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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

MAR 13 1980

Docket No. 70-1257
Project M-3

Dr. Roy Nilson, Manager
Corporate Licensing
Exxon Nuclear Company, Inc.
2955 George Washington Way
Richland, Washington

Gentlemen:

The purpose of this letter is to transmit for your information an increment of the analysis of the effects of natural phenomena relative to your plutonium fabrication operations at Richland, Washington. The subject increment of analysis is the environmental character around your Richland, Washington plant. A draft of the enclosure has been reviewed, and commented upon, by those analysts who require the results to carry out succeeding analyses and by the NRC staff. The NRC staff has adopted this final version of the review for application in succeeding analyses. However, we will consider challenge of our position when supported by credible technical bases.

Any questions you may have on the enclosed analysis should be addressed to James E. Ayer of this Branch. He will direct resolution of comments and any justifiable revision of the analysis.

Sincerely,

Leland C. Rouse

Leland C. Rouse, Chief
Advanced Fuel and Spent Fuel
Licensing Branch
Division of Fuel Cycle and
Material Safety

Enclosure: As stated

8003270189

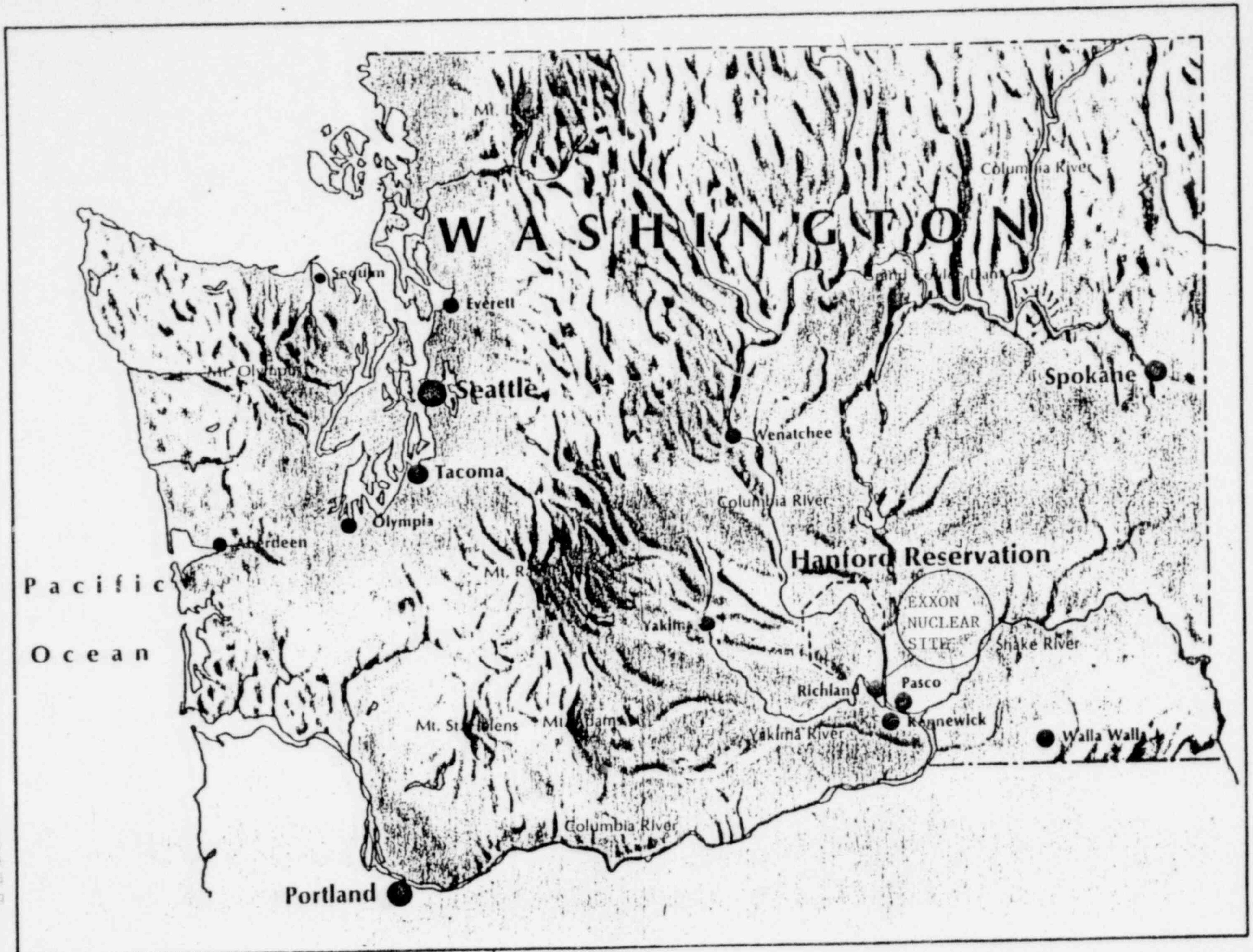
DESCRIPTION OF THE SITE ENVIRONMENT

A. THE EXXON NUCLEAR SITE

1. Geographic Location

The Exxon Nuclear site lies just inside the northern boundary of the city of Richland in the southeastern portion of the State of Washington, and is approximately 110 miles west of the Idaho-Washington border, 180 miles south of the Canadian border, and 225 miles east of the Pacific Ocean. As shown in Figure 1, it is bordered on the north by the 559 square mile Hanford Reservation. The site consists of the entire southwest quarter of Section 15, Township 10 North, Range 28 East, Willamette Meridian in Benton County. The site coordinates are 46° 22' north latitude and 119° 16' west longitude.

The 160 acre site is square shaped. The MOFP lies in the northwest corner of the site, and the center of the plant lies approximately 930 feet south of Horn Rapids Road, which forms the northern boundary of the site. The remaining site boundaries lie 410 ft. to the west, 1,700 ft. to the south, and 2,200 ft. to the east. The Columbia River flows southward at a point approximately 1-3/4 miles east of the MOFP and the Yakima River flows toward the southeast roughly 2-1/2 miles southwest of the plant. Table I gives the distance from the MOFP to a number of offsite developments.



Plant Location in State
FIGURE 1

TABLE I

DISTANCES FROM THE MOFP TO OFFSITE

DEVELOPMENTS

DEVELOPMENTS	DISTANCE	DIRECTION
Horn Rapids Rd.	930 ft.	N
Stevens Drive	4600 ft.	E
Industrial Plant (Battelle-Northwest)	1 mi.	E
State Route 240	2 mi.	SW
Closest Farm (Alfalfa Field)	1 mi.	SE
Closest School (Hanford School)	2-1/10 mi.	SE
Closest Residence (George Washington Way and Hanford St.)	2 mi.	SE
Closest Airport (Port of Benton)	3 mi.	S
Closest Hospital (Kadlec Hospital)	4-3/4 mi.	S

2. Major Topographic Features

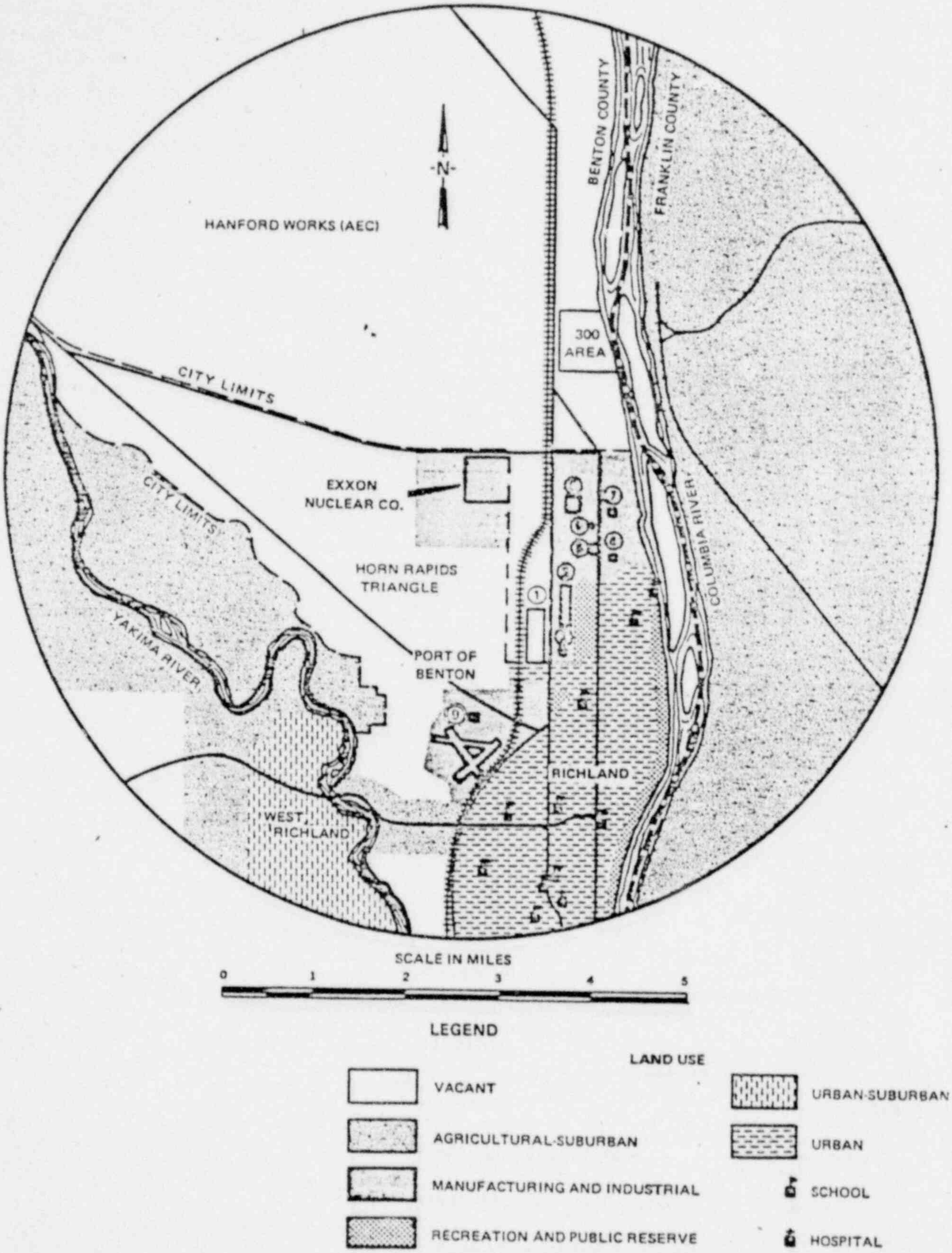
The Exxon Nuclear site is basically flat, but covered with a series of parallel wind-swept ridges that extend in the northeast and southwest directions, and range from 5 to 30 ft. in height. The Burbank loamy fine sand, Finley fine sandy loam, and Quincy loamy sand that forms the surface soil of the area supports typical desert vegetation dominated by bitterbrush and sagebrush. The general topographic trend is an upward slope from the site, which is at an elevation of 372 ft. above sea level, toward the north and northwest.

The site lies on a wedge of land between the Columbia and Yakima Rivers. The Columbia River is approximately 340 ft. above sea level in the vicinity of the site. The banks are generally 100 to 200 ft. above the River. Approximately three miles northeast of the site on the eastern bank of the Columbia is a continuous outcropping, known as the White Bluffs, which vary in altitude between 670 and 930 ft. above sea level. To the west and south are the Rattlesnake Hills, which reach an altitude of approximately 3600 ft. These features, cut by the Yakima River near Benton City, merge into the Horse Heaven Hills near Kennewick, approximately 14 miles southeast of the site.

The developments within a five mile radius of the site are shown on Figure 2 and 3. Approximately one mile to the east is an industrial park. The closest development within the Hanford reservation is the 300 Area, located about 1-1/2 miles northeast of the site. The access to the site is on the North from Horn Rapids Road. The Federal Government has leased to the State of Washington a solid waste burial ground on the Hanford Reservation several miles northwest of the site. Horn Rapids Road intersects Stevens Drive, the main north-south route to the Hanford Reservation, to the east of the site, and the Hanford Highway to the west. A Federally-owned and operated railroad which runs north and south is located roughly 2000 ft. east of the site.

The Horn Rapids ditch, which forms the southernmost boundary of the Horn Rapids Triangle, supplied irrigation water to agricultural areas adjacent to the Yakima River. A deserted gravel pit lies adjacent to the eastern boundary of the site, and an abandoned canal, running north and south, lies approximately 2000 ft. to the west of the site.

As shown in Figure 4, the MOFP is located approximately 110 ft. west of the UO_2 facility and 200 ft. south of the Exxon Nuclear office buildings. These buildings are roughly 750 ft south of Horn



LAND USE WITHIN FIVE MILE RADIUS OF EXXON NUCLEAR SITE
FIGURE 2

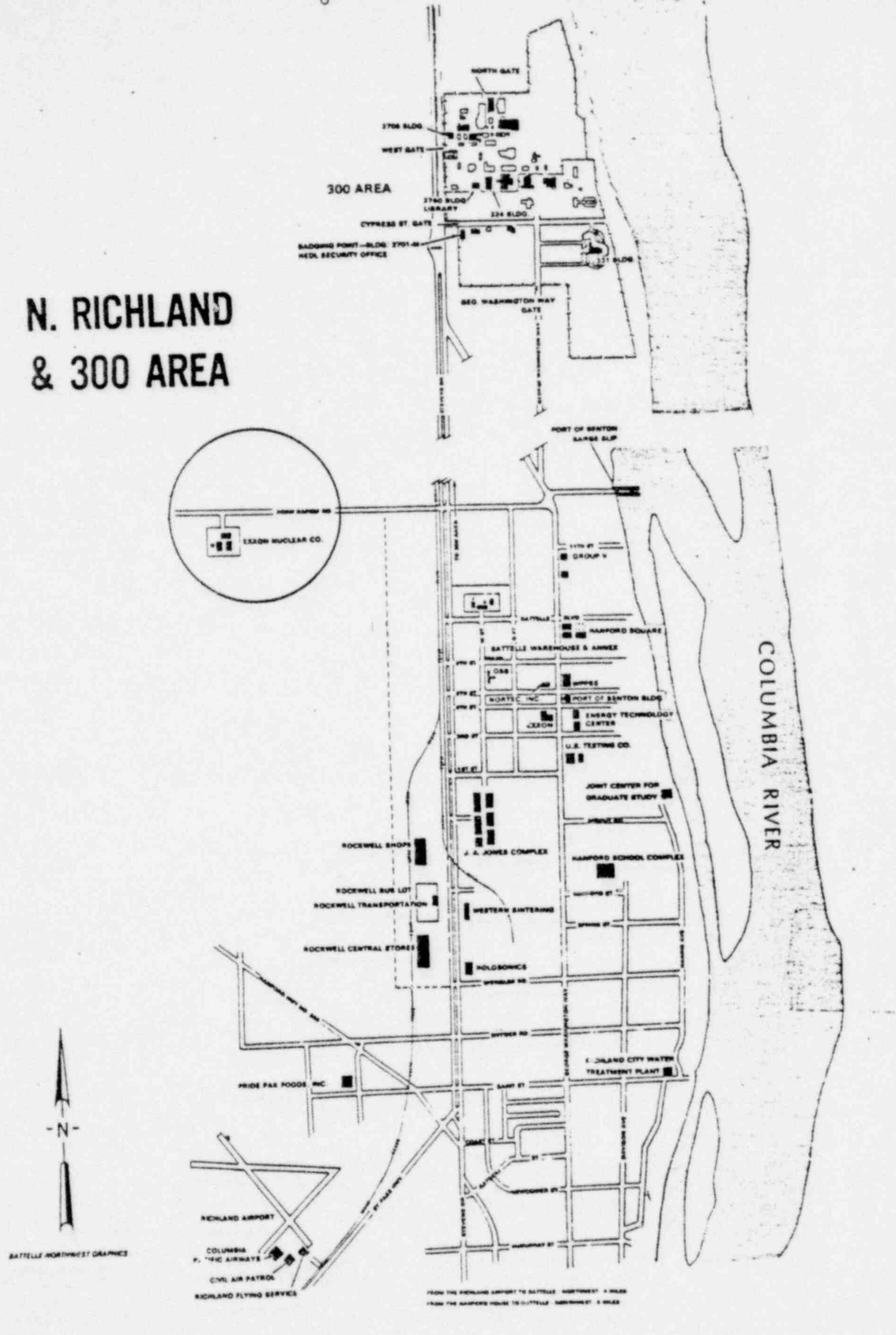
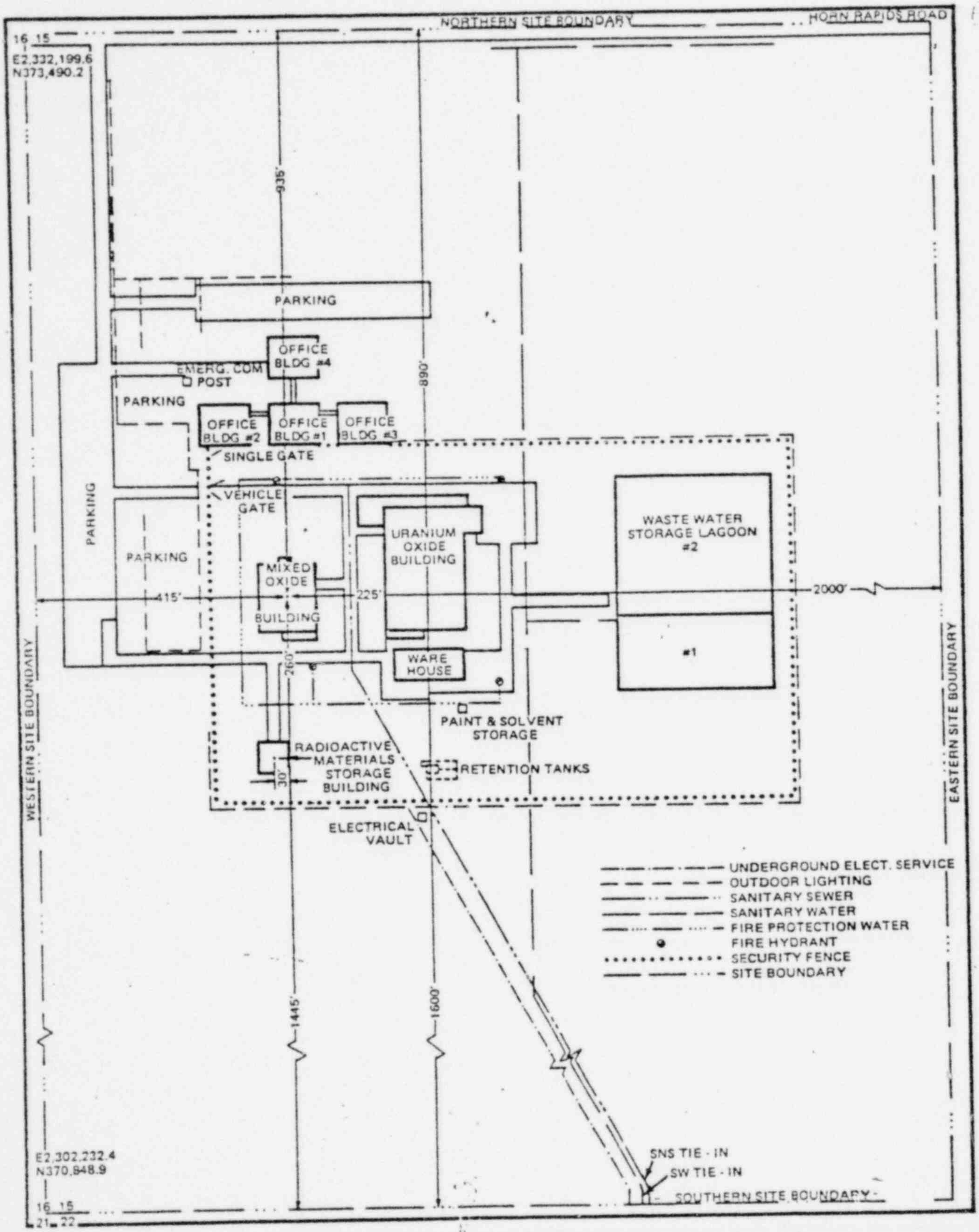

N. RICHLAND
& 300 AREA
NORTH GATE
2700 BLDG.
WEST GATE
300 AREA
2740 BLDG.
LIBRARY
324 BLDG.
CYPRESS ST. GATE
GEO. WASHINGTON WAY
GATE
PORT OF BENTON
BARGE SLIP
EXXON NUCLEAR CO.
GROUP V
HANFORD SQUARE
BATTELLE WAREHOUSE & ANNEX
PORT OF BENTON BLDG
ENERGY TECHNOLOGY
CENTER
U.S. TESTING CO.
JOINT CENTER FOR
GRADUATE STUDY
ROCKWELL SHOPS
J. A. JONES COMPLEX
HANFORD SCHOOL COMPLEX
ROCKWELL BUS LOT
ROCKWELL TRANSPORTATION
WESTERN SINTERING
ROCKWELL CENTRAL STORES
HOLOSONICS
PRIDE PAK FOODS INC.
TREATMENT PLANT
CIVIL AIR PATROL
RICHLAND FLYING SERVICE
COLUMBIA RIVER
N
BATTELLE NORTHWEST GRAPHICS

FIGURE 3



PLOT PLAN OF EXXON NUCLEAR SITE
FIGURE 4

Rapids Road. The production facilities are surrounded by an eight ft. security fence. The immediate area surrounding the Exxon Nuclear development is vacant.

B. LAND USE AND REGIONAL DEMOGRAPHY

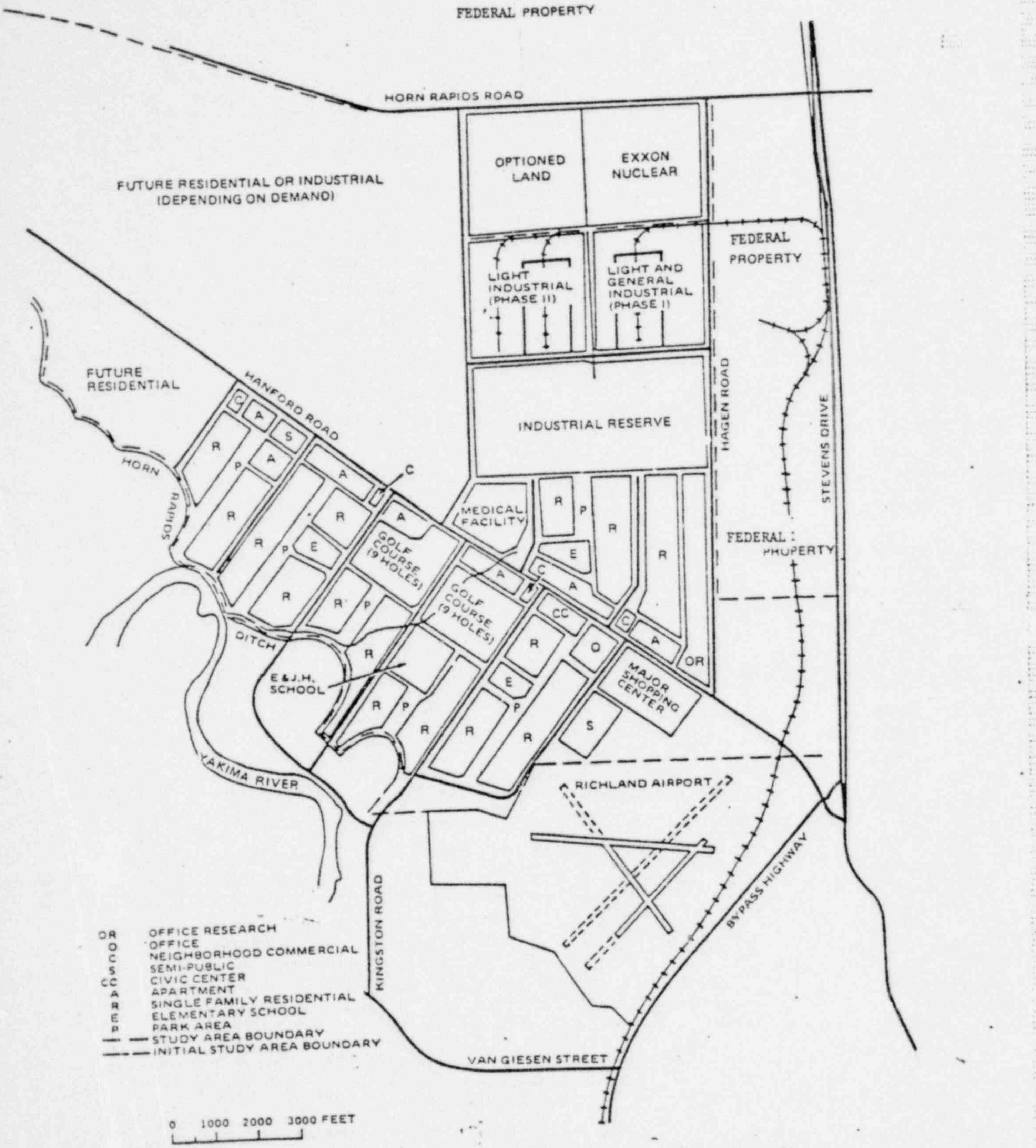
1. Land Use

The Exxon Nuclear site is the sole development on a 6,100 acre parcel of land known as the Horn Rapids Triangle. This land was acquired by the USAEC in 1942 as part of the Hanford Reservation and was subsequently annexed to the City of Richland in 1967. The triangular tract is bounded on the north by Horn Rapids Road, on the south by the Horn Rapids Irrigation Ditch, on the east by a strip of Federally-owned land, and on the southeast by the Port of Benton airport. State Route 240, Hanford Highway, runs diagonally through the Triangle.

The City of Richland owns two-thirds of the land in the Triangle; the remaining third, arranged in a checkerboard pattern, is owned by the Bureau of Land Management. At present, a portion of the Triangle is zoned for light industry and the remainder is zoned agricultural. The 160 acre Exxon Nuclear site lies in the northeastern portion of the 800 acre rectangle which is zoned industrial. Exxon Nuclear has an option on the 160 acre parcel directly to the west of its property.

The City has a comprehensive development plan for the entire area. A 1970 development study of the Horn Rapids Triangle[1] is used as a guideline for this section of the City within the present plan. The year 2000 plan for the Horn Rapids Triangle is shown in Figure 5. It is estimated that 2,000 to 3,000 acres of the Triangle will be required by the year 2000, assuming a population growth rate in the range of 2% to 2.5%. (2% is estimated by the Pacific Northwest Bell Telephone Company.) The residential development, which is planned adjacent to Hanford Road, is not expected to be required until 1980 or 1990 (if development in the area annexed in 1970 south of the Yakima River proceeds rapidly). It is planned that roughly 10-20% of the Triangle will be developed for industry, and that the industrial development will take place to the south and west of the existing Exxon Nuclear site.

The land use in Benton County within a five-mile radius of the MOFP comprises rural residential southwest of the plant, high density residential southeast of the plant, and unoccupied desert northeast and northwest of the plant. Approximately 180 acres of land are being farmed for alfalfa east-southeast of the plant, and an additional alfalfa field of about 65 acres lies southeast of the plant. Because the soil is salty, land close to the Exxon Nuclear plant is



HORN RAPIDS TRIANGLE YEAR 2000 DEVELOPMENT PLAN

FIGURE 5

not well-suited for cash crops. However, a number of acres of irrigated pasture supports, horses, beef cattle, and a few sheep and milk cows. It is estimated that there are a few hundred head of cattle within five miles of the plant in Benton County. The closest hear of about 50 beef cattle are located about three miles southwest of the plant.

That portion of Franklin County which lies within a five-mile radius of the MOFP is primarily an agriculture area. The principle crops are alfalfa, hay and potatoes. There are two commercial dairy herds in this area comprising roughly 150 cows. There are, perhaps, an equal number of beef cattle.

2. Population

The Exxon Nuclear site is on the northern border of the city of Richland, which constitutes, along with Pasco and Kennewick, a metropolitan area known as the Tri-Cities. The projected population of the Tri-Cities in 1980 is approximately 78,500. The centers of population within a 50 mile radius of the site are shown in Figure 6. The projected 1980 population distribution within 22.5° sectors is given in Figure 7. Table II gives population projections supplied by the Battelle Pacific Northwest Laboratories through the year 1990.

3. Traffic

Horn Rapids Road provides the only highway access to the Exxon Nuclear Site. A 1978 measurement in the vicinity of the site indicated an average daily traffic volume on this road of approximately 2000 vehicles. Stevens Drive, directly east of the site, provides the main north-south access to the Hanford Reservation, and consists of four lanes in the vicinity of the site. The average daily traffic volume on Stevens Drive approximately three miles south of the intersection with Horn Rapids Road, north of intersection with Route 240, is 8000-9000 vehicles. The average daily traffic volume on State Route 240 south of the site was roughly 3440 vehicles in 1978.[2]

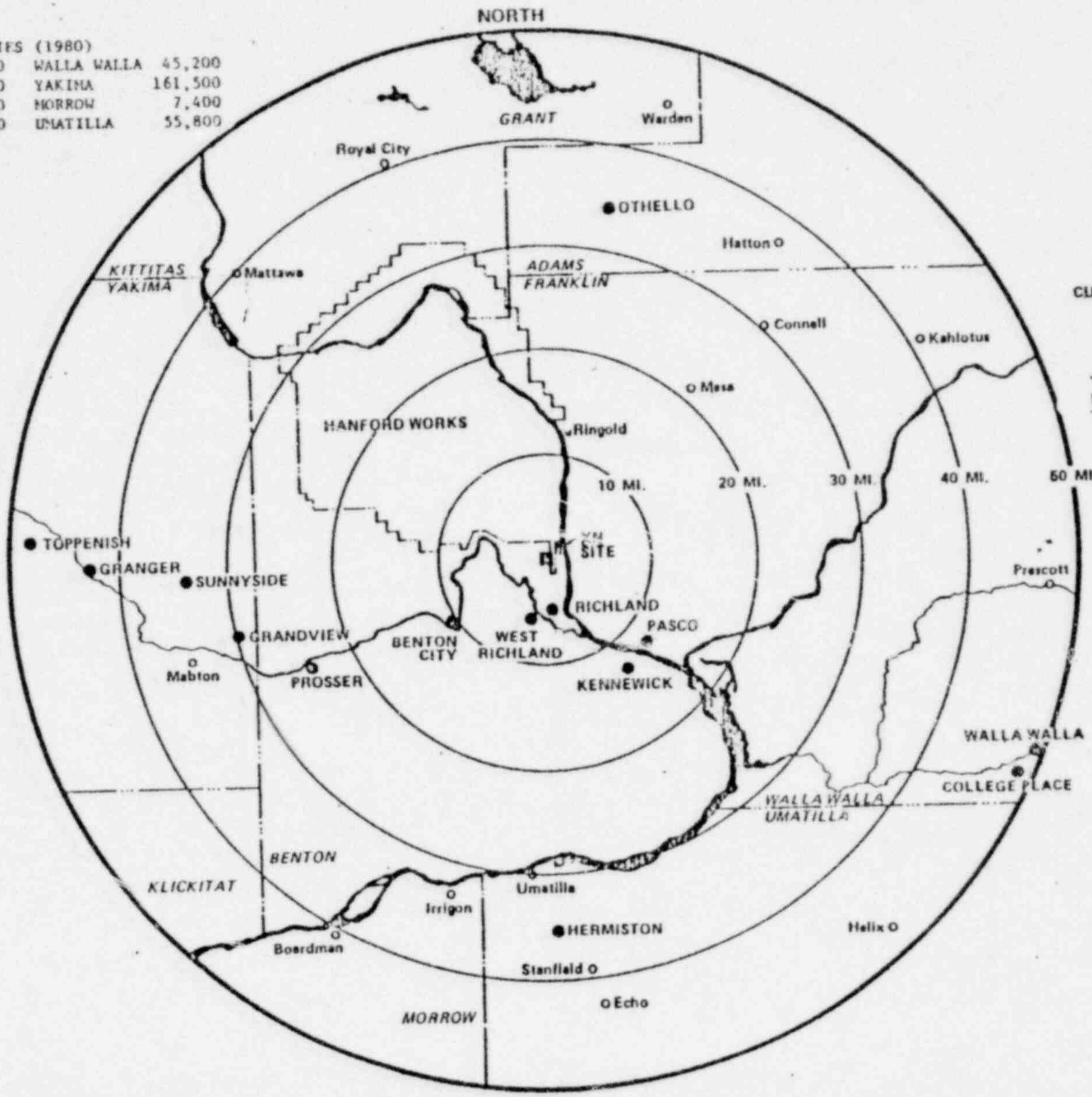
The railroad track to the east of the site is owned and operated by the Federal Government, and is used exclusively for freight. On the average, the track serves two trains per day.

The Port of Benton Airport, approximately 3 miles south of the site, is used for small private aircraft, including small private jets, and by a commercial commuter air carrier having approximately 30 flights per day.

The Tri-Cities Airport, approximately 10 miles southeast of the site, accommodates aircraft as large as the Boeing 727, and is served by approximately 12 DC-9 commercial flights and 20 or more commuter flights daily.

Key
CITY ● Incorporated > 1000 people RICHLAND
o Incorporated < 1000 people Mesa
x Unincorporated Area < 50 people

COUNTIES (1980)			
ADAMS	14,500	WALLA WALLA	45,200
BENTON	97,400	YAKIMA	161,500
FRANKLIN	31,300	MORROW	7,400
GRANT	49,300	UMATILLA	55,800

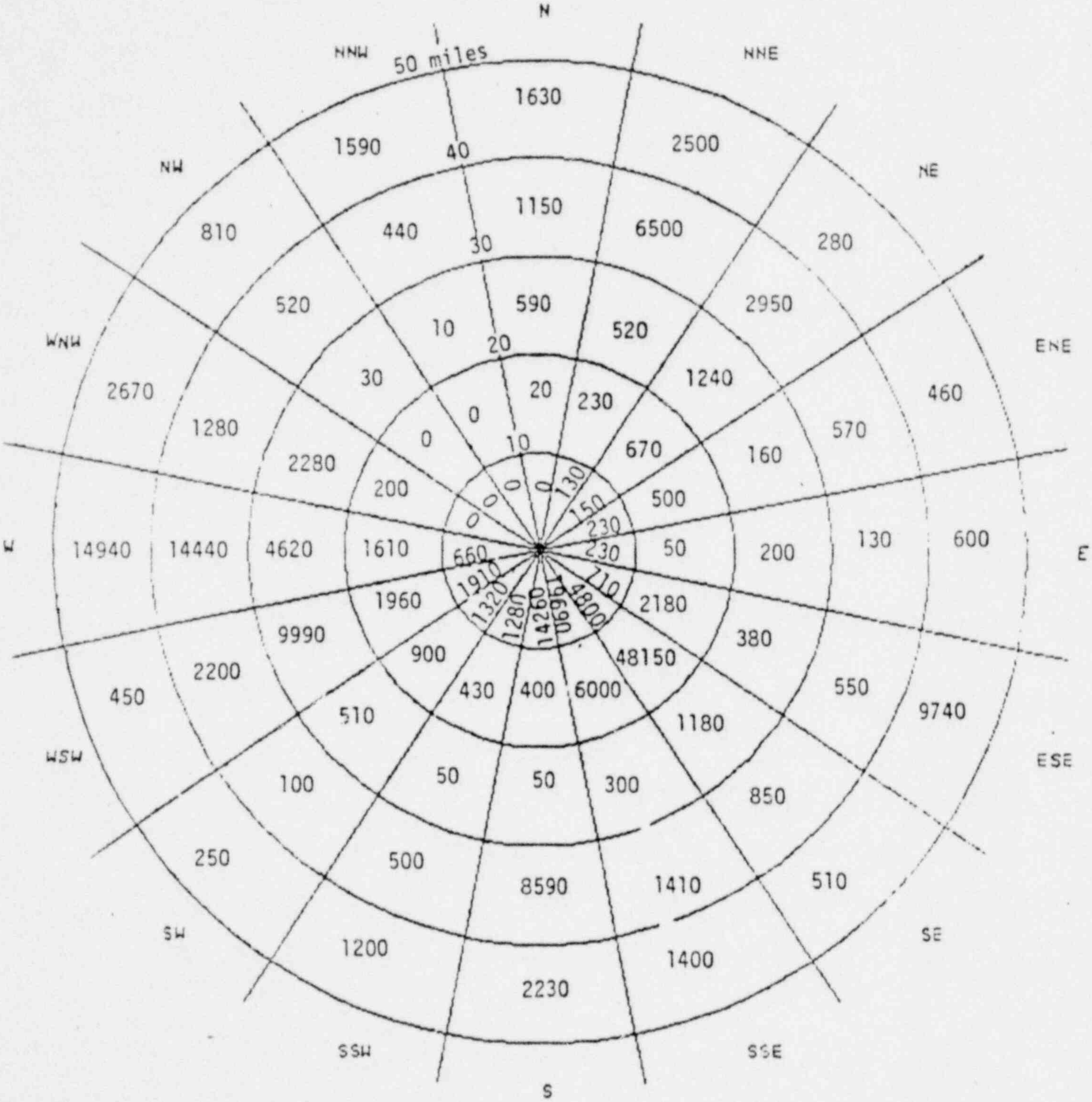


POPULATION CENTERS SURROUNDING EXXON NUCLEAR SITE

FIGURE 6

CURRENT POPULATION OF TOWNS AND CITIES WITHIN 50 MILES OF SITE

CITY	POPULATION 1970	POPULATION 1980
WASHINGTON		
BENTON CITY		1,800
COLLEGE PLACE	4,510	
CONNELL		2,074
GRANDVIEW		4,720
GRANGER	1,567	
HATTON	60	
KAHLOTUS	308	
KENNEWICK		29,760
MABTON	926	
MATTAWA	180	
MESA	274	
OTHELLO		4,670
PASCO		16,200
PRESCOTT	242	
PROSSER		3,788
RICHLAND		32,570
ROYAL CITY	477	
SUNNY SIDE		7,850
TOPPENISH	5,744	
WALLA WALLA		24,570
WARDEN	-	1,620
WEST RICHLAND		2,639
ZILLAH	1,138	
OREGON		
BOARDMAN		1,290
ECHO		430
HELIX	152	
HERMISTON		8,600
IRRIGON		490
STANFIELD		1,400
UMATILLA		3,050



PROJECTED 1980 POPULATION DISTRIBUTION WITHIN
50 MILES OF EXXON NUCLEAR SITE

FIGURE 7

TABLE II
POPULATION PROJECTIONS FOR RINGS
SURROUNDING THE EXXON NUCLEAR SITE

Radius	Population 1980	Population 1990
0 - 10 miles	45,370	54,440
10 - 20 miles	63,300	67,680
20 - 30 miles	22,110	27,010
30 - 40 miles	42,180	55,660
40 - 50 miles	41,260	47,200
Total	214,220	251,990

4. Commercial Activities

The major commercial activities in the Tri-Cities area are nuclear energy research, development, and application; and agriculture. The industrial park directly east of the Exxon Nuclear site is populated mostly by US Department of Energy contractors, as shown in Figure 3. These industries employ more than 1200 individuals.

The 559 square mile Hanford Reservation has served as a national nuclear center since 1943, when construction of the plutonium production reactors was initiated. Although only one reactor is in operation, the Reservation is still a center for nuclear energy research and development and some production activities. At present, approximately 3500 people are employed at Hanford. In July, 1970, construction was initiated on the Fast Flux Test Facility,[3] which is expected to be in operation in 1980, and is located roughly 6 miles north of the Exxon Nuclear site. The construction of the Hanford No. 2 Nuclear Plant,[4] an 1100 MWe generating facility owned by Washington Public Power Supply System and located approximately 8 miles north of the site, was begun at the end of 1972, and the plant is expected to be operational in 1981.

Agriculture is also important to the economy of the area. In 1978, the value of crops grown in the Columbia Basin Area was approximately $230,000,000, and livestock, poultry, and associated products were valued at about $71,000,000.[5] Many of the acres devoted to crops are irrigated and are planted with wheat, hay, and other small grains; potatoes, to a lesser extent vineyard, and orchard crops are grown. There are essentially no forest products harvested in this part of the state.

In 1967, there were approximately 60 manufacturing establishments in Benton and Franklin Counties, employing about 5300 individuals.[6] Chemical products, food products, and printing and publishing constituted the majority of the manufacturing establishments. A number of these plants are located along the Columbia River, southeast of the Tri-Cities.

The area between the Port of Benton Airport and Hanford Road, approximately 2-1/2 miles south of the MOFP, is the site of some recent industrial developments. A large food packaging plant, specializing in the processing of potatoes, has been located there. Additionally, a new airport terminal has been build including a restaurant. Nearby, computer software manufacturing and office facilities have been built.

C. METEOROLOGY

1. Regional Climatology

The climate of the Hanford area is relatively mild and dry and is controlled in part by the seasonal and synoptic variations in the strength and position of the Pacific high-pressure center. The area has the characteristics of both maritime and continental climates, modified by the Cascades and Rocky Mountains. The maritime influence of the ocean is strongest in winter due to the prevailing westerlies. Occasionally, very cold Canadian air enters the region from the east and north, resulting in very cold conditions. In summer, airflow from the Pacific is reduced, and the area is subject to clear skies, high temperatures, and low humidities during the afternoons, but the clear, dry air permits rapid radiation cooling after sundown, producing cool nights. Rainfall in summer is very light. Winters are cloudy and relative humidities are high, although total precipitation is quite low. Wind direction is strongly influenced by the terrain; windspeeds are moderate, with occasional calms and gales. The prevailing wind direction is southeast.

2. Local Climatology

Unless otherwise indicated, the climatological data used in this report were collected at the Hanford Meteorological Station (HMS), which is located about 32 km (20 mi) northwest of the site.[7] Temperature and precipitation records were collected by a U.S. Weather Bureau cooperative observer from 1912 to 1943 at a site about 16 km (10 mi) ENE of the HMS. Hourly observations at the HMS are continuous since December 1944. (There are small gaps in the record in 1943 and 1944.) The climatological data are given in Table III.

The average annual temperature of the site (based on the 1912-70 record) is 11.7°C (53.1°F); annual averages vary from 13.4°C (56.2°F) in 1934 to 10.1°C (50.2°F) in 1929 and 1958. January, with -1.4°C (29.4°F), is the coldest month; July is the warmest month, averaging 24.1°C (76.4°F). January means values have varied from 5.8°C (42.5°F) in 1952 to -11.1°C (12.1°F) in 1950. The summer variability of average temperatures is less; in July, the mean monthly temperature varies from 27.7°C (81.8°F) in 1960 to 22.7°C (72.4°F) in 1964.

Table III. Climatological Data for the Hanford Area[a]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature (°C)													
Extreme maximum	18.8	21.7	28.3	35.0	39.4	43.3	46.1	45.0	38.9	32.2	22.8	20.0	46.1
Average	-1.4	2.3	7.3	11.8	16.6	20.8	24.7	23.4	18.4	11.7	4.4	0.3	11.7
Extreme minimum	-30.6	-30.6	-14.4	-11.1	-2.2	0.6	5.0	4.4	-3.9	-14.4	-18.3	-32.8	-32.8
No. days max ≥ 37.8°C (100°F)					b	2	7	4	b				13
No. days max ≥ 32.2°C (90°F)				b	3	9	21	18	5	b			56
No. days max ≤ 0°C (32°F)	10	3	b							b	1	8	22
No. days min ≤ 0°C (32°F)	27	21	15	5	b				b	5	17	25	115
No. days min ≤ -17.8° (0°F)	2	1									b	1	4
Degree days[c] (base 65°F), °F	1094	778	642	381	153	34	3	5	67	373	746	991	5267
Precipitation (mm)													
Highest monthly	63	78	29	31	43	74	21	30	34	62	77	64	290
Average	24	16	9	10	11	14	4	5	8	15	22	22	159
Lowest monthly	3	d	0	0	0	0	0	0	d	0	d	3	83
No. days trace or more[e]	17	12	11	11	10	10	4	6	7	11	15	18	132
No. days ≥ 0.25 mm[e]	9	7	6	5	5	5	2	2	3	6	8	10	68
No. days ≥ 2.5 mm[e]	3	2	2	2	2	2	1	1	1	2	3	3	24
No. days ≥ 6.4 mm[e]	1	1	b	b	1	1	b	b	b	1	1	1	7
Average snowfall, mm	132	58	8	d						d	30	94	323
Other Meteorological Data													
Daytime sky cover, %[f]	78	74	67	64	58	52	27	33	41	59	75	81	59
No. clear days[f]	3	5	7	6	8	10	20	19	15	10	5	3	111
No. partly cloudy days[f]	6	5	8	10	11	10	7	7	7	7	5	5	88
No. cloudy days[f]	22	18	16	14	12	10	4	5	8	14	20	23	166
Avg. relative humidity, %[g]	76	70	55	46	42	39	32	35	40	58	73	81	53.8
Avg. dewpoint temp., °C[g]	-4.9	-2.6	-2.6	-0.9	2.2	5.1	5.7	6.0	4.2	2.7	-0.5	-2.5	1.0
No. days thunderstorm[c]	0	b	b	1	2	3	2	2	1	b	0	0	11
No. days hail[c]	b	b	b	b	b	b	b	b	b	0	0	0	1
No. days D or BD[c,h]	1	b	1	1	1	1	b	b	1	b	b	b	6
No. days fog[c,i]	9	6	1	b	b	b	b	b	b	2	8	12	38
No. days fog, dense[j]	6	3	1	b	b			b	b	1	5	8	24
No. days glare[c]	2	1	b								1	3	7

From Stone, Jenne, and Thorpe, "Climatology of the Hanford Area," BNWL-1605, June 1972.

[a] 1912-1970, unless otherwise indicated.
[b] Less than 0.5 day per month.
[c] 1945-1970.
[d] Trace.
[e] 1956-1970.
[f] 1946-1970.
[g] 1950-1970.
[h] Dust or blowing dust, visibility ≤ 9.7 km (6 mi).
[i] All fog regardless of visibility.
[j] Visibility 0.4 km (1/4 mi) or less.

Extreme temperatures are 46.1°C (115°F) in July 1939 and -32.8°C (-27°F) in December 1919. Maximum temperatures above 32.2°C (90°F) can be expected 56 days per year, above 37.8°C (100°F) 13 days per year, and below 0°C (32°F) 22 days per year. Mimimum temperatures below 0°C (32°F) can be expected on 115 days per year, and below -17.8°C (0°F) on four days per year. The average seasonal (July through June) degree-day total (in °F for the period 1945-70) is 5267; seasonal totals vary from 6045 (1949-50) to 4599 (1966-67). As is typical of arid areas, the daily temperature range is quite large. At the Yakima Airport, the annual daily range averages 14.9°C (26.9°F).[8] In July the range is 19.3°C (34.8°F), and in December it is 8.7°C (15.6°F).

Precipitation in the Hanford area averages 159 mm (6.25 in). January, with 24 mm (0193 in), is on the average the wettest month; July, with 4 mm (0.14 in), is the driest. Calendar months with no measurable precipitation have occurred year-round except in January and December. The greatest 24-hour rainfall was 49 mm (1.91 in) in October 1957, with 43 mm (1.68 in) falling in six hours. As is typical of arid regions, the variation in rainfall totals from year to year is large; annual totals range from 290 mm (11.45 in) in 1950 to 83 mm (3.26 in) in 1969. A trace or more of precipitation falls on 132 days per year. Days with precipitation equal to or greater than 6.4 mm (0.25 in) are infrequent, averaging seven days per year.

Snowfall, which accounts for 40% of all precipitation in the months of December through February, averages 323 mm (12.7 in). Seasonal amounts of frozen precipitation vary from 8 mm (0.3 in) in the winter of 1957-1958) to 1107 mm (43.6 in) in 1915 - 1916. The maximum recorded snow depth was 300 mm (12 in). A typical year has five days with 25 mm (1 in) or more of snow.

The average number of clear days per year is 111; cloudy days, 166. The average annual daytime (sunrise to sunset) cloud cover is 59%, and varies from 81% in December to 27% in July. The average annual relative humidity is 54%; the value is 81% in December and 32% in July. At Yakima, the afternoon (4 p.m. PST) humidity varies from 74% in winter to 25% in midsummer.[8] A value of 6% was recorded at the HMS in July 1951.

Thunderstorms are quite rare, averaging 11 days per year, mostly in summer. Hail has been observed on 16 days in 12 years of record. Dust has been recorded at the HMS on 2% of all days of observation (84 days in 14 years of record), with a distinct maximum frequency during the summer months.

Light fog occurs on 38 days per year. Heavy fog visibility no greater than 0.4 km or 0.25 mi) occurs on the average 24 days per year, varying from 9 days in 1948-49 to 42 days in 1950-51. Heavy fogs are most frequent on the average in December 8 (days), January (6 days), and November (5 days), and have never been observed in June or July. The average duration of fog is 3.2 hours; however, a light fog (visibility less than 9.7 km or 6 mi) persisted for 72.3 hours in December 1947.

Surface winds in the area are controlled in part by local topographic features. The long-term (1945-70) average annual windspeed at 15.2 m at the HMS site is 3.4 m/s (7.6 mph). Monthly averages vary from 2.7 m/s (6.0 mph) in November to 4.0 m/s (9.0 mph) in June.[7] This unusual annual cycle of windspeeds is caused by strong drainage winds from the nearby mountain ridges during clear summer evenings and nights. The prevailing wind direction for all months at HMS is either NW or WNW, reflecting drainage winds at night.[7] Wind from the W, WNW, and NW occur 42.4% of the time, compared to only 19.8% from the SSW, SW, and WSW. Strong winds from the NW sectors are relatively rare; 88.9% of all winds 13.9 m/s (31 mph) or faster come from the SSW, SW, and WSW, whereas only 6.8% are associated with flow from the W, WNW, and NW.[7]

The strongest wind ever observed at Hanford occurred on 11 January 1972.[9] A peak gust of 35.8 m/s (80 mph) was recorded at the 15.2-m height of the HMS meteorological tower; the average windspeed for the hour endi g at 0900 PST was 22.8 m/s (51 mph).

3. Dispersion Meteorology

No onsite wind data are collected at the Exxon site. Table IV is a joint frequency distribution of windspeed vs. direction at 10 m for one year at the Hanford-2 nuclear power plant site located about 13 km (8 mi) NNW of the site. Because the two sites have a similar exposure, the wind and stability data collected at the Hanford-2 site are representative of those at the Exxon site. The distribution of wind directions is biomodal, with maximums from the NW and S. Strong winds (9 m/s or 19 mph) occurred 479 hours during the one year of record (5.5% of the time).

The average annual relative-concentration (χ/Q and relative-deposition (D/Q) values for the Exxon facility were calculated using one year (April 1975-March 1976) of wind velocity and stability data collected at the Hanford-2 reactor site and the XOQDOQ model developed by NRC.[10] Tables V and VI provide χ/Q and D/Q values at selected distances for 16 directions from the Exxon plant. The χ/Q values in Table V were calculated for continuous ground-level releases. The model includes an allowance for plume meander during light winds and stable atmospheric conditions.[10] The D/Q values in Table VI represent only routine, continuous releases using a deposition velocity appropriate for ^{131}I and do not include a correction for the settling velocity of PuO particles resulting from their size and density. Considering the possible size spectrum of material and potential travel distance with varying windspeeds, the actual D/Q value may show some variation from that given in the table.

Table IV Joint Frequency Distribution--Windspeed vs. Wind Direction at 10 m--Hanford-2 Nuclear Plant, April 1975 through March 1976 (%)

Direction	*Speed Class (mph)*[a]							
	1-3	*4-7*	*8-12*	*13-18*	*19-24*	*>25*	*Unk*	*Total*
NNE	1.2	2.0	0.9	0.2	0.1	0.3	0	4.7
NE	0.9	1.6	0.4	0.1	0	0	0	2.9
ENE	0.7	1.1	0.4	b	0	0	b	2.3
E	0.9	0.7	0.1	0	0	0	b	1.8
ESE	1.0	0.9	0.3	0	0	0	0	2.1
SE	1.1	2.4	0.8	0.2	b	0	b	4.5
SSE	1.1	4.4	2.7	0.5	0	0	b	8.7
S	1.1	4.0	4.0	1.3	0.2	0	b	10.6
SSW	1.2	2.5	2.5	2.6	0.7	0.4	0.1	10.0
SW	1.1	1.8	1.2	1.6	0.7	0.4	0.1	7.0
WSW	1.1	1.5	1.0	0.7	0.4	0.2	0.1	5.0
W	0.9	1.6	1.0	0.5	0.4	0.1	0.1	4.6
WNW	1.6	2.6	2.3	1.2	0.4	0.1	b	8.1
NW	1.9	4.2	2.7	1.4	0.7	0.4	b	11.4
NNW	2.1	3.6	1.3	0.3	b	0	0.1	7.4
N	1.6	2.4	1.0	0.4	b	b	b	5.5
Unk	0.1	0.1	b	b	0	0		1.5
Var	1.1	1.0	0.1	0	0	0		2.2
Total	20.6	38.3	22.7	10.8	3.7	1.8		

[a] *Calms = 0.0%.*

[b] *Less than 0.1%.*

Table V Annual Average Relative Concentrations (s/m^3)
Based on Continuous Ground-Level Release and
One Year of Hanford-2 Meteorological Data,
Exxon Facility, Richland, Washington

	Distance (mi)						
Sector	*0.5*	*1.0*	*2.0*	*4.0*	*10.0*	*25.0*	*50.0*
N	6.1-6[a]	1.9-6	6.5-7	2.4-7	6.7-8	2.1-8	8.3-9
NNE	5.1-6	1.6-6	6.3-7	1.9-7	5.4-8	1.6-8	6.4-9
NE	3.9-6	1.2-6	4.2-7	1.5-7	4.2-8	1.2-8	5.1-9
ENE	3.6-6	1.1-6	3.8-7	1.4-7	3.9-8	1.2-8	4.7-9
E	3.4-6	1.0-6	3.6-7	1.3-7	3.6-8	1.1-8	4.4-9
ESE	5.9-6	1.8-6	6.2-7	2.3-7	6.3-8	1.9-8	7.5-9
SE	7.6-6	2.4-6	8.1-7	3.0-7	8.4-8	2.5-8	1.0-8
SSE	7.3-6	2.3-6	7.8-7	2.9-7	8.2-8	2.5-8	1.0-8
S	5.8-6	1.8-6	6.3-7	2.3-7	6.7-8	2.0-8	8.6-9
SSW	4.8-6	1.5-6	5.2-7	1.9-7	5.6-8	1.7-8	1.2-9
SW	4.2-6	1.3-6	4.6-7	1.7-7	5.1-8	1.6-8	6.6-9
WSW	3.2-6	1.0-6	3.5-7	1.3-7	3.7-8	1.1-8	4.8-9
W	2.8-6	8.8-7	3.1-7	1.1-7	3.3-8	1.0-8	4.2-9
WNW	2.9-6	8.9-7	3.1-7	1.1-7	3.2-8	9.7-9	4.0-9
NW	3.6-6	1.1-6	3.8-7	1.4-7	3.9-8	1.2-8	4.8-9
NNW	5.7-6	1.8-6	6.0-7	2.2-7	6.2-8	1.9-8	7.6-9

[a]*Scientific notation: 6.1-6 = 6.1 × 10^{-6}.*

Table VI Annual Average Relative Deposition (m^{-2}) Based on Continuous Ground-Level Release and One Year of Hanford-2 Meteorological Data, Exxon Facility, Richland, Washington

	Distance (mi)						
Sector	*0.5*	*1.0*	*2.0*	*4.0*	*10.0*	*25.0*	*50.0*
N	2.0-8[a]	6.4-9	2.0-9	5.7-10	1.2-10	2.4-11	6.6-12
NNE	1.9-8	6.1-9	1.8-9	5.4-10	1.1-10	2.3-11	6.2-12
NE	1.3-8	4.1-9	1.2-9	3.7-10	7.5-11	1.5-11	4.2-12
ENE	1.0-8	3.2-9	9.5-10	2.8-10	5.8-11	1.2-11	3.2-12
E	1.0-8	3.3-9	9.9-10	2.9-10	6.0-11	1.2-11	3.4-12
ESE	1.8-8	5.6-9	1.7-9	5.0-10	1.0-10	2.1-11	5.8-12
SE	2.2-8	6.9-9	2.1-9	6.1-10	1.3-10	2.6-11	7.0-12
SSE	1.6-8	4.9-9	1.5-9	4.4-10	9.0-11	1.9-11	5.1-12
S	1.2-8	3.7-9	1.1-9	3.3-10	6.8-11	1.4-11	3.8-12
SSW	9.1-9	2.9-9	8.7-10	2.6-10	5.3-11	1.1-11	2.9-12
SW	6.4-9	2.0-9	6.1-10	1.8-10	3.7-11	7.6-12	2.1-12
WSW	5.3-9	1.7-9	5.0-10	1.5-10	3.0-11	6.2-12	1.7-12
W	3.9-9	1.2-9	3.8-10	1.1-10	2.3-11	4.2-12	1.3-12
WNW	4.7-9	1.5-9	4.4-10	1.3-10	2.7-11	5.5-12	1.5-12
NW	8.5-9	2.7-9	8.1-10	2.4-10	4.9-11	1.0-11	2.7-12
NNW	1.6-8	5.1-9	1.5-10	4.5-10	9.3-11	1.9-11	5.2-12

[a]*Scientific notation: 2.0-8 = 2.0 × 10^{-8}.*

The accident-case (short-term, up to 2-h) relative concentrations have been computed, using the NRC accident dispersion model,[11] and are given in Tables VII and VIII. The model is direction-dependent and calculates the χ/Q values out to a distance of 5 km (3.1 mi) immediately following the natural destructive event. The calculation computes the χ/Q values that are exceeded 5% and 50% of the time as a function of distance and direction. This model, as well, includes allowance for plume meander during light winds and stable atmospheric conditions.

Table VII Five Percentile Short-Term (2-h) Relative Concentrations (s/m^3) for the Exxon Facility, Richland, Washington

	Distance in Miles (meters)				
Sector	*0.09 (145)*	*0.31 (500)*	*0.62 (1000)*	*1.24 (2000)*	*3.1 (5000)*
N	9.6-3[a]	1.5-3	5.6-4	2.0-4	7.5-5
NNE	8.5-3	7.6-4	2.8-4	1.8-4	6.4-5
NE	9.4-3	6.5-4	2.3-4	2.0-4	7.2-5
ENE	8.4-3	6.9-4	2.5-4	1.8-4	6.6-5
E	7.9-3	6.2-4	2.2-4	1.7-4	6.1-5
ESE	1.1-2	7.7-4	2.8-4	2.2-4	8.1-5
SE	1.4-2	1.0-3	3.8-4	3.0-4	1.0-4
SSE	1.8-2	8.1-4	3.0-4	2.7-4	1.3-4
S	1.9-2	7.0-4	3.2-4	2.2-4	1.4-4
SSW	1.9-2	6.8-4	3.0-4	2.1-4	1.4-4
SW	2.0-2	6.6-4	2.4-4	2.3-4	1.5-4
WSW	1.3-2	5.8-4	2.1-4	1.8-4	1.0-4
W	1.1-2	5.5-4	2.3-4	1.8-4	8.7-5
WNW	9.1-3	5.0-4	2.3-4	1.8-4	7.1-5
NW	8.9-3	6.0-4	2.2-4	1.9-4	6.9-5
NNW	9.3-3	1.2-3	4.3-4	2.0-4	7.3-5

[a] *Scientific notation:* $9.6\text{-}3 = 9.6 \times 10^{-3}$.

Table VIII Fifty Percentile Short-Term (2-h) Relative Concentrations (s/m^3) for the Exxon Facility, Richland, Washington

	Distance in Miles (meters)				
Sector	0.09 (145)	0.31 (500)	0.62 (1000)	1.24 (2000)	3.1 (5000)
N	8.4-4[a]	1.4-4	4.7-5	1.8-5	4.8-6
NNE	7.0-4	9.8-5	3.3-5	1.1-5	3.0-6
NE	8.0-4	9.9-5	3.3-5	1.2-5	3.5-6
ENE	8.9-4	1.3-4	4.7-5	1.8-5	4.8-6
E	8.6-4	1.4-4	4.7-5	1.8-5	4.8-6
ESE	8.6-4	1.4-4	4.7-5	1.8-5	4.8-6
SE	8.6-4	1.6-4	4.7-5	2.0-5	5.0-6
SSE	1.2-3	1.6-4	5.0-5	2.0-5	6.0-6
S	1.2-3	1.4-4	4.9-5	2.0-5	6.0-6
SSW	1.2-3	1.4-4	4.9-5	2.0-5	6.0-6
SW	1.9-3	2.0-4	7.0-5	3.3-5	1.3-5
WSW	1.3-3	1.8-4	6.5-5	2.8-5	9.0-6
W	1.3-3	1.6-4	6.5-5	2.9-5	8.0-6
WNW	1.3-3	1.5-4	5.2-5	2.1-5	7.0-6
NW	1.2-3	1.5-4	4.8-5	2.0-5	6.0-6
NNW	1.2-3	1.7-4	5.5-5	2.0-5	6.5-6

[a]*Scientific notation: 8.4-4 = 8.4 × 10^{-4}.*

Most dispersion models are applicable only to continuous releases during periods of light to moderate steady-state winds, with numerous experiments averaged to yield dispersion parameters. Concentrations and dimensions of a particulate cloud have been calculated for conditions when the release time is short, the windspeed is very high, and the time the particulate cloud travels across the area is very short.

The values of the dispersion parameters were extrapolated from values for unstable conditions and puff releases. As is standard for instantaneous releases, it is assumed that $\sigma_x = \sigma_y$. The release height for this calculation is assumed to be 8 to 10 m (25 to 30 ft). It was arbitrarily assumed that the centerpoint of the cloud of particulates released from the facility traveled downwind with the gust-front with no deposition at speeds of 42.5 m/s (95 mph) and 67.0 m/s (150 mph). Centerline-centerpoint concentrations are given in Table IX.

Table IX Centerline-Centerpoint Concentrations Resulting from Straight-Line Wind Dispersion of a 1-kg Source 42.5 m/s and 67.0 m/s

Distance (km)	*Concentration ($\mu g/m^3$)*
0.8	381
2.4	23
4.0	6
5.6	3
7.2	2
12.1	0.4
24.1	0.1
40.2	0.02
56.3	0.01
72.4	0.004
80.0	0.003

To determine the area impacted by the particulate cloud and the time it takes to pass, concentration limits set at two-sigma, or 0.135, of the centerline-centerpoint concentration. The dimensions of a particulate cloud at a point and time of its passage are given in Table X.

Table X Dimensions of a Particulate Cloud at a Point and Time of Passage of the Cloud, 42.5 m/s and 67.0 m/s

Distance (km)	*y,x (m)*	*Time (s) 42.5 m/s*	*Time (s) 67.0 m/s*
0.8	140	7	4
2.4	380	18	11
4.0	610	29	18
5.6	820	39	24
7.2	1 025	48	31
12.1	1 700	80	51
24.1	3 200	151	96
40.2	5 200	245	155
56.3	6 800	320	203
72.4	8 400	395	251
80	10 300	485	307

D. ECOLOGY OF THE SITE AND ENVIRONS

The Exxon Nuclear site is located in a relatively flat, desert steppe. Sagebrush and antelope bitterbrush predominate among the pristine plant communities in the area. Cheatgrass, brome, and Sandberg bluegrass prevail in the understory. The annual herbage production has been estimated to be roughly 100 gms of dry matter per square meter.[12]

Throughout the years, the local vegetation has been disturbed by homesteading, fire, and grazing, leaving areas exposed to wind erosion and dune formation. As a result, vegetation such as Russian thistle, mustard, and rabbitbrush have encroached on the native flora. A few barely surviving locust trees testify to the homesteading history. A severe wildfire in 1970 encompassed an area of approximately 19,000 acres of the Hanford Reservation north of the Exxon Nuclear site, but it did not spread into the Horn Rapids Triangle. The fire destroyed a majority of the established shrubs, forbs, and grasses in its path.[13] Initial revegetation of disturbed areas is dominated by annual grasses and forbs, such as cheatgrass, with little or no perennial plant recovery.

The most abundant mammals in the vicinity of the site are pocket mice and deermice. Jackrabbits and coyotes are also scattered throughout the area. By far, the most abundant mammal is the pocket mouse, which subsists largely on the seeds of grasses. Larger and more mobile mammals, such as mule deer, prefer the shores and islands of the Columbia River, with limited use of the more barren, inland steppe. In the fall and winter, however, the mule deer may wander inland to forage upon the shoots of cheatgrass and the leaves and smaller twigs of bitterbrush. In the summer, the deer are frequently found in the distant Rattlesnake Hills.

The most abundant reptile is the side-blotched lizard. Snakes, especially the gopher snake and the Pacific rattlesnake, are occasionally encountered.

Birds are not abundant in the sagebrush-bitterbrush type of vegetation. The most common resident birds are meadowlarks and horned larks. The loggerhead shrike, although not an abundant bird, is conspicuous. During periods when food and cover are adequate, game birds, such as the chukar partridge, quail, ringneck pheasant, and mourning dove may be found in the vicinity of the site. The region is used as a hunting ground for birds of prey, such as the marsh hawk and golden eagle in the winter and the burrowing owl and Swainson's hawk in the summer. The bald eagle is occasionally observed in the area, and the southern bald eagle is the only wildlife species in the vicinity that is on the list of endangered species.[14] During the fall and winter, migrating flocks of Canadian geese forage upon the cheatgrass and alfalfa in the vicinity of the site.

Waterfowl are of major importance in the area. Approximately 200 pairs of Canadian geese reside on the river islands in the vicinity of the site, and produce an average of roughly 700 goslings annually. An estimated 100 pairs of ducks also rest on these islands.[15] Two islands, one near Ringold and another near Coyote Rapids, are used as rookeries by colonies of California and ring-billed gulls. Approximately 6000 nesting pairs produce 10,000-20,000 young annually.

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