmosphere, (0.5 for iodine)

$(q_s/P_o)_i$ is the saturation inventory of the ith isotope contained by the reactor per unit reactor power, (Curies/Mwt)

λ_1 is the containment leak rate to the atmosphere, (hours $^{-1}$)

λ_2 is the radiological decay constant for the ith isotope (hours^{-1})

λ_3 is the containment iodine removal system constant (hours $^{-1}$)

t is the time interval since the start of release during which exposure is assumed to take place, (seconds)

P_o is the rated reactor power level (1500 Mwt)

4. Release Rate - ESF

The iodine activity released to the ESF pump rooms due to leakage within the recirculation system is calculated by the following equation:

$$A = (L A_o/\lambda) \; 1 - \exp(-\lambda t) \; PF$$

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Table 6.5-3
Activity Initially in the Containment Building
Sump at Time of Recirculation Mode

Nuclide	Activities (Curies)
I-131	2.09 (7)
I-132	2.66 (7)
I-133	4.15 (7)
I-134	3.17 (7)
I-135	3.75 (7)

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6.5 Radiological Consequences Study of a Loss of Coolant Accident (Continued)

6.5.3 Mathematical Models Used (Continued)

4. Release Rate - ESF (Continued)

where A = activity released, Ci
L = leakage rate, hr^{-1} ($1.49x10^{-6}$)
AO = activity in containment sump water at recirculation startup, Ci
λ = radioactive decay constant, hr^{-1}
t = time after initiation of recirculation, h
PF = partition coefficient for iodine (0.001)

The leakage from ESF systems to the auxiliary building is assumed to be 2486 cc/hr. All of the leakage rates assume that 2 containment spray and 2 HPSI pumps are in operation. Leakage rates include LPSI components that are not operating during recirculation.

6.5.4 Uncertainties and Conservatisms

The uncertainties and conservatisms in the assumptions used to evaluate the radiological consequences of the LOCA are as follows:

1. The ECCS is designed to prevent fuel cladding damage that would allow the release of the fission products contained in the fuel to the reactor coolant. Severe degradation of the ECCS, i.e., to the unlikely extent of simultaneous failure of redundant components, would be necessary in order for the release of fission products to occur of the magnitude assumed in analysis.

2. The release of fission products to the containment is assumed to occur instantaneously.

3. It is assumed that 50% of the iodines released to the containment atmosphere are absorbed onto internal surfaces of the containment or adhere to internal components; however, it is estimated that the removal of airborne iodines by various physical phenomena such as adsorption, adherence, and settling could reduce the resultant doses by a factor of 3 to 10.

4. The activity released to the containment atmosphere is assumed to leak to the environment at the containment leakage rate of 0.2 vol%/d for the first 24 hours and 0.1 vol%/d thereafter. The initial containment leakage rate is based on the peak calculated

6.5 Radiological Consequences Study of a Loss of Coolant Accident (Continued)

6.5.4 Uncertainties and Conservatisms (Continued)

4. (Continued)

internal containment pressure anticipated after a LOCA as stated in the OPPD FSAR. The pressure within the containment actually decreases with time. Taking into account that the containment leak rate is a function of pressure drop, the resultant doses could be reduced by a factor of 5 to 10.

5. Credit for iodine removal by the containment iodine removal system is not taken until 0.02 hours following the accident. Credit for organic iodine removal is not taken after a reduction of 50% is achieved.

6.6 Radiological Consequences Study of Post-LOCA Control Room Personnel

This analysis will be supplied under separate cover at a later date.

6.7 Radiological Consequences of a Main Steam Line Break

6.7.1 Physical Model

To evaluate the radiological consequences due to a postulated main steam line break (outside containment), it is assumed that there is a complete severance of a main steam line outside the containment with the plant in a hot zero power condition where the transient is initiated shortly after full power operation. It is also assumed that there is a simultaneous loss of offsite power. The hot zero power condition assures the maximum water inventory in the steam generators and the shutdown from full power (in conjunction with the loss of offsite power) assures the maximum decay heat which must be removed by manual control of the atmospheric dump valve associated with the intact steam generator.

The main steam isolation valves are installed in the main steam lines from each steam generator, downstream from the safety relief valves and atmospheric dump valves outside containment. The severance of the main steam line is assumed to be upstream of the main steam isolation valve. A reactor trip is actuated by a low steam generator pressure signal. A main steam isolation signal (MSIS) is actuated to shut the main steam isolation valves from both steam generators. The affected steam generator (steam generator connected to the severed steam line) blows down completely. The steam is vented

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Table 6.7-1
Parameters Used in Evaluating the Radio.ogical nsequences of a Main Steam Line Break Accident (MSLBA)

Parameter	Assumptions	Reference
Data and assumptions used to estimate radioactive source		
General		
Power level, Mwt	1500	FSAR
Burnup	End of cycle	Assumption
Percent of fuel perforated	0	Assumption
Reactor coolant activity after accident Iodine spike caused by accident	60 μCi/gm DEC I-131	Assumption
Steam generator activity before accident	0.1 μCi/gm dose equiv. I-131	Assumption
General		
Loss of site power	yes	Assumption
Credit for radioactive decay in transit to dose point	no	Assumption
Affected steam generator		
Primary-to-secondary leakage rate, lb/d	8,640 (1 gal/min)	Assumption
Secondary mass release to atmosphere (through severed line), lb_m	233,498	
Mass of primary-to-secondary leakage, lbm	491	Assumption
Steam generator decontamination factor between steam and water phase	1	Assumption
Unaffected steam generator		
Primary -to-secondary leakage rate, lb/d	0	Assumption
Dispersion Data:		
Atmospheric dispersion factors, sec/m^3		
EAB	4.4×10^{-4}	
LPZ (0-8 hours)	1.57×10^{-5}	

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6.7 Radiological Consequences of a Main Steam Line Break (Continued)

6.7.1 Physical Model (Continued)

directly to the atmosphere. The atmospheric dump valve of the unaffected steam generator is used to initiate a 75F/h cooldown of the reactor coolant system 1800 seconds after initiation of the accident. The steam is vented directly to the atmosphere. Mass release from the unaffected steam generator is terminated when the shutdown cooling system is initiated at a reactor coolant system temperature of 300°F.

In this evaluation, a case with an iodine spike caused by the main steam line break accident was evaluated for radiological consequences. The mathematical models, assumptions, and parameters used in this analysis were identical with the design basis main steam line break accident without an iodine spike and described in the above paragraphs with the following exception:

Prior to the main steam line break accident the reactor coolant system activity is based on 1% failed fuel.

However, at the initiation of the MSLB accident, the I-131 equivalent source term (released from fuel) is assumed to increase. The iodine release rate is assumed to increase by a factor of 500.

6.7.2 Assumptions and Conditions

The major assumptions, parameters, and calculational methods used in the design basis analysis are presented in Table 6.7-1. Additional clarification is provided as follows:

1. Reactor Coolant Activity

   The reactor coolant equilibrium activity is based on long term operation at 100% of the ultimate core power level of 1500 Mwt and 1% failed fuel. Source terms are listed in Table 6.7-1.

2. Secondary System Activity

   The activity in steam generators is conservatively assumed to be equal to 0.1 µCi/gm dose equivalent Iodine-131 (I-131).

3. Primary-to-Secondary Leakage

   The primary-to-secondary leakage of 1 gal/min (Technical Specification limit) was assumed to continue through the affected steam generator at a constant rate until shutdown cooling is initiated.

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Table 6.7-2
Activity Released from the Steam Generator

Nuclide	Activity (Curies)
DEC I-131	23.93
Kr-83m	1.86 (-2)
Kr-85m	1.08 (-1)
Kr-85	1.93
Kr-87	4.8 (-2)
Kr-88	2.12 (-1)
Xe-131m	1.61 (-1)
Xe-133m	2.44 (-1)
Xe-133	2.20 (1)
Xe-135m	4.83 (-3)
Xe-135	3.63 (-1)
Xe-138	1.54 (-2)

6.7 Radiological Consequences of a Main Steam Line Break (Continued)

6.7.3 Mathematical Models Used

Mathematical models used in the analysis are described in the following sections:

1. The atmospheric dispersion factors used in the analysis are based on meteorological conditions assumed present during the course of the accident.

2. The potential thyroid inhalation dose and total-body gamma immersion dose to an individual exposed at the exclusion area boundary or outer boundary of the low population zone (LPZ) are analyzed using the models described in Subsection 6.3.3 and results are in Table 6.7-3.

6.7.4 Uncertainties and Conservatisms

1. An 8640 lbm/d (1 gal/min) steam generator primary-to-secondary leakage is assumed, which is greater by a factor of 50 to 200 than that normally observed in past PWR operation.

2. The steam generator equilibrium activity for both steam generators is assumed to be equal to the Technical Specification limit (0.1 μCi/g dose equivalent I-131) for the duration of the accident. This specific activity is greater than the normal steam generator equilibrium activity (refer to Table 6.7-1) by a factor of approximately 1300.

3. The meteorological conditions assumed to be present at the site during the course of the accident are based on χ/Q values for the exclusion area boundary or LPZ outer boundary. Furthermore, no credit has been taken for the transit time required for activity to travel from the point of release to the exclusion area boundary or LPZ outer boundary. Hence, the radiological consequences evaluated under these conditions will be conservative.

6.8 Radiological Consequences of a Single Reactor Coolant Pump Seizure

6.8.1 Physical Model

Following seizure of a reactor coolant pump shaft, the core flowrate rapidly decreases to the value that would occur with only 3 reactor coolant pumps operating. The reduction in coolant flowrate causes a reactor trip on low coolant flow.

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Table 6.7-3
Radiological Consequences Due to a Postulated
Main Steam Line Break

Result	Iodine Spike Caused by Accident
Exclusion Area Boundary Dose (duration) rem:	
Thyroid	5.41
Total Body Gamma	1.19×10^{-3}
LPZ Outer Boundary Dose * (duration), rem:	
Thyroid	1.91×10^{-1}
Total Body Gamma	4.22×10^{-5}

Results:

As these values for thyroid and whole body gamma dose show the dose calculated using these conservative assumptions are well within the limits of 10CFR100.

* For conservatism, the LPZ dose calculations are based on a dispersion factor for 0-8 hours.

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6.8 Radiological Consequences of a Single Reactor Coolant Pump Seizure (Continued)

6.8.1 Physical Model (Continued)

The reactor trip produces an automatic turbine trip. Following the turbine trip, offsite power is available to provide AC power to the auxiliaries. Due to the turbine trip, the turbine bypass valves would normally open. If the steam bypass control system is in the manual mode and no credit is taken for immediate operator action, the steam generator safety valves will open to relieve steam and provide an ultimate heat sink for the NSSS. The operator can initiate a controlled system cooldown using the turbine bypass valves any time after reactor trip. The steam release to the atmosphere, even if operator action is delayed for 30 minutes following first indication of the event, would be no more than that following a loss of all normal AC power. This is due to the fact that the steam bypass system is unavailable for loss of normal AC power. This results in significantly higher releases for the loss of normal AC power.

The analysis of the radiological consequences of a reactor coolant pump shaft seizure considers the most severe release of secondary activity as well as reactor activity leaked. The inventory of iodine and noble gas fission product activity available for release to the environment is a function of the primary-to-secondary coolant leakage rate, the percentage of defective fuel in the core, and the mass of steam discharged to the environment. Conservative assumptions are made for all these parameters.

In this evaluation, 2% of the fuel pins were assumed to experience DNB and all that experience DNB are assumed to fail for the purpose of radiological release calculations.

6.8.2 Assumptions and Conditions

The major assumptions and parameters assumed in the analysis are itemized in Table 6.8-1.

The following assumptions and parameters are used to calculate the activity releases and offsite doses for a single reactor coolant pump shaft seizure:

1. The RCS equilibrium activity is given in Table 6.8-1.

2. The steam generator equilibrium activity for both steam generators is assumed to be 0.1 μCi/gm dose equivalent I-131 prior to the accident.

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Table 6.8-1
Parameters Used in Evaluating the Radiological Consequences of a Single Reactor Coolant Pump Shaft Seizure

Parameter	Assumption	Reference
<u>Source Data:</u>		
Power Level, Mwt	1500	
Fraction Failed Fuel, %	1	
Steam Generator Tube Leakage, lb/d of equilibrium reactor coolant activity	8640 (1 gal/min)	
Coincident (existing)Fuel Failure, %, due to DNB	2	
Equilibrium Secondary System Activity	0.1 μCi/gm DEC I-131	
Initial RCS Activity Inventory, μCi/gm isotope		(a)
Kr-85	8.7 (+1)	
Xe-131m	7.1 (-1)	
Xe-133	9.9 (+1)	
I-131	2.6 (0)	
Gas Gap Activity Ci/assembly isotope		(b)
Kr-85	7.584 (+2)	
Xe-131m	5.195 (+3)	
Xe-133	5.77 (+4)	
I-131	2.499 (+4)	
<u>Activity Release Data</u>		
Steam Discharge, lb		
Mass of steam released (0-2.78 hrs)	8.181 (+5)	(c)
<u>Dispersion Data:</u>		
Atmospheric Dispersion Factors, sec/m^3		
EAB	4.4×10^{-4}	
LPZ (0-8 hours)	1.57×10^{-5}	
Iodine Decontamination Factors for Steam Generators (between water and steam phase)	10	

Notes:

(a) RCS Specific Activities estimated per ANSIN237 Standard methods, with following assumptions employed to yield conservative values:

1. adjustment factor of "8" introduced to yield results for operation with 1% failed fuel
2. Noble Gases: Reactor coolant removal rate conservatively assumed to be zero
3. Iodines: Reactor coolant removal rate conservatively teaken as 0.039 hr^{-1}

(b) Based on plant operation at full power with burnup at 15-15-18 month cycle reload scheme.

(c) Determined from conservative plant data.

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6.8 Radiological Consequences of a Single Reactor Coolant Pump Seizure (Continued)

6.8.2 Assumptions and Conditions (Continued)

3. Following the accident, no additional steam and radioactivity are released to the environment when the shutdown cooling system is placed in operation.

4. Amount of steam released is released in 2.78 hours.

5. The amount of noble gas activity released is equal to the amount present in the reactor coolant discharged into the secondary side due to primary-to-secondary leakage. The amount of noble gas activity contained in the secondary system is negligible in comparison.

6. Iodine activity released is based on the equilibrium activity present in the steam generators (0.1 μCi/gm dose equivalent I-131) and the amount of activity present in the reactor coolant due to failed fuel.

7. 2.78 hours after the accident, total cooldown period is reached. No steam and fission product activities are released from the steam generator thereafter.

8. The total amount of discharge of reactor coolant into the secondary system through leakage is assumed to be 1389 pounds (in 2.78 hours).

9. A post-accident DF of 10 was used in the steam generator between the water and steam phases.

10. The primary-to-secondary leakage of 8640 lbm/day (1.0 gal/min) is assumed to be applicable to both steam generators. The portion of the noble gas activity from the primary-to-secondary leakage attributed to the steam generators is assumed to be released during the course of the accident.

11. The amount of discharge of steam from the steam generators is assumed to be 8.181×10^5 pounds (in 2.78 hours).

12. The activity released from the steam generators is immediately vented to the atmosphere. No credit for radioactive decay for isotopes in transit to dose points.

Table 6.8-2
Activity Released from Steam Generator

Nuclide	Activity (Curies)
DEC I-131	2.627 (+1)
Kr-85	61.76
Xe-131m	46.98
Xe-133	579.63

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6.8 Radiological Consequences of a Single Reactor Coolant Pump Seizure (Continued)

6.8.3 Mathematical Models Used

Mathematical models used in the analysis are described in the following sections:

1. The atmospheric dispersion factors used in the analysis are based on meteorological conditions assumed present during the course of the accident.

2. The potential thyroid inhalation dose and total-body gamma immersion dose to an individual exposed at the exclusion area boundary or outer boundary of the low population zone (LPZ) are analyzed using the models described in Subsection 6.3.3 and results are listed in Table 6.8-3.

6.8.4 Uncertainties and Conservatisms

The uncertainties and conservatisms in the assumptions used to evaluate the radiological consequences of a single reactor coolant pump shaft seizure are as follows:

1. Reactor coolant equilibrium activities are based on 1% failed fuel, which is greater by a factor of 2 to 8 than that normally observed in past PWR operation.

2. Steam generator equilibrium activity for both steam generators is assumed to be equal to the Technical Specification limit. The Technical Specification limits are conservatively derived based on accidents such as the SGTR.

3. Conservative values for both the RCS and gas gap activities were chosen, based upon plant operation at full power with 3-year burnup.

4. 2% of the fuel pins in the core were assumed to experience DNB, and all that experienced DNB were assumed to fail.

5. The meteorological conditions assumed to be present at the site during the course of the accident are based on X/Q values which are expected to be worse 5% of the time. This condition results in the poorest values of atmospheric dispersion calculated for the exclusion area boundary or LPZ outer boundary. Furthermore, no credit has been taken for the transit time required for activity to travel from the point of release to the exclusion area boundary or LPZ outer

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Table 8-3
Radiological Consequences of a Postulated Single Reactor Coolant Pump Shaft Seizure

RESULTS	VALUE
Exclusion Area Boundary Dose (0-2 hr), Rem	
Thyroid	5.94
Total Body Gamma	5.05×10^{-3}
LPZ Outer Boundary Dose (Duration, 0-2.78 hr), Rem	
Thyroid	2.12×10^{-1}
Total Body Gamma	1.79×10^{-4}

Results:

As these values for thyroid and whole body gamma dose show the dose calculated using these conservative assumptions are well within the limits of 10CFR100.

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6.8 Radiological Consequences of a Single Reactor Coolant Pump Seizure (Continued)

6.8.4 Uncertainties and Conservatisms (Continued)

5. (Continued)

boundary. Hence, the radiological consequences evaluated under these conditions are conservative.

6. A conservative steam generator decontamination factor (DF) of 10 is used in the cooldown phase (release to atmospheric dump valve).

7. No credit is taken for radioactive decay of isotopes in transit to dose points.

6.9 Radiological Consequences Study of a Steam Generator Tube Rupture

6.9.1 Physical Model

The evaluation of the radiological consequences of a postulated steam generator tube rupture assumes a complete severance of a single steam generator tube while the reactor is operating at full rated power and a coincident loss or offsite power at the time of reactor trip. Occurrence of the accident leads to an increase in contamination of the secondary system due to reactor coolant leakage through the tube break. A reactor trip occurs automatically as a result of low pressurizer pressure after the tube rupture occurs. The reactor trip automatically trips the turbine.

The resulting increase in radioactivity in the secondary system is detected by radiation monitors. The coincident of offsite station power causes closure of the turbine bypass valves to protect the condenser. The steam generator pressure will increase rapidly, resulting in steam discharge as well as activity release through the main steam safety valves. Venting from the affected steam generator, i.e., the steam generator which experiences tube rupture, continues until the secondary system pressure is below the main steam safety valve setpoint. At this time, the affected steam generator is effectively isolated, and thereafter, no steam or activity is assumed to be released from the affected steam generator. The remaining unaffected steam generators remove core decay heat by venting steam through the main safety valves, atmospheric dump valve, and steam driven auxiliary turbine until cooldown can be accomplished with the shutdown cooling system.

The analysis of the radiological consequences of a steam generator tube rupture considers the most severe release of secondary activity as well as reactor activity leaked from the tube break. The inventory of iodine and noble gas fissi

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Table 6.9-1
Parameters Used in Evaluating the Radiological Consequences of a Steam Generator Tube Rupture

Parameter	Assumption	Reference
Source Data:		
Power level, Mwt	1,500	FSAR
Steam generator tube leakage, lb/d	8,640 (1 gal/min)	Assumption
Equilibrium reactor coolant activity		
Coincident (existing) iodine spike µc/g dose equivalent I-131	60	Assumption
Equilibrium secondary system activity	0.1 µc/g dose equivalent I-131	Assumption
Activity Release Data:		
Steam discharge, lb		
Affected steam generator		
Reactor coolant leakage to steam generator (0-30 min)	42,300	
Mass of steam released	3.551×10^{6}	
Dispersion Data:		
Atmospheric dispersion factors, sec/m^3		
EAB	4.4×10^{-4}	
LPZ (0-8 hours)	1.57×10^{-5}	
Iodine decontamination factors for steam generators (between water and steam phase)	10	Assumption

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6.9 Radiological Consequences Study of a Steam Generator Tube Rupture (Continued)

6.9.1 Physical Model (Continued)

product activity available for release to the environment is a function of the primary-to-secondary coolant leakage rate, the percentage of defective fuel in the core, and the mass of steam discharged to the environment. Conservative assumptions are made for all these parameters.

In this evaluation, a case with coincident iodine spike which already exists due to a previous power transient was considered. The mathematical models, assumptions, and parameters used in this analysis were identical with the design basis SGTR without an iodine spike as described in the above paragraphs with the following exception:

The reactor coolant system inventory was assumed to be 60 μC/g dose equivalent Iodine 131. This 60 μC/g is the Technical Specification limit for full power operation following an iodine spike for up to 48 hours.

6.9.2 Assumptions and Conditions

The major assumptions and parameters assumed in the analysis are itemized in Table 6.9-1.

The following assumptions and parameters are used to calculate the activity releases and offsite doses for a steam generator tube rupture (SGTR):

1. The reactor coolant system equilibrium activity is 60 μC/cc DEC I-131.

2. The steam generator equilibrium activity for both steam generators is assumed to be 0.1 μC/g dose equivalent I-131 prior to the accident.

3. Offsite power is lost; the main condenser is not available for steam relief via the turbine bypass system.

4. Following the accident, no additional steam and radioactivity are released to the environment when the shutdown cooling system is placed in operation.

5. There is no main condenser evacuation system release and no steam generator blowdown during the accident.

6. Only 1 steam generator is affected.

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Table 6.9-2
Activity Released from Steam Generator

Nuclide	Activity (Curies)
DEC 1-131	2.7423 (2)
Kr-83m	1.74
Kr-85m	9.61
Kr-85	1.67 (3)
Kr-87	4.71
Kr-83	17.17
Xe-131m	13.64
Xe-133m	21.08
Xe-133	1.90 (3)
Xe-135m	6.5 (-1)
Xe-135	32.07
Xe-138	2.12

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6.9 Radiological Consequences Study of a Steam Generator Tube Rupture (Continued)

6.9.2 Assumptions and Conditions (Continued)

7. The amount of noble gas activity released is equal to the amount present in the reactor coolant discharged into the secondary side following the tube rupture. The amount of noble gas activity contained in the secondary system is negligible in comparison.

8. Iodine activity released is based on the equilibrium activity present in the steam generators (0.1 μC/g dose equivalent I-131) and the amount of activity present in the reactor coolant discharged into the affected steam generator.

9. Thirty minutes after the accident, the affected unit is isolated. No steam and fission product activities are released from the affected steam generator thereafter.

10. The total amount of discharge of reactor coolant into the secondary system through the rupture is 42,300 pounds (in 30 minutes).

11. A post-accident DF of 10 was used in the steam generator between the water and steam phases.

12. The primary-to-secondary leakage of 8640 lbm/d (1.0 gal/min) is assumed to be applicable to the unaffected steam generator. The portion of the noble gas activity from the primary-to-secondary leakage attributed to the unaffected steam generator is assumed to be released during the course of the accident.

13. The amount of discharge of steam from the affected steam generator is assumed to be 3.55×10^6 pounds.

14. The activity released from the affected and unaffected steam generators is immediately vented to the atmosphere. No credit for radioactive decay for isotopes in transit to dose points.

6.9.3 Mathematical Models Used

Mathematical models used in the analysis are described in the following sections:

1. The atmospheric dispersion factors used in the analysis are based on meteorological conditions assumed present during the course of the accident.

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Table 6.9-3
Radiological Consequences of a Postulated
Steam Generator Tube Rupture

Results	Value
Exclusion Area Boundary Dose (duration), Rem	
Coincident (existing) iodine spike	
Thyroid	62
Total Body Gamma	2.72×10^{-2}
LPZ Outer Boundary Dose (duration)*, rem	
Coincident (existing) iodine spike	
Thyroid	2.21
Total Whole Body	9.7×10^{-4}

Results:

As these values for thyroid and whole body gamma dose show the dose calculated using these conservative assumptions are well within the limits of 10CFR100.

* For conservatism, the LPZ dose calculations are based on a dispersion factor for 0-8 hours.

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6.9 Radiological Consequences Study of a Steam Generator Tube Rupture (Continued)

6.9.3 Mathematical Models Used (Continued)

2. The potential thyroid inhalation dose and total-body gamma immersion dose to an individual exposed at the exclusion area boundary or outer boundary of the low population zone (LPZ) are analyzed using the models described in Subsection 6.3.3 and results are listed in Table 6.9-3.

6.9.4 Uncertainties and Conservatisms

The uncertainties and conservatisms in the assumptions used to evaluate the radiological consequences of a steam generator tube rupture are as follows:

1. Reactor coolant equilibrium activities are based on 1% failed fuel, which is greater by a factor of 2 to 8 than that normally observed in past PWR operation.

2. Steam generator equilibrium activity for both steam generators is assumed to be equal to the Technical Specification limit. The Technical Specification limits are conservatively derived based on accidents such as the SGTR.

3. Tube rupture of the steam generator is assumed to be a double-ended severance of a single steam generator tube. This is a conservative assumption since the steam generator tubes are constructed of highly ductile materials. The more probable mode of tube failure is 1 of minor leaks of undetermined origin. Activity in the secondary steam system is subject to continual surveillance, and the accumulation of activity from minor leaks that exceed the limits established in the Technical Specifications would lead to reactor shutdown. Therefore, it is unlikely that the total amount of activity considered available for release in this analysis would ever be realized.

4. The coincident loss of offsite power with the occurrence of the reactor trip following the steam generator tube rupture is a conservative assumption. In the event of availability of offsite power, the turbine bypass valves will open, relieving steam to the main condenser. This will reduce the amount of steam and entrained activity discharged directly to the environment from the unaffected steam generators.

5. The meteorological conditions assumed to be present at the site during the course of the accident are based on X/Q values for the exclusion area boundary

6.9 Radiological Consequences Study of a Steam Generator Tube Rupture (Continued)

6.9.4 Uncertainties and Conservatisms

5. (Continued)

or LPZ outer boundary. Furthermore, no credit has been taken for the transit time requried for activity to travel from the point of release to the exclusion area boundary or LPZ outer boundary. Hence, the radiological consequences evaluated under these conditions are conservative.

6. A conservative steam generator decontamination factor (DF) of 10 is used in the cooldown phase (release to atmospheric dump valve).

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SECTION 7 - ALTERNATE ENERGY SOURCES

No cost effective and/or reliable alternatives exist to replace the power which could be obtained by stretching the Fort Calhoun Station. Replacement power could be provided by purchasing additional power, upgrading other existing generating facilities, or base loading peaking units. Purchased power is not a dependable alternative and projections show limited availability in the near future. Upgrading of other existing generating facilities is not considered cost effective, since these units were not designed to support stretch ratings, as was the Fort Calhoun Station. Upgrading would therefore require extensive rebuilding. Base loading peaking plants would result in higher fuel costs, as these units are fired by oil. Burning oil for electric generation is not consistent with our national energy policy. The introduction to this report discussed the differential fuel costs associated with alternate generation.

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