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Addendum to the Remedial Investigation for the Chemical Plant Area of the Weldon Spring Site

November 1992

U.S. Department of Energy
Oak Ridge Field Office
Weldon Spring Site Remedial Action Project

Documents Comprising the Draft
Remedial Investigation/Feasibility Study-Environmental Impact Statement
for the Weldon Spring Site Remedial Action Project

DOE/EIS-0185D

Baseline Assessment for the Chemical Plant Area of the Weldon Spring Site, DOE/OR/21548-091, U.S. Department of Energy, Oak Ridge Field Office, Oak Ridge, Tennessee, November 1992.

Feasibility Study for Remedial Action at the Chemical Plant Area of the Weldon Spring Site, DOE/OR/21548-148, Volumes I-II, U.S. Department of Energy, Oak Ridge Field Office, Oak Ridge, Tennessee, November 1992.

Proposed Plan for Remedial Action at the Chemical Plant Area of the Weldon Spring Site, DOE/OR/21548-160, U.S. Department of Energy, Oak Ridge Field Office, Oak Ridge, Tennessee, November 1992.

Remedial Investigation for the Chemical Plant Area of the Weldon Spring Site, DOE/OR/21548-074, Volumes I-II, U.S. Department of Energy, Oak Ridge Field Office, Oak Ridge, Tennessee, November 1992.

Addendum to the Remedial Investigation for the Chemical Plant Area of the Weldon Spring Site, DOE/OR/21548-272, U.S. Department of Energy, Oak Ridge Field Office, Oak Ridge, Tennessee, November 1992.

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November 1992

prepared by

MK-Ferguson Company and Jacobs Engineering Group

prepared for

U.S. Department of Energy, Oak Ridge Field Office, Weldon Spring Site Remedial Action Project, under Contract DE-AC05-86OR21548

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ENVIRONMENTAL SUMMARY FOR OFF-SITE DISPOSAL

1 INTRODUCTION

The U.S. Department of Energy (DOE) is preparing an integrated *Remedial Investigation/ Feasibility Study-Environmental Impact Statement* (RI/FS-EIS) for the Weldon Spring site (DOE 1987a) that complies with requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended, and that incorporate values of the National Environmental Policy Act (NEPA). Components of the environmental documentation process addressed in this addendum include the Remedial Investigation and the Feasibility Study.

The Weldon Spring Site Remedial Action Project (WSSRAP) Remedial Investigation report describes the site and the nature and extent of site contamination. The WSSRAP Feasibility Study identifies remedial options that include both on-site and off-site disposal alternatives. Due to the iterative nature of the RI/FS-EIS process, it is necessary to supplement the information provided in the RI to address the site conditions at the off-site disposal locations being considered in the FS. The selected off-site disposal locations are the Envirocare of Utah, Inc., facility at Clive, Utah, and the DOE's Hanford Reservation at Richland, Washington. Environmental studies have been completed for the Clive site and additional environmental studies are currently being conducted by Envirocare of Utah. Environmental impact statements and other environmental reports have been prepared for various activities on the Hanford Reservation. No environmental reports have been prepared for Hanford disposal of Weldon Spring waste or for a disposal cell in the 200-West area.

This addendum to the WSSRAP RI report describes the environmental characteristics of the alternative disposal sites, allowing a general comparison of environmental impacts. The WSSRAP FS is a source of more detailed information for the alternative disposal sites.

Information in this report was largely extracted from the following documents:

- *The Draft Environmental Impact Statement for the Aptus Industrial and Hazardous Waste Treatment Facility* (U.S. Department of Interior 1988).
- The *Environmental Impact Statement for the Remedial Actions at the Former Vitro Chemical Company site, South Salt Lake, Salt Lake County, Utah* (DOE 1984).
- The *Final Environmental Impact Statement, Disposal of Hanford Defense High-Level, Transuranic and Tank Waste* (DOE 1987b).
- *Characterization of the Hanford Site and Environs* (PNL 1991).

Envirocare of Utah, Inc. provided valuable assistance and information for this report.

2 ENVIROCARE OF UTAH, CLIVE, UTAH

2.1 Location

The Envirocare of Utah, Inc. facility at Clive, Utah is a commercial disposal facility for low specific activity radioactive and mixed wastes. The Envirocare facility is located on the extreme eastern margin of the Great Salt Lake Desert in Tooele County, Utah, 129 km (81 mi) west of Salt Lake City and 81 km (51 mi) east of the Utah-Nevada border. The facility is 4 km (2.5 mi) south of U. S. Interstate 80 and 1.6 km (1 mi) south of the Union Pacific Railroad (Figure 2-1).

The elevation of the facility is 1,311 m (4,300 ft) above mean sea level (msl). The surface slopes uniformly toward the southwest at a gradient of approximately 0.0019. Topographic relief of the area is approximately 3.3 m (11 ft) (Bingham Environmental 1991).

Low-lying hills surround the area on the south, north, and east. The area abuts the Cedar Mountains approximately 24 km (15 mi) east of the site; the Greyback Hills are approximately 6.5 km (4 mi) to the north, across U. S. Interstate 80.

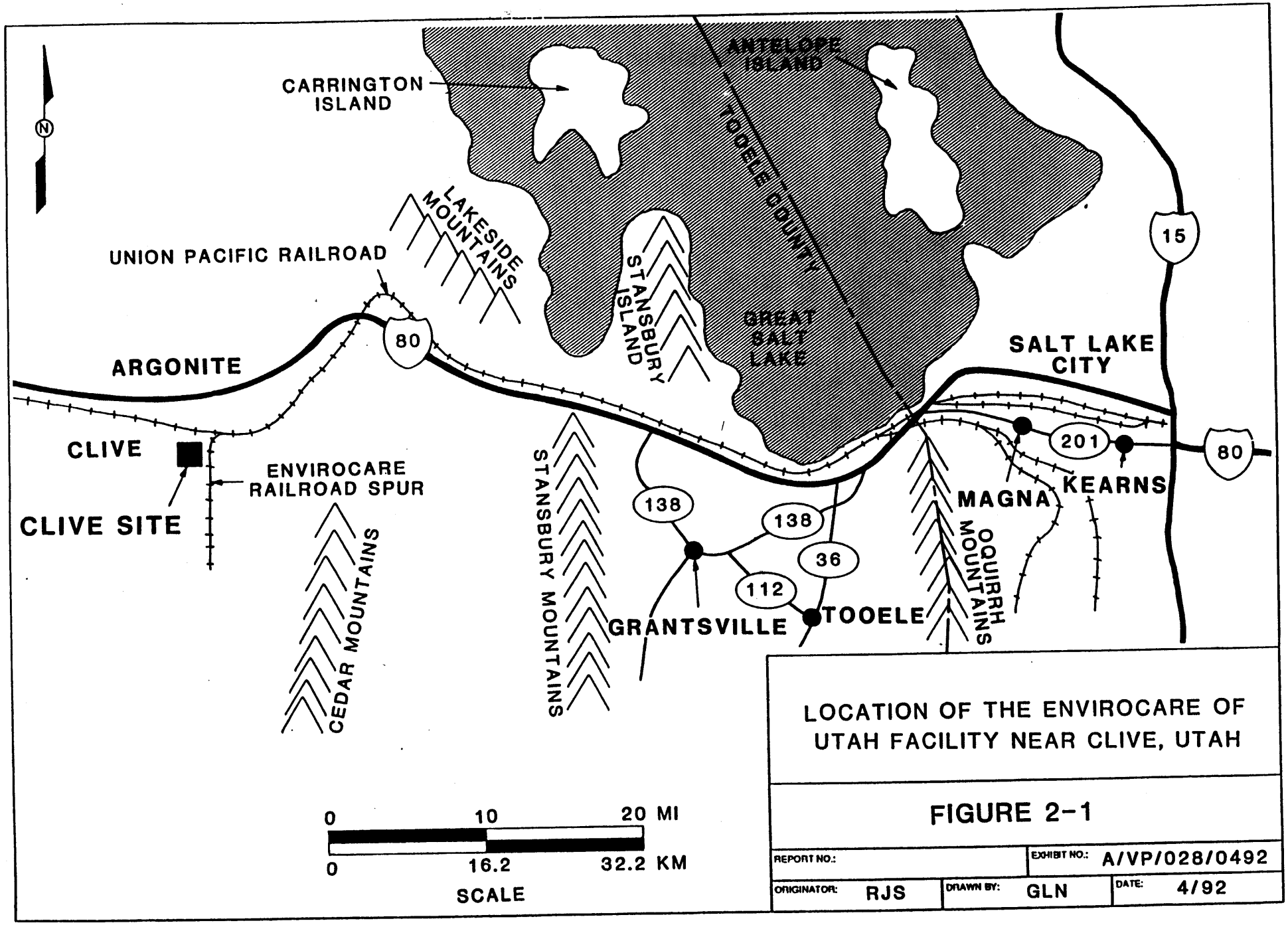
The Envirocare facility occupies 227 ha (560 acres) in a county set-aside area zoned for radioactive and hazardous waste disposal. The site lies in the northern half of Section 32 Township 1 South Range 11 West, a one-square-mile area located 0.62 km (1 mi) south of a rail siding identified as Clive. Section 32 was originally delineated and studied as a potential disposal site by the U.S. Department of Energy (DOE); it was subsequently selected by the DOE as an Uranium Mill Tailings Remedial Action (UMTRA) Project disposal site.

In this document, the term "Envirocare facility" refers only to the land that is occupied by Envirocare of Utah, Inc.; the term "Clive site" refers to the original one-square-mile site identified and studied by the DOE. In various other documents the original one-square-mile of land is identified as "Clive" or "South Clive".

2.2 Land Use

More than 80% of Tooele County land is owned and controled by the Federal government. Most of the land, 779,367 ha (1,948,417 acres), is in the public domain administered by the BLM; the U. S. Department of Defense controls 623,545 ha (1,558,862 acres); and national forests occupy 60,889 ha (152,223 acres) of Tooele County land. Scattered parcels of State owned land are interspersed throughout the area.

The area is used primarily for sheep grazing and recreational vehicles. The lands are used very rarely because of their remoteness from urbanized areas, the unproductive soil, occasional muddy conditions, and sparse vegetation characteristics.



LOCATION OF THE ENVIROCARE OF UTAH FACILITY NEAR CLIVE, UTAH

FIGURE 2-1

REPORT NO.:		EXHIBIT NO.: A/VP/028/0492	
ORIGINATOR: RJS	DRAWN BY: GLN	DATE: 4/92	

2.3 Permits

Envirocare holds Radioactive Material License No. UT 2300249 which was issued on February 2, 1988, by the Utah Bureau of Radiation Control. The license and its amendments permit Envirocare to accept naturally occurring radioactive material (NORM) and other low-level radioactive waste. The Resource Conservation and Recovery Act (RCRA), Part B, permit UTD982598898 was issued to Envirocare by the Bureau of Solid and Hazardous Waste November 30, 1990. This permit allows disposal of "mixed" hazardous/radioactive waste providing the radioactive fraction is acceptable under the Envirocare radioactive materials license. Envirocare is pursuing a license from the NRC to permit them to dispose of 11(e)2 by-product materials; it is expected that the facility will be licensed to receive the Weldon Spring Site Remedial Action Project (WSSRAP) contaminated materials by the time the WSSRAP soil removal activities begin.

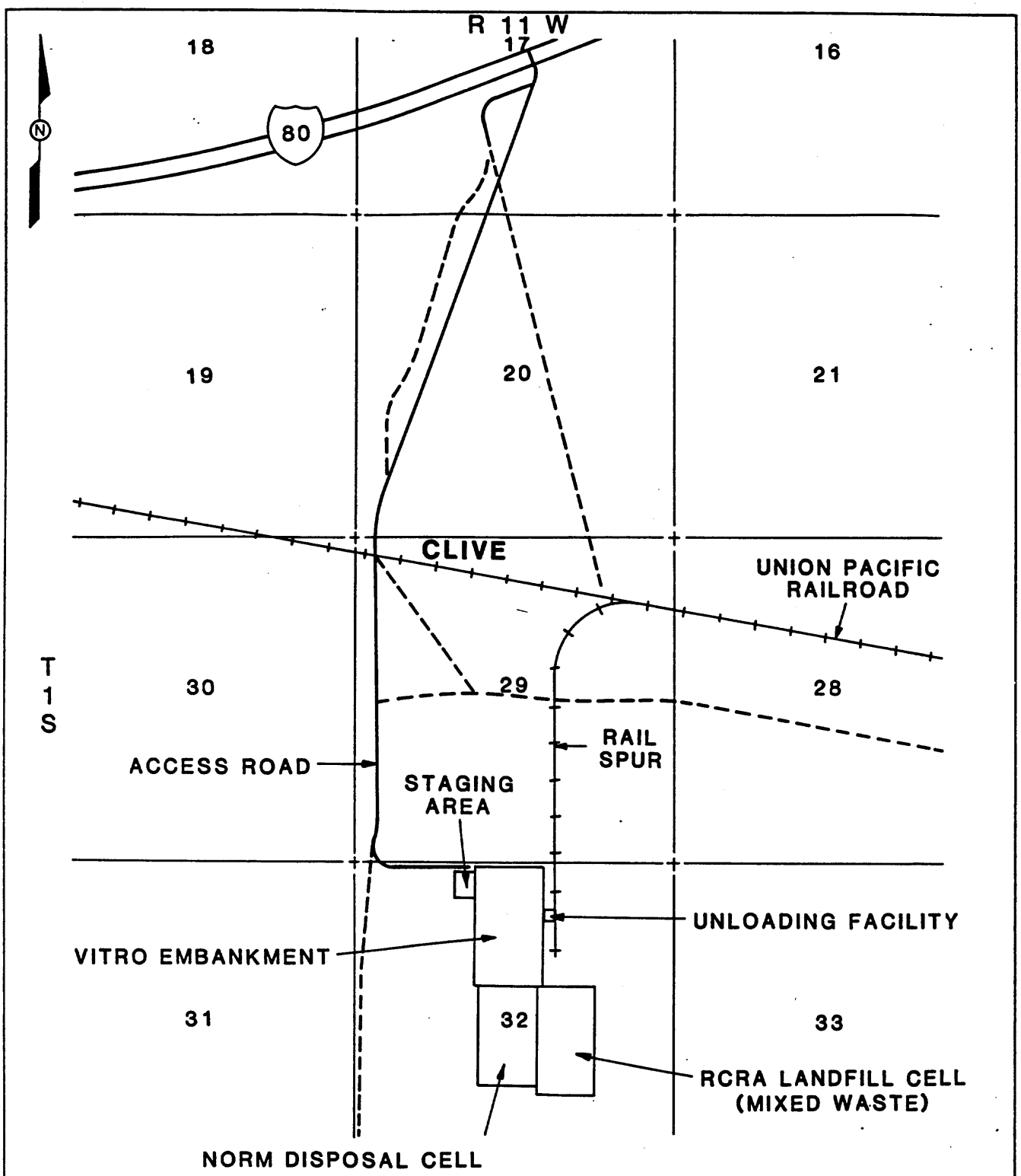
The Clive site was originally selected by the DOE as the disposal site for 4.1 billion kg (4.5 million tons) of low-level radioactive waste that was removed under the UMTRA Project from the Vitro Chemical facility in Salt Lake City, Utah during the 1950s and early 1960s. Figure 2-2 identifies the operational areas within the Envirocare facility. Eight years of intensive investigation by professional organizations including the DOE, the State of Utah Bureau of Radiation Control, Dames & Moore, and Ford Bacon and Davis-Utah, Inc. preceded the selection and permitting of the Clive site.

2.4 Demographics

The Clive site is owned by the State of Utah under the control of the Division of State Lands and Forestry. Most lands within a 16.1 km (10 mi) radius are within the public domain administered by the U.S. Bureau of Land Management (BLM). Other areas owned by the state of Utah or by private parties are scattered throughout the area.

The area south of the Clive site is rural, undeveloped, and sparsely populated. The 1980 census reported 25,500 people residing within 80 km (50 mi) of the Clive site. The nearest residents live 20 km to 32 km (15 mi to 20 mi) to the northeast of the site. The nearest towns are located approximately 72.4 km (45 mi) east-southeast of site. The largest number of people live 48 km to 80 km (30 mi to 50 mi) to the east and southeast of the site in the Tooele-Grantsville area (Figure 2-3).

The U. S. Bureau of the Census, 1990 Census of Population and Housing reported the total population of Tooele County to be 26,601; the reported number of housing units in the county is 9,510.



0 2000 4000 FT

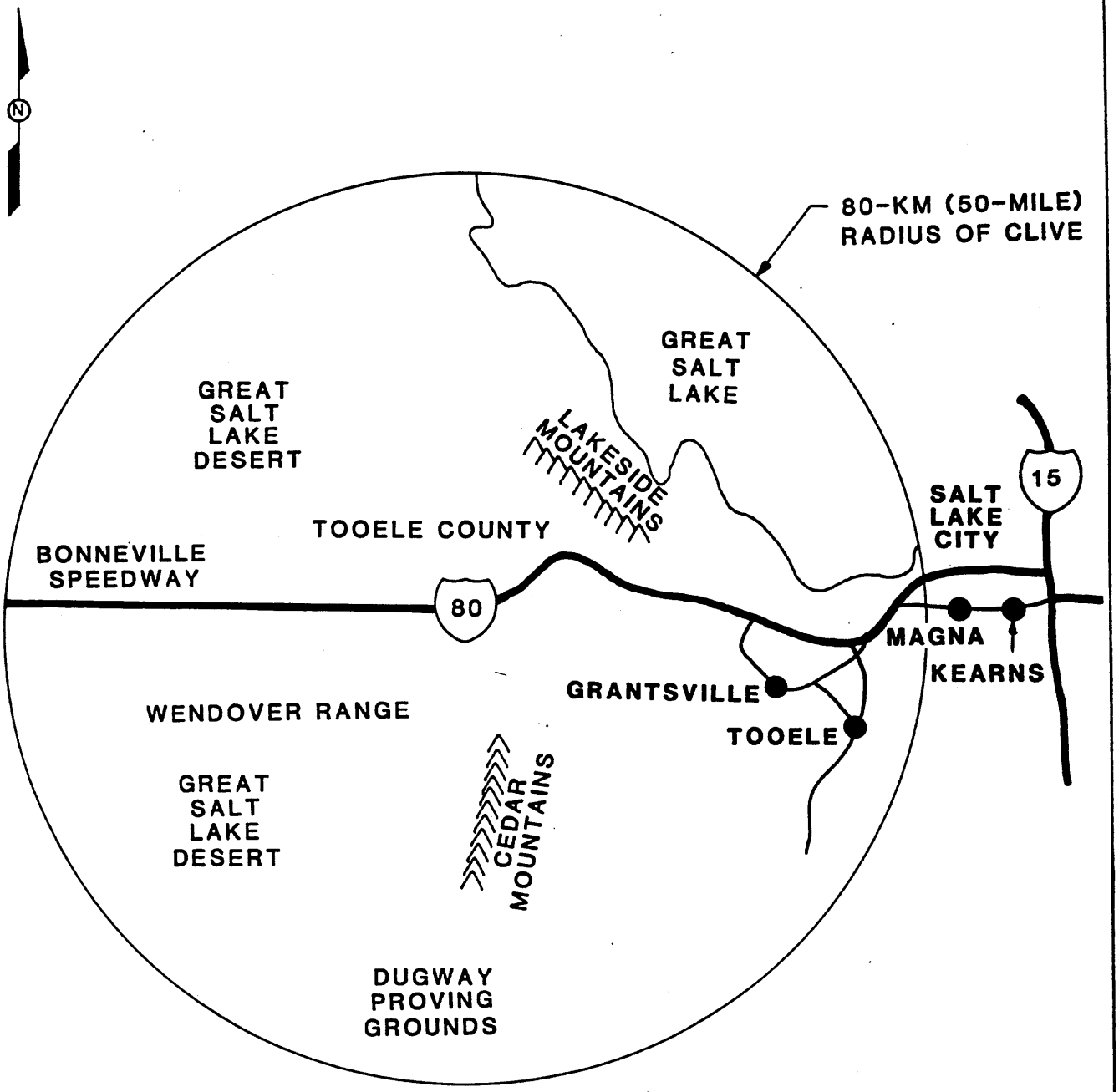
0 609.6 1219.2 M

SCALE

OPERATIONAL AREAS WITHIN THE ENVIROCARE FACILITY

FIGURE 2-2

REPORT NO.:		EXHIBIT NO.: A/VP/029/0492	
ORIGINATOR: RJS	DRAWN BY: GLN	DATE: 4/92	



0 20 40 MI

0 32.2 64.4 KM

SCALE

POPULATION WITHIN 80-KM (50-MILE) RADIUS OF THE CLIVE SITE

FIGURE 2-3

REPORT NO.:		EXHIBIT NO.: A/VP/030/0492	
ORIGINATOR: RJS	DRAWN BY: GLN	DATE: 4/92	

There are no immediate prospects for residential or industrial growth in the area other than waste disposal facilities. Development of the area in the foreseeable future is unlikely due to its remoteness from urbanized areas, lack of water, and the unproductive soil (DOE 1984).

2.5 Transportation

The site is accessed from U.S. Interstate 80 by a restricted truck exit which leads directly to the facility. A main line of the Union Pacific Railroad runs east and west approximately 1.6 km (1 mi) north of the site. An Envirocare railroad spur extends from the Union Pacific Railroad main line to the Envirocare facility (DOE 1984).

2.6 Geology

The Clive site is located in the Great Salt Lake Desert which is a part of the Basin and Range Province of North America. Basin and range topography is typified by discontinuous normal block-faulted mountain ranges separated by basins. The north-south trending mountain ranges at the Clive site often display several thousands of feet of vertical displacement. The mountain ranges are separated by basins filled with Tertiary age valley fill composed of semi-consolidated clays, sands, and gravel 150 m to 240 m (492 ft to 787 ft) thick. Most of the faulting at the Clive site occurred between one million and 25 million years ago (DOE 1983).

Paleozoic sedimentary rocks (limestones, dolomite, shale, quartzite, and sandstones) underlie most of the area at depth and form the cores of the mountain ranges. Tertiary igneous extrusive rocks of basaltic lavas and pyroclastics occur in isolated areas in the Great Salt Lake Desert. Little detailed subsurface bedrock data is available.

Quaternary lacustrine Lake Bonneville colluvial and alluvial deposits (gravel, sand, silt, and clay) make up the basin sediments of the greater portion of the Clive site. The sedimentary deposits in this area are as thick as several thousand feet. The majority of the area consists of soil deposits with interspersed bedrock exposures of limited extent.

Soils at the Clive site are deep and well drained on level to gently sloping basin floors and low lake terraces. Soils are typically formed in alluvium and lacustrine sediments derived from mixed rock sources. Surficial soils are generally fine grained, low permeability silty clay to clayey silt, that range from 4.6 m to 5.5 m (15 ft to 18 ft) thick. These soils contain bedding layers that range from approximately 0.15 cm to 2.54 cm (0.06 in to 1 in.) in thickness. The thickness of surficial soil varies from 0.92 m (3 ft) at the northern edge of the site to 3.35 m to 3.65 m (11 ft to 12 ft) at the southern edge of the site. The low permeability of the upper clay soil results in a very low potential for infiltration in the upper soils and migration to the groundwater table.

Below this upper layer the soils are typically a silty sand layer of variable depth and thickness (Bingham Environmental 1991). The substratum material generally has a high saline content resulting from extensive sodium and gypsum accumulations (BLM 1988), rendering it

unsuitable for most plant growth. Underlying the surficial material is an interlayered lacustrine deposit that ranges from relatively clean, fine-grained and medium-grained sands to silty clays. This interlayered soil sequence appears to be random, and no definite pattern or predominant material type can be correlated. In general, the soils are layered in thicknesses varying from 0.25 cm (0.1 in.) stringers to 1.22 m (4 ft) layers. The cohesive materials encountered are generally classified as stiff to very stiff while the cohesionless materials are generally medium dense to dense. This interlayered sequence extends to depths between 13.7 m and 15.5 m (45 ft and 51 ft) below the existing grade.

Beneath the interlayered sequence, the predominant material is silty sand with a consistency ranging from medium dense to very dense. At a depth of 22.8 m (75 ft), zones containing coarse sand and gravel were noted. At a depth of approximately 39 m (128 ft), the material is classified as very dense (DOE 1984).

2.7 Hydrogeology

The aquifer system underlying the Clive site consists of two major groundwater systems; unconsolidated basin-fill and alluvial-fan aquifers which extend to depths of approximately 180 m (590 ft). The lacustrine deposits, which comprise the majority of the aquifer system, are variable in depth and thickness which makes delineation of aquifers and aquitards difficult. The shallow, unconfined aquifer is separated from a deeper, confined aquifer by an aquitard composed of layers of silty clay material. In general, the groundwater flow directions in both the shallow and deep aquifers are from south to north.

A shallow, unconfined aquifer has been identified below the site in the upper 18 m to 21 m (60 ft to 70 ft) of the lacustrine deposits. The surface of the shallow aquifer is relatively flat; the horizontal hydraulic gradient ranges from 0.0001 to 0.0005 with an average horizontal hydraulic gradient of 0.0003. The water table beneath the site ranges from 5.5 m to 11 m (18 ft to 36 ft) below the ground surface. Groundwater in five monitoring wells at the Clive site ranges in depth from approximately 6 m to 9 m (20 ft to 30 ft) beneath the surface. There are no groundwater wells other than the monitoring wells on the Clive site. Two groundwater wells are near the Clive site; one is located approximately 4.8 km (3 mi) northwest of the site, and the other is located approximately 5.4 km (3.4 mi) east of the site (DOE 1984).

Bingham Environmental reports the hydraulic conductivity of the shallow saturated zone to range from 8.4×10^{-6} m/sec to 1.75×10^{-4} m/sec. The horizontal groundwater velocities range from less than 0.3 m/yr (1 ft/yr) to approximately 7.0 m/yr (23 ft/yr). The estimated horizontal groundwater velocities were calculated from data collected from slug tests from monitoring wells with only 3 m (10 ft) screened intervals, therefore they may not be representative of the overall aquifer (Bingham Environmental 1991).

The deeper confined aquifer consists primarily of lacustrine deposits which occur below a depth of 21 m to 24 m (70 ft to 80 ft). The deeper aquifer exhibits a slightly higher potentiometric level than the shallow aquifer. Both the aquifers and aquitards are characterized

by low vertical hydraulic conductivity and high horizontal hydraulic conductivity relative to the aquitard (Bingham Environmental 1991).

Vertical hydraulic gradients for the deeper confined aquifer, calculated after normalizing the water levels to adjust for variations in fluid density, range from approximately 0.023 to 0.009. Vertical groundwater velocities, calculated using hydraulic conductivities ranging from 4×10^{-7} m/sec to 5×10^{-9} m/sec, range from 0.6 m/yr to 0.009 m/yr (2 ft/yr to 0.03 ft/yr) in the saturated aquifer zone (Bingham Environmental 1991).

Solute and isotopic data indicate that vertical downward movement from the shallow unconfined aquifer to the deeper confined aquifer is minimal. Solute and isotopic data do not preclude upward vertical movement from the confined aquifer to the unconfined aquifer, however. Deeper saturated zones encountered below approximately 18.3 m (60 ft) exhibit higher potentiometric levels than the shallower saturated zone, resulting in an upward vertical gradient below the Clive site. The upward vertical gradient and the low vertical permeability should protect the deeper aquifer from migration of contaminants from the shallow groundwater (Bingham Environmental 1991).

Due to relatively low precipitation and high evapotranspiration, little or no direct infiltration from precipitation recharges the upper shallow aquifer. Groundwater recharge occurs primarily as infiltration at bedrock and alluvial fan deposits and as vertical leakage from the deeper confined aquifer. Recharge to the deeper aquifer probably occurs southeast of the Clive site in coarse alluvial materials adjacent to the hills and mountains (Bingham Environmental 1991).

2.8 Groundwater

2.8.1 Hydrologic Characteristics

The general movement of the regional groundwater is northwest toward the center of the Great Salt Lake Desert Basin. Due to local modifications by surface topography and the stratigraphy, groundwater flow beneath the Clive site is principally to the northeast. Depth to groundwater at the site ranges from 5.5 m to 11 m (18 ft to 36 ft) below the ground surface and extends to depths of 18 m to 21 m (60 ft to 70 ft) (DOE 1984).

Groundwater in the shallow unconfined aquifer is considered saline, with specific gravities ranging from 1.017 to 1.041. It contains high levels of sodium, chloride, magnesium, sulfate, bicarbonate, and total dissolved solids (TDSs). TDSs range from 20,000 mg/l to 50,000 mg/l. Groundwater in the shallow unconfined aquifer is classified as Class IV based on the Utah Groundwater Quality Protection Regulations (Bingham Environmental 1991).

2.8.2 Groundwater Quality

There is little water-quality data available for Tooele County, a reflection of the arid conditions and lack of population centers in the area. There is a water quality station at the source of Big Spring, 45 km (28 mi) to the east near Timpie (DOE 1984).

The results of laboratory analyses of background groundwater samples from on-site wells were compared to the 1984 U.S. Environmental Protection Agency (EPA) primary and secondary drinking water standards. Sulfate, chloride, and TDSs concentrations exceeded the EPA secondary drinking water standards. Total hardness is high, placing the groundwater in the hard to very hard range. Arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver concentrations in two or more background samples exceed EPA primary drinking water standards. Iron and manganese exceed EPA secondary drinking water standards. Analytical results for the radionuclide parameters indicate that gross alpha, gross beta, and uranium also exceed EPA drinking water standards in two or more of the wells (DOE 1984). Without extensive treatment, use of the groundwater is limited to a few industrial processes and mineral extraction (Bingham Environmental 1991).

The deeper aquifer exhibits slightly better water quality; however, it is still saline, with TDS concentrations of 20,000 mg/l (Bingham Environmental 1991).

2.9 Surface Water

No surface water bodies are present on the Clive site. Big Spring, located just south of U. S. Interstate 80 approximately 45 km (28 mi) to the east, is the nearest body of surface water. The perennial stream that flows from Big Spring, 305 m (1,000 ft) south of U. S. Interstate 80, feeds the Timpie Springs Waterfowl Management Area. Big Spring is not used for any domestic, agricultural or industrial purposes.

There is no outlet for the Great Salt Lake Basin watershed. Headwaters of streams flowing from surrounding high elevations have well-defined channels. Throughout the stream course, water in the channels infiltrates into the ground surface and evaporates to the dry desert air. In response to the diminished flow, the size of the channels reduces until there is no evidence of a stream channel.

The Clive site lies to the west of the Cedar Mountains in a relatively flat basin. The watershed above the site covers approximately 120 km^2 (46 mi^2). The streams within the watershed do not normally reach the site; the stream channel nearest the site ends approximately 3 km (1.9 mi) east of the site. Any water flowing past the site would pond in a playa several miles to the west.

There are no marshes, estuaries, or designated wetlands at the Clive site (DOE 1984).

2.10 Seismicity

No active Holocene faults occur in the vicinity of the Clive site (Bingham Environmental 1991). Recent seismic activity is believed to be the result of rebound from the dewatering of ancient Lake Bonneville 15,000 years ago (Bingham 1991). Recent earthquake activity on the west side of the Great Salt Lake has been concentrated in an area approximately 56 km (35 mi) north of Clive (University of Utah 1988). Seismic zoning maps of the United States (Algermissen et al. 1982) indicate the type of energy release, based on historic records, that can be expected from earthquakes. Bedrock accelerations in Clive would range from 0.2 g to 0.4 g (acceleration due to gravity) with a 90% probability of not being exceeded for 250 years (BLM 1988).

The Clive site is located approximately 130 km (80 miles) west of the Wasatch fault. Doser and Smith (1982) estimate a recurrence interval of 387 to 667 years for a 6.5 to 7.5 magnitude earthquake (as measured on the Richter scale) along the Wasatch fault. Significant liquefaction due to a maximum credible earthquake is improbable; at most, self-healing "cracks" may result (DOE 1984).

2.11 Climate and Meteorology

Normal annual precipitation at the Wendover meteorological station located approximately 80 km (50 mi) west of the Clive site is 12.50 cm (4.9 in.). Precipitation is usually lowest in January at 0.75 cm (0.3 in.) and highest in June at 1.75 cm (0.7 in.). The greatest rainfall event recorded during a 24-hour period is 3.3 cm (1.3 in.) . Maximum monthly rainfall is 7.60 cm (3.0 in.). The average annual lake evaporation at Clive is 114.3 cm (45 in.).

Lake evaporation between the months of May to October averages 91.4 cm (36 in.) (DOE 1984). Bingham Environmental (1991) reports precipitation of 15 cm (6 in.) per year with more than 150 cm (60 in.) of evaporation potential for the Clive site.

No wind data are available for the Clive site. Salt Lake City, approximately 100 km (65 mi) to the east, and Dugway, 60 km (38 mi) south of the Clive site, exhibit similar wind patterns with frequency maximums from the southeast and northwest; southwest and northeast winds are less common. The similarity suggests there is no widespread geographical variability in wind patterns, although local topographic influences may be important. The maximum peak gust recorded at Dugway Proving Ground 64 km (40 mi) southeast of the Clive site during the period 1957 to 1965 was 114 km/hr (71 mph) (DOE 1984).

2.12 Air Quality

Baseline air quality sampling was conducted near the Clive site during the calendar year 1982. The resulting data yields monthly means ranging from 5 $\mu g/m^3$ to 42 $\mu g/m^3$ total suspended particulates (TSP), with an average annual mean of approximately 18 $\mu g/m^3$ TSP. These levels are probably representative of background TSP concentrations for the general area (BLM 1988). Salt Lake City and other cities in Tooele County along the Wasatch front range are generally downwind of the Clive site.

Tooele County is designated an attainment area for carbon monoxide, TSP, ozone, nitrogen dioxide, and lead. However, portions of Tooele County and adjacent sections of Salt Lake County along the Oquirrh Mountains are nonattainment areas for sulfur dioxide, primarily due to emissions from the Kennecott Corporation copper smelter near Magna, 85 km (53 mi) east of the Clive site. Salt Lake County is a nonattainment area for carbon monoxide, ozone, and particulates. Designation as an attainment area for one of these pollutants would imply that the area complies with National Ambient Air Quality Standards (NAAQS) for that pollutant.

Tooele County is designated as a Class II Prevention of Significant Deterioration (PSD) area. Moderate deterioration is allowed in Class II areas. No Class I areas would be affected by the disposal of Weldon Spring waste at the Clive site.

2.13 Radiation Levels

Radon levels at the Clive site have been determined by Dames & Moore and Argonne National Laboratory (ANL). Using the track etch method, ANL measured ambient air concentrations of Rn-222 at the three locations surrounding the Clive site. The three-month average Rn-222 concentration at the Clive site was 0.31 pCi/l. All of the values obtained for the Clive area were below 1 pCi/l (DOE 1984).

Radionuclide concentrations in surface soil at the Clive site are in secular equilibrium, with the exception of slightly elevated concentrations of Pb-210, probably due to natural atmospheric deposition. The surface soil concentrations of Ra-226 ranged from 0.9 pCi/g to 1.2 pCi/g dry weight; U-238 concentrations ranged from 0.7 pCi/g to 1 pCi/g; Th-230 concentrations ranged from 1.2 pCi/g to 1.6 pCi/g; and Pb-210 concentrations ranged from 1.1 pCi/g to 2.3 pCi/g (DOE 1984).

2.14 Biological Resources

The vegetation of the Clive site is a homogeneous, semi-desert low shrubland, primarily composed of shadscale. The shrubland is part of the Northern Desert Shrub Biome of the Cold Desert Formation (Oosting 1956) and has been described by Kuchler (1964) as a saltbush (shadscale)-greasewood shrub complex. Plant communities identified on the site are shadscale-gray molly, a transitional community type of shadscale-gray molly-black greasewood, and black greasewood-Gardner saltbush (Figure 2-4). Vegetation patterns of the Clive site are correlated with soil salinity and corresponding shifts in presence or abundance of species. All three communities are low in species diversity.

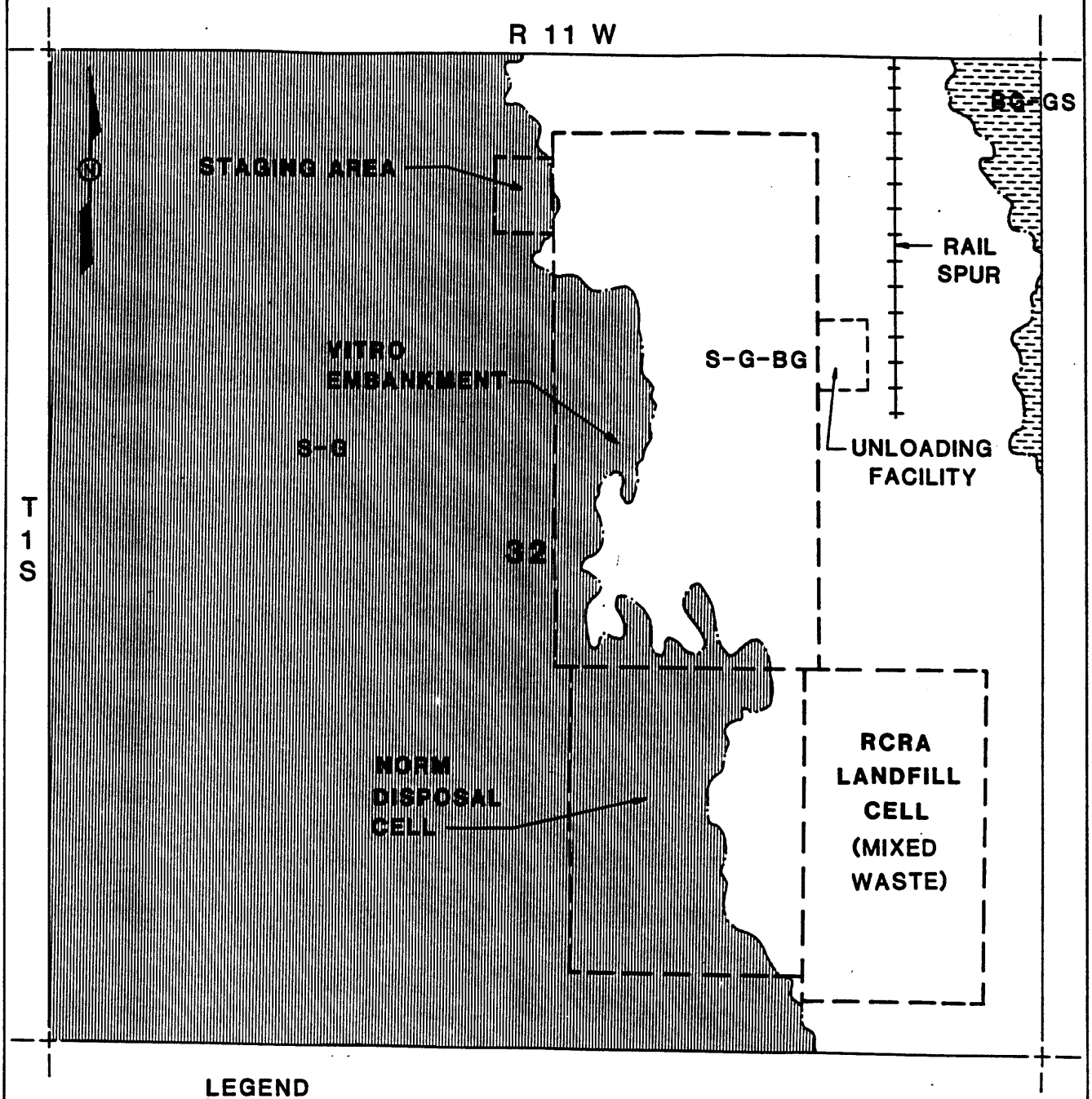
Seep-weed or inkweed and scattered perfoliate pepperweed are the only prominent understory species of the shadscale-gray molly community. The shadscale-gray molly community occurs over most of the Clive site, although black greasewood becomes prominent in the eastern quarter to form a shadscale-black greasewood-gray molly community. Except for black greasewood and occasional stands of halogeton, the population is similar to the more prominent shadscale-gray molly community (Table 2-1).

TABLE 2-1 Plant Species and Communities on the Clive Site

Species	Common Name	Latin Name
	Shadscale	Atriplex confertifola
	Seep-weed/inkweed	Suaeda torreyana
	Perfoliate pepperweed	Lepidum perfoliatum
	Halogeton	Halogeton glomeratus
	Great Basin fishhook cactus	Sclerocactus pubispinus

Community	Type
	Shadscale–gray molly (Kochia americana var. vestita)
	Shadscale–gray molly–black greasewood (Sarcobatus vermiculatus)
	Black greasewood–Gardener saltbush (Atriplex nuttallii)

The black greasewood-Gardner saltbush community type is floristically the most diverse, but occurs only in the extreme northeast corner and eastern edge of the Clive site. In addition



LEGEND

S-G - SHADSCALE-GRAY MOLLY

S-G-BG - SHADSCALE-GRAY MOLLY-BLACK GREASEWOOD

BG-BS - BLACK GREASEWOOD-GARDNER SALTBUSH

0 800 1600 FT

0 243.8 487.6 M

SCALE

VEGETATION MAP WITHIN THE ENVIROCARE FACILITY

FIGURE 2-4

REPORT NO.:		EXHIBIT NO.: A/VP/031/0492	
ORIGINATOR: RJS	DRAWN BY: GLN	DATE: 4/92	

to Gardner saltbush, the flora is composed of all the species found in the other communities except halogeton (DOE 1984).

The Clive site is located in the Desert Alkali range, which is rated by the Bureau of Land Management (BLM) as being poor for grazing or forage production. The lack of water and desirable vegetation in the Clive area limits wildlife. However, the vegetation that is able to grow in the desert soils forms an important ground cover, acts as a deterrent to soil erosion, and provides habitat for wildlife species (DOE 1984).

Two habitat types, shadscale flats (on the western part of the site) and greasewood (on the northeast corner of the site), occur at the Clive site. Animal species typical of the site include blacktail jackrabbit, deer mouse, grasshopper mouse, horned lark, desert horned lizard, Townsends ground squirrel, and Ords kangaroo rat. Species diversity is low (Table 2-2) (DOE 1984, Fairchild 1991).

TABLE 2-2 Animal Species on the Clive Site

Habitat Types	Common Name	Latin Name
Shadscale flats	Blacktail jackrabbit	Lepus californicus
Greasewood	Deer mouse	Peromyscus maniculatus
	Grasshopper mouse	Onychomys leucogaster
	Horned lark	Eremophila alpestris
	Desert horned lizard	Phyrnosoma platyrhinos
	Townsends ground squirrel	Spermophilus townsendii
	Ords kangaroo rat	Dipodomys ordii

The bald eagle and American peregrine falcon are federally-listed endangered species that could occur within the project area (Fairchild 1991).

Utah has one of the largest wintering populations of bald eagles in the United States. They begin to arrive in late November and depart in March for nesting grounds in the northern United States and Canada. The population varies with the weather, food supply, and time of year, and reaches a maximum during January and early February. Approximately 200 wintering bald eagles have been counted in Rush Valley; a lesser number winter in Cedar Valley and Skull Valley, which is east of the Clive site (Johnson 1991). Bald eagle roosts do not occur within the site. However, in Tooele County the black-tailed jackrabbit is the primary food source of the bald eagle; therefore, eagles may hunt in this area (Fairchild 1991).

Hack towers have been built near the marshes around the Great Salt Lake in an attempt to reintroduce peregrine falcons into the historical cliff habitat along the Wasatch Front east of the lake. Towers have been constructed on the north end of the Stansbury Mountains near Timpie, Utah, approximately 42 km (26 mi) east, and on Antelope Island, approximately 85 km (55 mi) northeast of the Clive site. Each tower now has a nesting pair of peregrines returning to use the boxes (Johnson 1991). However, due to the distance between the towers and the Clive site, it is not likely that any peregrines utilize the site (Fairchild 1991).

State- and federal-listed candidate species that occur within the Clive site are the ferruginous hawk and Swainson's hawk. Golden eagle, prairie falcon, turkey vulture, red-tailed hawk, and burrowing owl are among the other raptors that are found in the area. No nesting raptors have been identified within 0.8 km (0.5 mi) os the site (Fairchild 1991).

TABLE 2-3 Listed Endangered and Threatened Species and Candidate Species that May Occur on the Clive Site

Listed Species	
Peregrine falcon	Falco peregrinus
Bald eagle	Haliaeetus leucocephalus
Candidate Species	
Ferruginous hawk	Buteo regalis
Swainson's hawk	Buteo swainsonii

Source: Fairchild 1991, Johnson 1991

The Cedar Mountains are home to approximately 125 wild horses protected under the Wild and Free Roaming Horse and Burro Act of 1971. The herd ranges along the Cedar Mountains, but are seldom encountered on the Clive site (Fairchild 1991).

No Federal or state-listed threatened, endangered, or candidate plant species are known to occur within the Clive site (Fairchild 1991). The Great Basin fishhook cactus, which is associated with gravelly beach terraces of Lake Bonneville in western Tooele County, is currently under review for threatened status; this specie is not expected to occur in the Clive area (DOE 1984).

2.15 Cultural Resources

An intensive cultural resource inventory of the South Clive site and vicinity was conducted by the Archaeological-Environmental Research Corporation in 1981. No cultural resource sites were identified during the inventory. One isolated artifact, four pieces of broken purple glass, was found during the inventory. It does not appear that such a find indicates the

existence of significant archaeologic artifacts on the site. There are no historic sites within 16 km (10 mi) of the Clive site (DOE 1984).

3 HANFORD SITE, RICHLAND, WASHINGTON

3.1 Location

The candidate disposal site is located in the 200-West Area of the Hanford site on the Hanford Reservation near Richland, Benton County, Washington. The approximately 19,500 km^2 (570 mi^2) Hanford site is owned by the U.S. Department of Energy (DOE 1986). The Hanford Reservation is bordered on the north and east by the Rocky Mountains and on the west by the Cascade Range (Figure 3-1). The Umtanum Ridge, Saddle Mountains, Gable Butte, and Gable Mountain lie to the north; Umtanum Ridge, Yakima Ridge and Rattlesnake Hills to the west; Rattlesnake Hills, the Blue Mountains, and the Horse Heaven Hills to the south. Elevations in the area range from 200 m to 220 m (655 ft to 720 ft) above msl.

The Hanford Reservation is near the confluence of the Yakima River and Columbia River. The Columbia River flows through the northern part of the site and turns south to form part of its eastern boundary. The Yakima River flows along part of the southern boundary and joins the Columbia River at the southeast corner of the site. The confluence of the Snake River with the Columbia River is immediately downstream of the confluence of the Yakima River with the Columbia River.

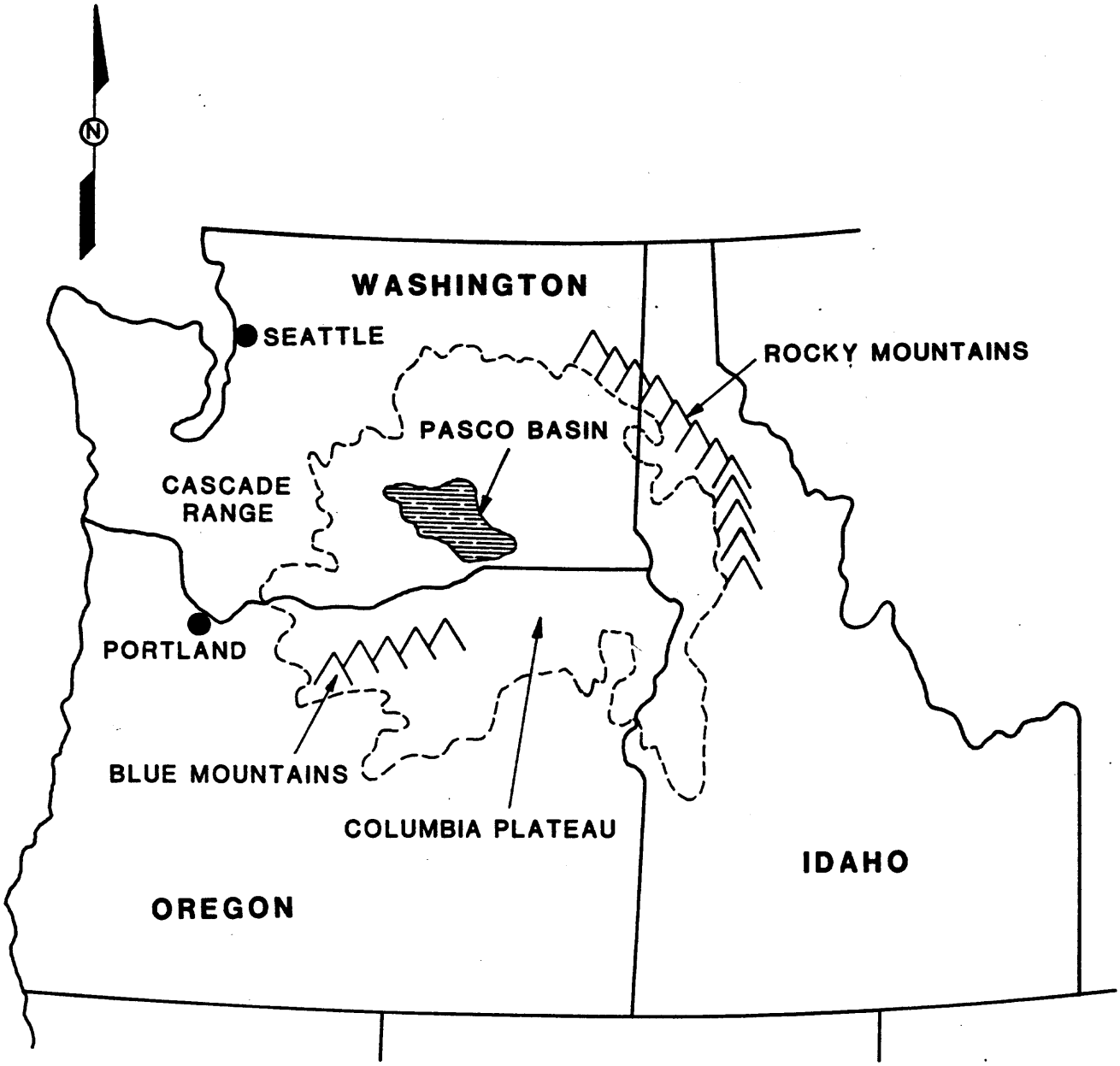
3.2 Land Use

In the immediate vicinity of the Hanford Reservation, the Hanford reach of the Columbia River is used for boating, fishing, hunting, and swimming (DOE 1988). The nearest downstream water intake, the Ringold Fish Hatchery, is located 24 km (15 mi) below the Hanford Reservation.

Land to the north, east, and west of the Hanford Reservation is primarily range and agricultural land. The land supports irrigated and dry-land farming, livestock grazing, and urban and industrial development. Principal agricultural crops include hay, wheat, potatoes, corn, apples, soft fruit, hops, grapes, and vegetables. Most industrial activities in the area are associated with either agriculture or energy production (DOE 1987b).

Benton County currently zones the Hanford Reservation as an unclassified use district. Under the county's comprehensive land use plan, the reservation may be used for nuclear-related activities. Non-nuclear activities are authorized only upon approval from the DOE. It is expected that for reasons of national security, as well as to ensure public health and safety, access to the entire Hanford Reservation will remain controlled (DOE 1987b).

The Hanford site and vicinity includes nuclear-related installations that have been operating since 1943. Several DOE operational areas are within the control zone. These areas, delineated in Figure 3-2, are:

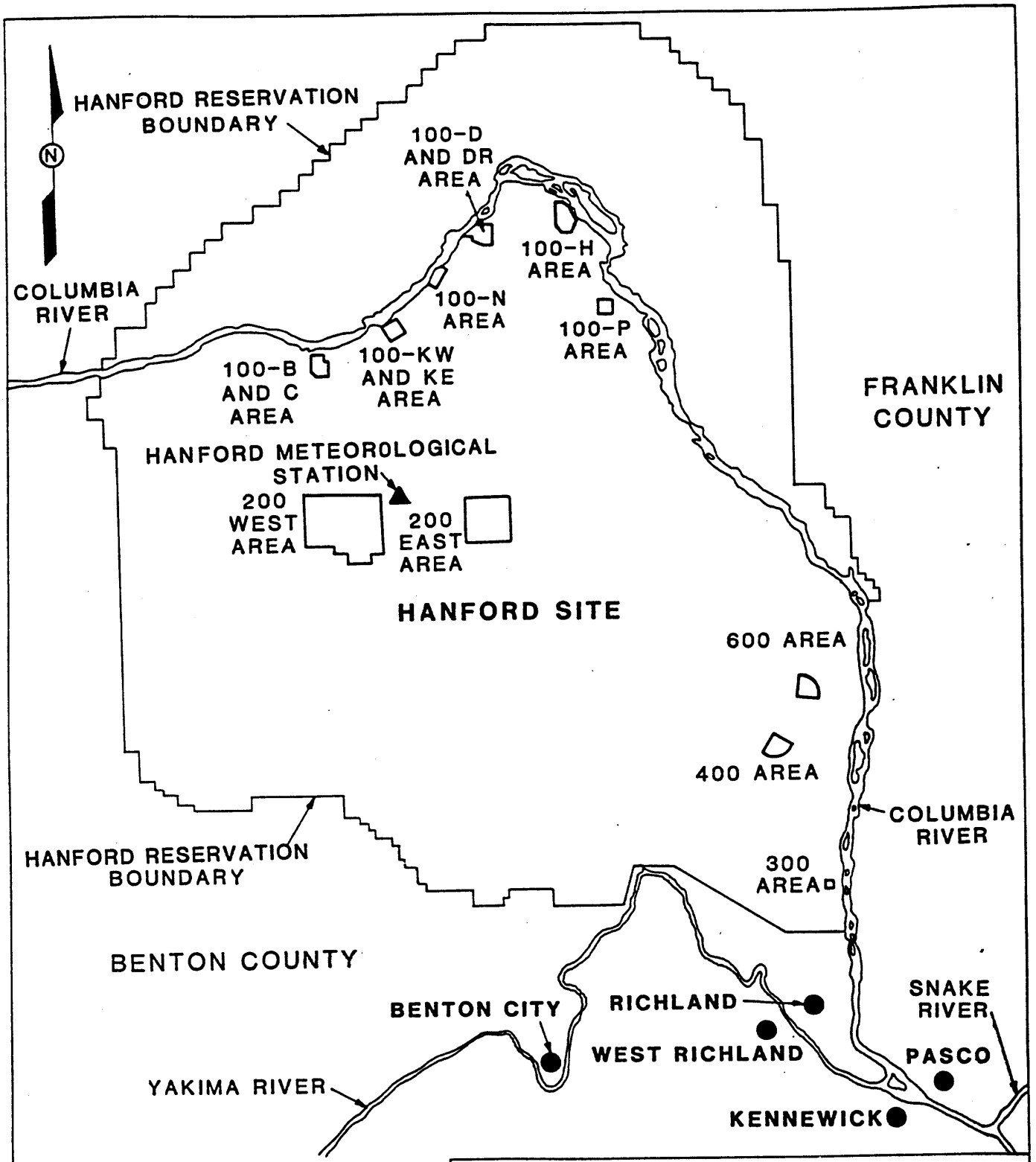


NOT TO SCALE

LOCATION OF THE HANFORD SITE NEAR RICHLAND, WASHINGTON

FIGURE 3-1

REPORT NO.:		EXHIBIT NO.: A/VP/021/0392
ORIGINATOR: RJS	DRAWN BY: GLN	DATE: 3/92



0 5 10 MI
0 8 16 KM
SCALE

DOE OPERATIONAL AREAS WITHIN THE HANFORD RESERVATION

FIGURE 3-2

REPORT NO.:		EXHIBIT NO.: A/VP/022/0392
ORIGINATOR: RJS	DRAWN BY: GLN	DATE: 3/92

The 100-Area, bordering the south shore of the Columbia River, is the site of the dual-purpose N reactor and eight Federal government plutonium production reactors that operated from the early 1940s until 1971. Radioactive wastes are stored or disposed in the 100-Area, which occupies approximately 11 km^2 (1.7 mi^2).

The 200-Area, located on a plateau approximately 8 km to 11 km (5 mi to 6.9 mi) from the Columbia River, has been dedicated to spent nuclear fuel reprocessing and radioactive waste processing management and disposal activities for more than 40 years. The candidate disposal site area is located in the 200-West Area of the Hanford site, which occupies approximately 16 km^2 (2.5 mi^2).

The 300-Area, located just north of the City of Richland, is the site of the Pacific Northwest Laboratory (PNL) nuclear research and development laboratories and nuclear fuel fabrication facility. Radioactive wastes are stored or disposed in the 300-Area, which occupies approximately 1.5 km^2 (0.23 mi^2).

The 400-Area, located approximately 8 km (5 mi) north of the 300-Area, is the site of the Fuels and Materials Examination Facility and the Fast Flux Test Facility used in the testing of breeder reactor systems.

The 600-Area includes the remainder of the Hanford Reservation. The following are located in the 600-Area:

- The Arid Lands Ecology Reserve.
- Land leased to Washington State for low-level waste disposal, occupying approximately 4 km^2 (0.6 mi^2).
- Washington Public Power Supply System nuclear generating station and low-level radioactive waste burial site, located between the 200-West and 200-East Areas.
- Land transferred to Washington State as a potential site for the disposal of nonradioactive hazardous wastes, occupying approximately 2.6 km^2 (0.4 mi^2).
- Support facilities for the controlled access areas.
- The Near-Surface Test Facility in Gable Mountain.
- The repository site for the basalt waste isolation project (BWIP).
- Retired dry waste disposal sites and low-level liquid waste disposal sites (DOE 1987b).

An Exxon nuclear fuel fabrication plant is located on private land south of the Hanford site.

3.3 Permits

The DOE must establish policies and procedures to allow the disposal of Weldon Spring waste at the Hanford Reservation. An agreement with the State of Washington would also be required. None of these activities has been initiated.

3.4 Demographics

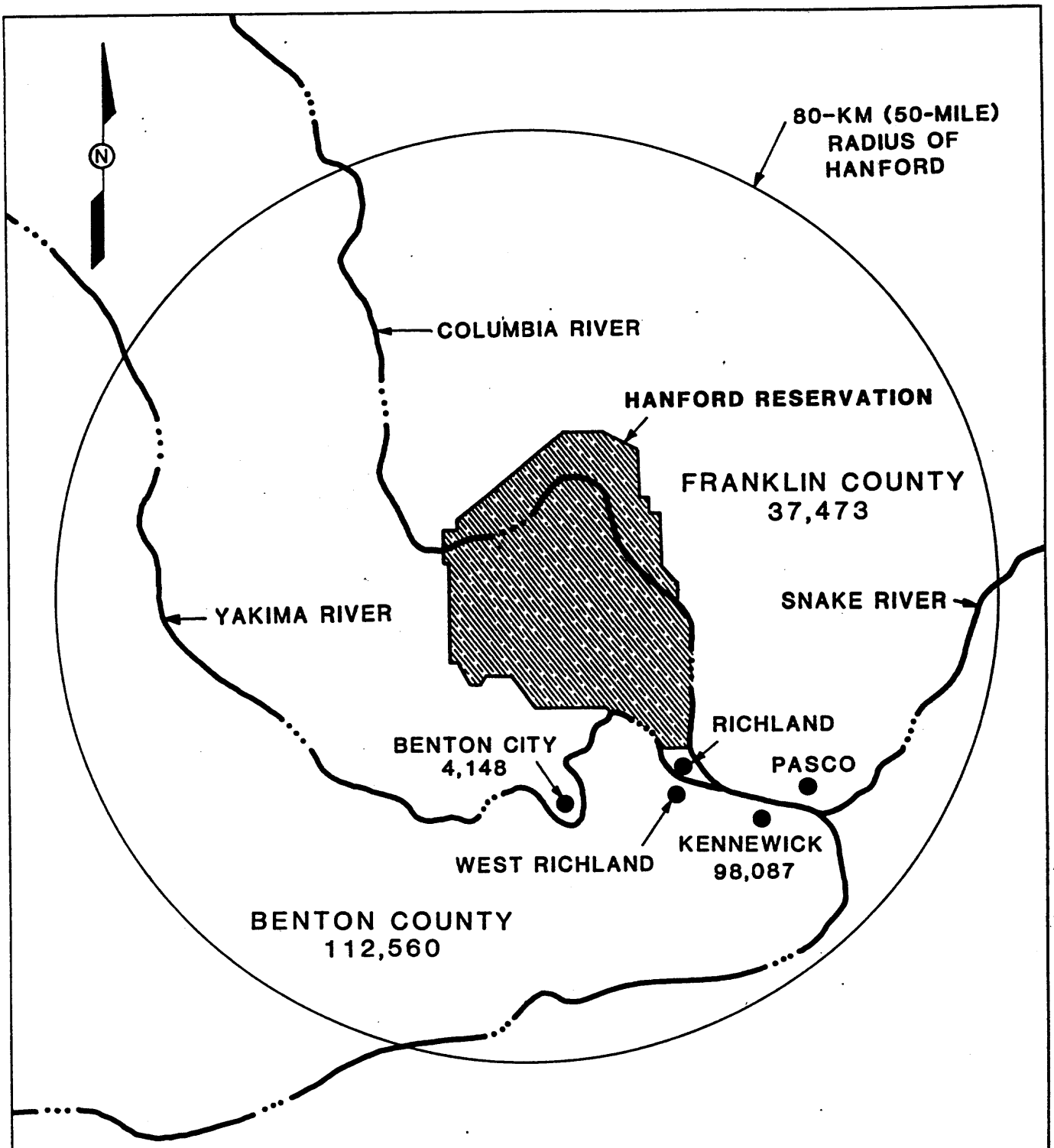
Land to the west, north, and east of the Hanford Reservation is principally range land and agricultural land. The cities of Richland, Kennewick, and Pasco, Washington, usually referred to as the "Tri-Cities", are located south and east of the Hanford Reservation. Richland is at the southeast corner of the Hanford Reservation near the confluence of the Columbia and Yakima Rivers; Kennewick and Pasco are located approximately 50 km (30 mi) southeast of the Hanford Reservation at the confluence of the Snake River (DOE 1987b). Portland, Oregon and the Pacific Ocean are downstream of the Hanford Reservation via the Columbia River; Lewiston, Idaho is upstream of the Hanford Reservation via the Snake River.

There is no resident population on the Hanford Reservation or within 4.8 km (3 mi) of the candidate disposal site. The land use zoning of the area requires that residential units be located at least 6 km (3.8 mi) from the Hanford Reservation. In 1986 the U.S. Bureau of the Census reported approximately 340,000 people residing within 80 km (50 mi) of the candidate disposal site (U.S. Bureau of the Census 1986). The 1986 census projected the population within an 80-km (50-mi) radius of the site to be approximately 420,000 by 1990 (Sommer et al. 1981).

The U. S. Bureau of the Census, 1990 Census of Population and Housing reported the total population of Benton County to be 112,560 and the total population of Franklin County to be 37,473. The 1990 census reported the populations of incorporated areas of the two counties as follows: Richland-Kennewick, 98,087; Benton City, 4,148; and Pasco-Pasco North, 31,230. The 1990 census reported a total of 44,877 housing units in Benton County and a total of 13,664 housing units in Franklin County. The reported numbers of housing units in the incorporated areas are as follows: Richland-Kennewick, 39,716; Benton City, 1,492; and Pasco-Pasco North, 11,548 (Figure 3-3) (U.S. Bureau of the Census, 1990).

3.5 Transportation

The Hanford Reservation is accessed from U. S. Interstate 82, which runs south of site, by State Highway 240. Washington State maintains Route 24 which traverses east-west across



0 15 30 MI

0 24 48 KM

SCALE

POPULATION WITHIN 80-KM (50-MI) RADIUS OF THE HANFORD RESERVATION

FIGURE 3-3

REPORT NO.:		EXHIBIT NO.: A/VP/023/0392	
ORIGINATOR: RJS	DRAWN BY: GLN	DATE: 3/92	

the northern third of the Hanford Reservation; all other roads within the reservation are maintained by the DOE.

The Tri-Cities are served by five major highways: U.S. Interstate 182 connects U.S. Interstate 82 with U.S. Route 395 north of Pasco. U.S. 395 connects to the north with Interstate 90, and runs northeast to Spokane, Washington. Southwest of the Hanford Reservation U.S. Route 12 links the region with Yakima to the northwest; Lewiston, Idaho to the east; and Walla Walla to the southeast.

The Union Pacific and Burlington Northern Railroads pass through Richland, and the Hanford site is accessed by a railroad spur. Barge service on the Columbia and Snake Rivers connects the Tri-Cities with Lewiston, Idaho; Portland, Oregon; and the Pacific Ocean.

3.6 Geology

The Hanford site overlies the structural low point of the Pasco Basin. The Pasco Basin is one of six basins within the Columbia Basin subprovince of the Columbia Intermontane physiographic province of the Columbia Plateau. The term Columbia Plateau is used to designate the area that is covered by the Columbia River Basalt Group. The dominant geologic characteristic of the Columbia Intermontane physiographic province is the Columbia River Basalt Group. The Columbia Basin subprovince, bounded by the Cascade Range on the west, northern Rocky Mountains on the north and east, and the Blue Mountains on the south, contains most of the Columbia River Basalt Group.

The topography of the Pasco Basin is relatively flat to gently undulating (DOE 1984). North-east trending, low, longitudinal sand dunes are scattered throughout the south-central and eastern portions of the Pasco Basin (PNL 1991). The Pasco Basin area was significantly modified during the Pleistocene (approximately 13,000 years ago), when the central part of the site was covered by glacial floodwaters which deposited the sediments that are now known as the Hanford Formation. These floods occurred when ice dams in western Montana and northern Idaho were breached, allowing massive volumes of glacial water to spill across eastern and central Washington (DOE 1986). The area has undergone minimal erosion since the Pleistocene (Meyers et al., 1979).

The principal geologic units beneath the Hanford site are: basement rocks (inferred to be sedimentary and volcaniclastic in origin and composition); the Miocene-Pliocene Columbia River Basalt Group; the late Miocene-Pliocene fluvial-lacustrine Ringold Formation; a Plio-Pleistocene unit; and the Pleistocene Hanford Formation. Locally, Holocene sand, silt, and loess exist as surficial material (PNL 1991).

The Columbia River Basalt Group is a layered sequence of continental flood basalts which erupted from north-northwest trending linear volcanic vents in north-central and northeastern Oregon, eastern Washington, and western Idaho. The Columbia River Basalt Group consists of approximately 170,000 km^3 (41,504 mi^3) of basalts that cover an area of

approximately 160,000 km^2 (62,500 mi^2) (DOE 1988). Interpretations of existing data indicate that in most portions of the Pasco Basin the basalts are between 3,000 m (9,845 ft) and 5,000 m (16,404 ft) thick (DOE 1988). The basalt flows, are estimated to range in age from 17 to 6 million years (Watkins and Baksi 1974). They are interbedded with relatively minor amounts of Miocene-Pliocene epiclastic and volcaniclastic sediments of the Ellensburg Formation (Myers et. al. 1979).

Along the western margin of the Columbia Plateau the basalt flows lie on an irregular surface that resulted from erosion of a complex terrain of Mesozoic metamorphics, Mesozoic to early-Tertiary sedimentary rocks, and early-Tertiary intrusives and volcanics. Along the northern margin of the Columbia Plateau, the basalt flows are underlain by pre-Cambrian metamorphic and sedimentary rocks, Paleozoic metasedimentary and volcaniclastic sedimentary rocks, Mesozoic marine lavas and sedimentary rocks, and Mesozoic to early-Tertiary granitic rocks. Along the eastern margin of the Columbia Plateau the basalt flows rest on pre-Cambrian metasedimentray rocks and Mesozoic intrusive and volcanic rocks. Along the southern margin of the Columbia Plateau, the basalt flows overlie Paleozoic sedimentary rocks, Mesozoic volcanic rocks, metamorphic and intrusive rocks, and early-Tertiary volcanic and sedimentary rocks (PNL 1991).

Directly overlying the Columbia River Basalt Group are the fluvial-lacustrine/flood plain sediments of the Ringold formation. The Ringold formation was deposited in generally east-west trending valleys by the ancestral Columbia River and its tributaries approximately 3.7 to 8.5 million years before the present time (Myers et al. 1979). The Ringold formation has been divided locally into four lithologic units: the basal and middle units of the Ringold Formation are predominantly semiconsolidated gravels and sands; the lower and upper units are bedded clay, silts, fine sand, and minor gravel lenses (Brown 1959). Thickness of the Ringold Formation ranges from 150 m (490 ft) near the western boundary to 90 m (295 ft) near the eastern boundary of the site.

The Hanford formation consists of catastrophic flood sediments composed of gravels, sands, and silts that were deposited on the eroded surface of the Ringold Formation by glaciofluvial floods during the Pleistocene. Thick sequences of sediments were deposited by several episodes of Pleistocene flooding. The last major flood sequence occurred approximately 13,000 years before the present (Myers et al. 1979).

The Pleistocene floods locally eroded the Ringold formation, the basalts, and sedimentary interbeds, and left a network of buried channels crossing the Pasco Basin (Tallman et al. 1979). In some locations the Hanford Formation lies unconformably on the Columbia River Basalts and interbedded Ellensburg sediments. The Hanford formation is approximately 110 m (360 ft) thick in the vicinity of the 200-East Area.

A Plio-Pleistocene unit composed of eolian silt and fine sand with relatively high caliche content overlies the Ringold Formation in the western part of the site (Brown 1960). This unit was formed when the wind reworked and deposited the Ringold sediments.

The surface of the Hanford site is locally veneered with alluvium, colluvium, and loess (DOE 1987b). Surface material at the site is essentially fine loose sand of the Hanford formation and wind-deposited dune sand. Soil types at the site vary from sand to silty and sandy loam (PNL 1991). Estimates of hydraulic conductivity for sand/sandy soils fall generally within the range of 10^{-4} cm/sec to 10^{-6} cm/sec, depending on the soil type and depth (Gee et al. 1985). The erosion potential of the Hanford surficial material is low because of the relatively flat slopes and the low annual precipitation (PNL 1991).

The area contains some stabilized sand dunes as well as active low dunes to the northwest and east. Larger sand dunes, with relief of approximately 6 m (20 ft), occur northeast of the area. The dunes are moving away from the site to the northeast (Watson et al. 1984).

3.7 Hydrogeology

The regional hydrogeologic setting of the Pasco Basin consists of continental flood basalts of the Columbia River Basalt Group; interbedded fluvial and volcaniclastic Ellensburg Formation sediments; and fluvial, lacustrine, and glaciofluvial sediments of the Hanford Formation and Ringold Formation. Lateral groundwater movement occurs within the shallow unconfined aquifers of the Ringold Formation and Hanford Formation, and within deeper confined to semiconfined aquifers consisting of basalt flow tops, flow bottom zones, and sedimentary interbeds (DOE 1988).

The water table, representing the upper limit of the unconfined aquifer, ranges in depth from approximately 110 m (360 ft) below the surface at the eastern boundary of the site, to 56 m to 100 m (184 ft to 328 ft) beneath the surface in the 200-Areas, to approximately 140 m (460 ft) below the surface at the western boundary of the site. The unconfined aquifer is more than 70 m (230 ft) thick in some areas, but thins to zero thickness along the flanks of the rock formations that border the site. Some local basalt formations within the site extend above the water table (DOE 1987b).

The Hanford Formation and gravels of the Ringold Formation form the uppermost hydrogeologic unit in the unconfined aquifer beneath the 200-East Area. The Ringold gravels display generally high transmissivities with values in the range of 1.5×10^{-2} m^2/s to 1.2×10^{-1} m^2/s, and hydraulic conductivities between 3.5×10^{-4} m/s and 2.5×10^{-2} m/s (PNL 1991). Graham et al. (1981) reported storativity values of 0.002 for the Ringold gravels; storativity values of 0.07 for the Hanford Formation; effective porosities of 10% for the Ringold gravels; and effective porosities of 30% for the Hanford formation.

The middle unit of the Ringold Formation comprises the uppermost part of the unconfined aquifer in the 200-West Area. Transmissivity values for this unit vary from 1.5×10^{-5} m^2/s to 5.5×10^{-2} m^2/s. Hydraulic conductivities for the unit range from 7.0×10^{-5} m/s to 2.1×10^{-3} m/s (PNL 1991). Transmissivities in the more consolidated sediments at the base of the unconfined aquifer were between 4.5×10^{-4} m^2/s and 9.7×10^{-4} m^2/s. Hydraulic conductivities in the more consolidated sediments at the base of the

unconfined aquifer were between 3.8 x 10^{-7} m/s to 3.5 x 10^{-5} m/s. Storativity values for the 200-West area vary from 0.001 to 0.038.

Confined and semiconfined aquifers within the basalt flows display hydraulic conductivities as high as 1.5 m/s for horizontally permeable zones. Confined and semiconfined aquifers within the basalt formations display vertical hydraulic conductivities as low as 1.5 x 10^{-8} m/s (DOE 1988).

Due to the semiarid climate of the region, little natural recharge from surface waters occurs to the unconfined aquifer in the Hanford Formation. Sources of natural recharge are believed to result from infiltration of precipitation and runoff from the higher bordering elevations along the margins of the Pasco Basin, water infiltrating from small ephemeral streams, and river water along influent reaches of the Columbia and Yakima Rivers (DOE 1987b). Recharge to the Hanford Formation by upward leakage from lower aquifers is thought to occur in the northern and eastern portions of the site. The discharge areas for the deep groundwater is uncertain, but flow is believed to be generally to the southeast with discharge to the south of the Hanford site (DOE 1986).

Artificial recharge by irrigation water applied to the land west of the Hanford site provides recharge to the underlying unconfined aquifers in the Ringold Formation and Hanford Formation. Groundwater flows downgradient from the recharge area west of the Hanford site to discharge areas along the Columbia River.

Depth to groundwater in the central portions of the Hanford site is in the range of 56 m to 100 m (184 ft to 328 ft). Groundwater mounds have developed in the vicinity of the 200-East and 200-West Areas due to artificial recharge to the unconfined aquifer from waste-disposal ponds. The water table has risen as much as 26 m (85 ft) since the start of disposal operations in 1944. Artificial recharge to the aquifer from waste disposal activities is estimated to be approximately ten times the amount of natural recharge entering the unconfined aquifer beneath the 200-Areas from the surrounding highlands (DOE 1987b).

The general west-to-east flow of groundwater is interrupted by the groundwater mounds in the 200-Areas. From the 200-Areas there is a component of groundwater flow to the north. These flow directions represent current hydrogeological conditions; the unconfined aquifer system is dynamic and responds to changes in natural and artificial recharge.

Erosional "windows" through the confining beds (dense basalt flows) north of the 200-East Area provide potential direct interconnections between the unconfined and the uppermost confined aquifers.

3.8 Groundwater

3.8.1 Hydrologic Characteristics

Lateral groundwater movement is known to occur within a shallow, unconfined aquifer consisting of glaciofluvial sands and gravels lying on top of the basalts and within the fluvial flood plain sediments of the Ringold formation. Deeper-confined to semiconfined aquifers consist of basalt flow tops, flow bottom zones, and sedimentary interbeds and/or interflow zones that occur between dense basalt flows in the Columbia River Basalt Group (PNL 1991). The deeper aquifers are interbedded with aquitards consisting of basalt flow interiors. Vertical flow and leakage between aquifers is inferred but has not been quantified (DOE 1988).

The vadose zone ranges from less than 1 m (3.3 ft) near the Columbia River to more than 140 m (460 ft) in the eastern portion of the Pasco Basin. Sediments at depth at the Hanford site have generally low water content that ranges from 2% to 7% by weight in coarse- and medium-grained soils and 7% to 15% by weight in silts (Gee and Heller 1985).

Surface drainage enters the Pasco Basin from five other basins within the Columbia Plateau. Sources of natural recharge to the unconfined aquifer are rainfall and runoff from higher bordering elevations, water infiltrating from small ephemeral streams, and river water along influent reaches of the Columbia River and Yakima River (PNL 1991). Natural recharge of the unconfined aquifer by the Columbia River generally occurs during high water stages where the underlying basalt flows crop out in the river canyons. Another source of natural recharge occurs from the Yakima River along the southwest boundary of the basin. Potentiometric measurements indicate that the upper basalt discharges to the unconfined aquifer within the central and eastern portions of the Pasco Basin.

Mean annual runoff from the basin is estimated to be only 3% of the total precipitation. The remaining precipitation is assumed to be lost through evapotranspiration. A small component, estimated to be less than 1% of precipitation, recharges the groundwater system (DOE 1988) in the western portion of the site (PNL 1991).

3.8.2 Groundwater Quality

The shallow, unconfined aquifer beneath the Hanford site contains waters of a dilute (less than or about 350 mg/l TDS) calcium bicarbonate type. Other chemical constituents in the water include sulfate, silica, magnesium, and nitrates (DOE 1991). The deep, basalt aquifers beneath the Hanford site contain waters of a sodium chloride chemical type. There is some evidence of vertical interconnections between the unconfined and upper confined aquifers (DOE 1987b).

Wastewaters discharged on the Hanford site have reached the unconfined aquifer. Elevated levels of some constituents in the Hanford site groundwater result from releases from the liquid-waste disposal facilities in the 200-Areas. Confined groundwater zones beneath the

Hanford site have been shown to contain nitrates, tritium, Sr-90, I-129, and Cs-137 (DOE 1986; DOE 1987b).

Groundwater studies to determine if contaminants have migrated downward from the unconfined aquifer indicate that some contamination has reached the upper, confined aquifer (Strait and Moore 1982; Graham et al. 1984). Analyses of the Hanford site groundwater showed higher levels of chemical constituents and temperatures than the analyses of off-site samples (Graham et al. 1981). Variability in chemical composition exists within the unconfined aquifer, in part because of the natural variation in the composition of the aquifer material; in part because of agricultural and irrigation practices north, east, and west of the Hanford site; and, on the Hanford site, in part because of liquid waste disposal.

Graham (1983) reported contamination levels in the Hanford site groundwater are below the limits established in drinking water standards. Under present groundwater flow conditions, contaminants in the upper, confined aquifer are likely to eventually discharge back to the unconfined aquifer.

Nitrate, chromium, carbon tetrachloride and trichloroethylene levels in the groundwater beneath several of the operational areas exceed primary drinking water standards. Cyanide has been detected in the groundwater north of the 200-East Area; no drinking water standard has been proposed for cyanide (DOE 1987b).

Nitrates, tritium, and total beta contamination have migrated away from these sites in a general west-to-east direction. Some longer-lived radionuclides such as Sr-90 and Cs-137 have reached the groundwater, primarily through liquid-waste disposal cribs on the Hanford site. Minor quantities of longer-lived radionuclides have reached the water table via a failed groundwater monitoring well casing; and through reverse well injection, a disposal practice that was discontinued at Hanford in 1947 (Smith 1980).

The Hanford site monitoring wells contain nitrates and chromium in concentrations above the maximum contaminant levels as set forth in the national primary drinking water regulations. However, the groundwater is not currently a withdrawn as a source of public drinking water. Discharge of nitrate and chromium to the Columbia River from the unconfined aquifer appears to be the primary pathway for public exposures to these substances.

Approximately 50% of the wells in the Pasco Basin are used for domestic water supply. Agricultural wells, used for irrigation and stock supply, make up the second largest category of water wells; industrial users account for approximately 3% of the wells (DOE 1988).

3.9 Surface Water

The Columbia River and Yakima River are the primary surface water features associated with the Hanford site. The drainage divide between the Columbia River and Yakima River passes through the site; runoff from approximately the northern 10% of the 200-West Area

flows northeast to the Columbia River; the remaining runoff flows southeast to the Yakima River. Due to the relatively flat topography, there are no well developed drainage patterns in the area of the Hanford disposal site.

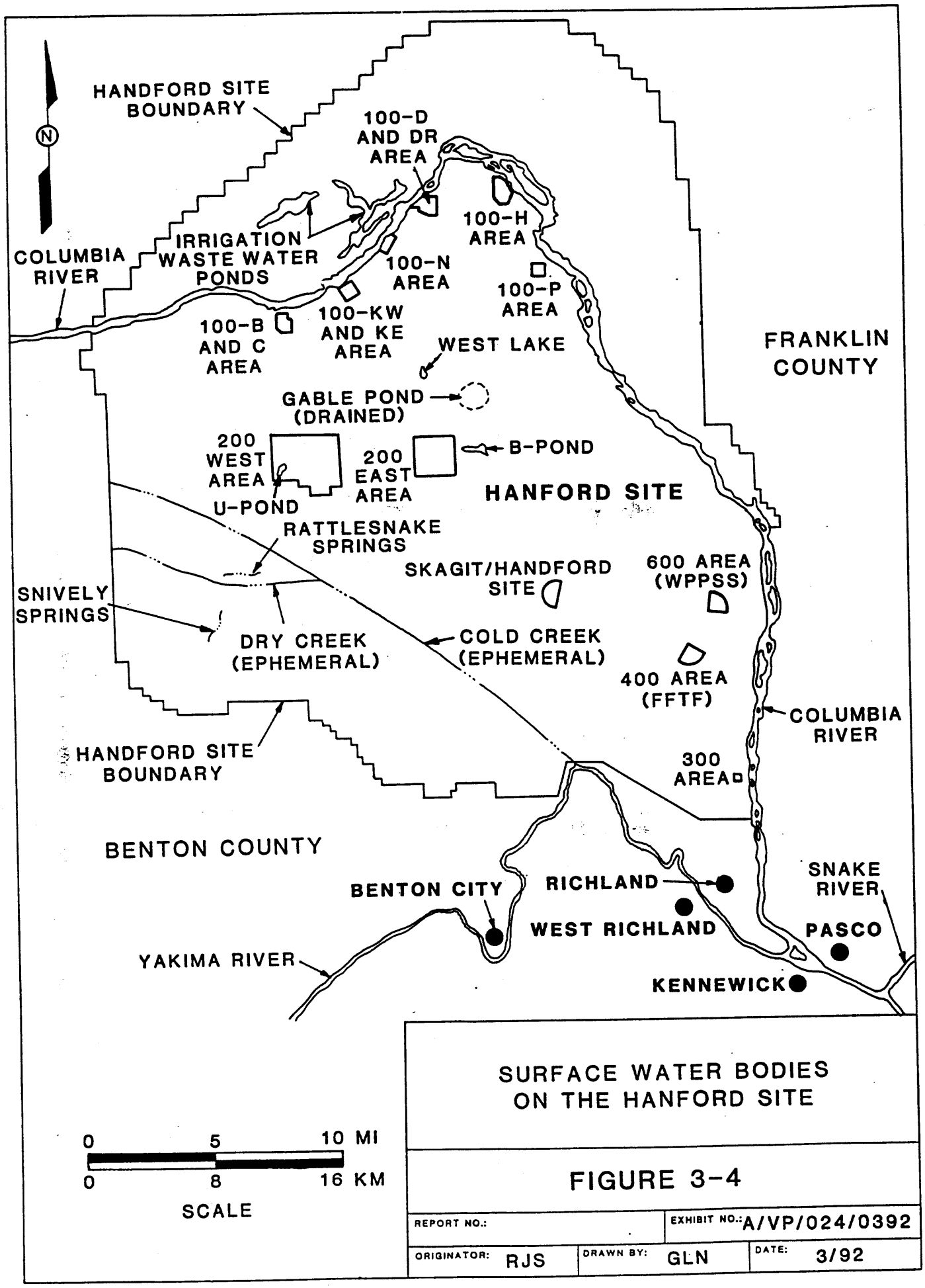
The Hanford reach of the Columbia River forms the northeastern boundary of the site. This free-flowing reach is regulated by the Priest Rapids Dam located 39 km (24.2 mi) upstream of the site. The quantity of discharge in the Hanford reach fluctuates significantly because of Priest Rapids Dam operations. Daily discharge ranges to 7,000 m^3/sec (247,000 cfs) with peak spring runoff flows as high as 12,600 m^3/sec (444,600 cfs). Annual average discharge rates run from 2,800 m^3/sec to 3,400 m^3/sec (98,800 cfs to 120,000 cfs). Monthly mean discharges generally peak from April to June and are lowest from September to October (DOE 1989).

For 57 years of record, the average annual flow of the Yakima River has been approximately 1.4 m^3/sec (50 cfs), with monthly maximum and minimum flows of 490 m^3/sec and 4.6 m^3/sec (17,300 cfs and 162 cfs), respectively.

Cold Creek, an ephemeral tributary to the Yakima River (Figure 3-4), drains most of the candidate disposal site area (the 200-West Area). On rare occasions the flow in Cold Creek is sufficient to increase the 1 km (0.62 mi) reach to 10 km (6 mi). Cold Creek Valley ends at the Yakima River approximately 48 km (30 mi) southeast of the 200-West Area (DOE 1986). The potential for flash flooding from the Cold Creek drainage has been examined (Skaggs and Walters 1981), and a maximum flood depth of 2.3 m (7.5 ft) was estimated along the southwestern part of the 200-Areas plateau and extending to the 200-West Area. A 200-year peak-stage flood, estimated to be approximately 1 m (3.3 ft) above the Cold Creek Valley floor, would not reach the 200-Areas.

There are three onsite surface water bodies located near the operating areas (Figure 3-4) (DOE 1987). In 1987 Gable Pond, located north of the 200-East Area, was decomissioned. Subsequent to draining Gable Pond, the volume of B Pond increased (PNL 1991).

There are no marshes, estuaries, or designated wetlands at the Hanford site (PNL 1991).



SURFACE WATER BODIES ON THE HANFORD SITE

FIGURE 3-4

REPORT NO.:		EXHIBIT NO.: A/VP/024/0392	
ORIGINATOR: RJS	DRAWN BY: GLN	DATE: 3/92	

3.10 Seismicity

The Columbia Plateau is an area of low seismicity, however since 1969 earthquakes within the central Columbia Plateau have been instrument located. Seismic activity above magnitude 3.0 has occurred; activity above Richter magnitude of 3.5 is most commonly found around the northern and western portions of the Columbia Plateau, with a few events occurring along the border between Washington and Oregon (DOE 1984). A number of small earthquakes (less than Modified Mercalli Intensity V) have occurred in the area around Milton-Freewater, Oregon and Walla Walla, Washington. The largest known earthquake in the Columbia Plateau occurred in 1918, in the area near Milton-Freewater, Oregon; the earthquake registered 5.75 on the Richter scale (DOE 1987b).

The region north and east of the Hanford site is a region of concentrated earthquake swarm activity, the predominant seismic events of the Columbia Plateau. Swarms of small, shallow earthquakes have also occurred in several locations within the Hanford site (PNL 1991). Earthquake swarms may be made up of as many as 100 locatable earthquakes of Richter magnitude 1.0 to 3.5 (DOE 1984). Earthquake swarms may occur over areas approximately 2 km by 5 km (1.25 mi by 3.1 mi) horizontally and 3 km to 5 km (1.9 mi to 3.1 mi) vertically during a period that lasts a few days or as much as several months (DOE 1984). Earthquake swarms do not follow a mainshock-aftershock sequence; they tend to gradually increase and decay in frequency of events, but not in magnitude. There is usually no one outstanding large event within the sequence. Earthquake swarms occur at shallow depths, with 75% of the events located at depths less than 4 km (2.5 mi) (Catchings and Mooney 1988; Glover 1985).

Earthquakes to depths of 28 km (17.5 mi) occur in the central Columbia Plateau; however, these deeper quakes are much less frequent than the shallow swarm events (DOE 1984). The deeper quakes are less clustered and occur more often as a single, isolated event. Deep seismic activity generally occurs randomly and is not associated with known geologic structures or with patterns of shallow seismicity (DOE 1984). Based on seismic refraction surveys in the region, the shallow earthquake swarms occur in the Columbia River Basalts, and the deeper earthquakes occur in crustal layers below the basalts (Catchings and Mooney 1988; Glover 1985). The earth's crust, as determined by seismic refraction studies by Caggiano and Duncal (1983), is approximately 28-km (17.5 mi) thick beneath this portion of Washington State.

The annual probability of the maximum ground acceleration exceeding 0.20 g in the area is 10^{-4} (0.0001%). Seismic activity and related phenomena such as liquefaction, fault rupture, and subsidence are not believed to be plausible events.

3.11 Climate and Meteorology

Climatological data are available for the Hanford Meteorological Station (HMS) which is located in the central portion of the Hanford site between the 200-Areas. Data, collected at the HMS since 1945, are representative of the general climatic conditions for the region. Local

variation in the topography of the Hanford site may cause variations in the climatic conditions, e.g., winds near the Columbia River are different than those at the HMS, and precipitation along the slopes of the Rattlesnake Hills differ dramatically from that at the HMS.

Average annual precipitation in the Pasco Basin ranges from less than 25.4 cm (10 in.) in the central low-lying desert areas to more than 63.5 cm (25 in.) in the higher mountains. The Hanford site receives approximately 16 cm (6.3 in.) precipitation during the winter months. Approximately half of the annual precipitation occurs during the period from November through February.

The highest average amount of rainfall, 2.4 cm (0.93 in.), occurs in January; the lowest average amount of rainfall, 0.36 cm (0.14 in.), occurs in July. The highest recorded 24-hr rainfall, 4.9 cm (1.9 in.), occurred in October 1950. Rainfall intensities of 2.54 cm/hr (1 in./hr) for 1 hr are expected once every 500 years (PNL 1991).

Snowfall accounts for approximately 38% of all precipitation during the period December through February. The record snowfall, 61 cm (24 in.), occurred in February 1916; the second highest snowfall of record is less than half that amount.

The average summer temperature is 23°C (73°F); the average winter temperature is 0°C (32°F). The hottest temperature of record, 46°C (115°F), occured in July 1939; the coldest temperature of record, -33°C (-27°F), occured in December 1919.

The average annual relative humidity at the HMS is 54%; winter relative humidity averages approximately 75%; and summer relative humidity averages approximately 35% (DOE 1987b).

Prevailing winds at the HMS are the from north-northwest through northwest every month of the year (DOE 1986), in part due to channeling of the air by topographic features. During the spring and autumn, the frequency of southwesterly winds increases with a corresponding decrease in northwest flow (PNL 1991). Monthly average wind speeds are lowest during the winter months; monthly average wind speeds are highest during the summer months, with gusts from the southwest that often exceed 64 km/hr (40 mph). The average annual wind speed is 12 km/hr (7.5 mph), varying from 16 km/hr (10.0 mph) in June to 9.7 km/hr (6.0 mph) in November. This unusual annual cycle of wind speeds is caused by strong drainage winds from the Cascade Mountains during summer evenings and nights.

3.12 Air Quality

Air concentrations of nitrogen dioxide and TSP are routinely monitored on the Hanford site. The maximum annual average concentration of nitrogen dioxide is less than 15 $\mu g/m^3$ maximum ambient concentrations for the Hanford site and surrounding area are 36 $\mu g/m^3$ nitrogen dioxide (annual arithmetic mean), 0.5 $\mu g/m^3$ sulfur dioxide (annual arithmetic mean),

11,800 $\mu g/m^3$ carbon monoxide (one hour maximum), and 20 $\mu g/m^3$ TSPs (not counting natural events) (DOE 1987b).

State-wide monitoring indicates that the concentrations of TSPs periodically reach relatively high levels in eastern Washington State due to high winds that pick up dust from the desert and the wheat fields. Accordingly, high levels of TSP have been measured at the HMS. TSPs were sampled near the 200-West Area beginning in 1986. In 1987, the annual geometric mean was 33 $\mu g/m^3$, and the maximum 24-hr value was 91 $\mu g/m^3$ (PNL 1991).

Neutral and unstable stratification exist approximately 57% of the time during the summer. Less favorable dispersion conditions are common during the winter when moderately to extremely stable stratification exists approximately 66% of the time (DOE 1987b).

3.13 Radiation Levels

Liquid radioactive wastes are stored in the 200-Areas of the Hanford site in large underground single-shell tanks. Process liquids containing dilute low-level liquid wastes have been disposed in cribs, ponds, ditches and drains (ERDA 1975). Solid low-level radioactive wastes are buried in trenches.

The radioactive waste inventory at Hanford is 233,000 m^3 (606,000 yd^3; 420 million Ci) of high-level radioactive waste in the form of liquid sludge and salt cake stored in underground tanks; 340,000 m^3 (884,000 yd^3; 5.9 million Ci) of low-level radioactive waste; 91,700 m^3 (239,000 yd^3) of buried transuranic radioactive wastes; and approximately 13,700 m^3 (35,600 yd^3) of retrievable stored transuranic radioactive wastes (ORNL 1985).

Nuclear activities conducted at the Hanford site during 1984 have given an estimated 7 person-rem/yr dose to the surrounding population. This dose is only a small fraction of the 34,000 person-rem/yr received by this same population from natural background sources of radiation. As a result of nuclear activities at the Hanford Reservation, a dose to the maximally exposed individual is estimated to be 0.1 mrem/yr; such an individual would receive a dose of approximately 100 mrem/yr from background radiation sources (Price 1986).

3.14 Biological Resources

The Hanford site is located on a semiarid bench above the Columbia River. The site has been botanically characterized as a shrub steppe region. Steppe is the extratropical grassland of areas where the zonal soils are too dry for trees and herbaceous perennial grasses are well represented. Shrub steppe is characterized by shrubs rising above the grasses to form a discontinuous upper layer (Daubenmire 1978). Because of the aridity of the steppe, productivity of both plants and animals is relatively low compared with other natural communities.

The Hanford site has undergone various landscape alterations as a result of construction, operations, and decommissioning activities. The natural vegetation consists mostly of a sparse covering of desert shrubs and drought-resistant grasses. The predominant vegetation type is the big sagebrush/cheatgrass-bluegrass community. Bitterbrush and rabbitbrush are also common. A narrow riparian zone, consisting of herbs interspersed with a few scattered deciduous shrubs and trees, exists along the Columbia River (DOE 1987b).

The Columbia River is the fifth largest river in North America. It has a total length of about 2,000 km (1,250 mi) from its origin in Canada to its mouth at the Pacific Ocean. It has been dammed upstream and downstream from the Hanford Site, and the reach flowing through the area is the last free-flowing but regulated reach of the Columbia in the United States. The Columbia River is the dominant aquatic ecosystem on the Hanford Site. It supports a large and diverse community of plankton, benthic invertebrates, fish and other communities (PNL 1991).

The vegetation mosaic of the Hanford site consists of eight major plant communities: sagebrush-bluebunch wheatgrass, sagebrush-cheatgrass or sagebrush/Sandberg's bluegrass, sagebrush-bitterbrush-cheatgrass, greasewood-cheatgrass-saltgrass, winterfat-Sandberg's bluegrass, thyme buckwheat-Sandberg's bluegrass, cheatgrass-tumble mustard, and willow (PNL 1991).

3.14.1 Plants

More than 240 species of vascular plants have been identified on the Hanford site. The 200-Area is primarily sagebrush-cheatgrass or Sandberg's bluegrass and greasewood/cheatgrass-saltgrass communities. The dominant plants on the 200-Area plateau are desert shrubs, big sagebrush, bitterbrush, rabbitbrush, spiny hopsage, cheatgrass, and Sandberg's bluegrass. The herbaceous understory to the shrubs is dominated by grasses, especially cheatgrass and Sandberg's bluegrass (DOE 1987b). The predominant vegetation type on the 200-Areas plateau is the sagebrush-cheatgrass. Cheatgrass, an alien annual species introduced from Eurasia in the late 1800's, provides half of the total plant cover (ERDA 1975).

Thompson's sandwort, a Federally designated threatened specie, and Columbia yellow-cress, a Federally designated candidate specie, exist on stabilized sand dunes in the vicinity of the 200-Areas. Two Federally designated threatened candidate species, Columbia milk-vetch and Hoover's desert parsley, exist on the Hanford site (DOE 1987b). There are no listed critical habitats on the Hanford Site.

TABLE 3-1 Endangered, Threatened, and Sensitive Plants on the Hanford Site (Washington Natural Heritage Program 1984)

Taxa	Status[a]	Relationship to the 200-Areas
Columbia Milk-Vetch *Astragalus columbianus* Barneby	Threatened C	A local endemic with its major populations located on the Yakima Firing Center; not expected to occur in the vicinity of the 200-Areas
Persistentsepal Yellowcress *Rorippa columbiae* Suksd. ex Howell	Endangered C	Known to occur on the wetted shoreline of the Columbia River on the Hanford Site; not likely to occur in the vicinity of the 200-Areas
Thompson's Sandwort *Arenaria franklinii* Dougl. var. Thompsonii Peck	Threatened	Exists as *A. franklinii* on stabilized sand dunes in the vicinity of the 200-Areas; taxonomic status is currently under consideration
Hoover's Desert Parsley *Lomatium tuberosum* Hoover	Threatened C	A local endemic in Yakima, Benton, Grant, and Kittitas Counties, not known from the vicinity of the 200-Areas
Gray Cryptantha *Cryptantha leucophea* Dougl. Pays	Sensitive	Occurs on stabilized sand dunes of the Hanford Site near the Wye Barricade; occurrence in the vicinity of the 200-Areas has not been established
Piper's Daisy *Erigeron piperianus* Cronq.	Sensitive	A local endemic, occurs on the Arid Lands Ecology Reserve; occurrence in the vicinity of the 200-Areas has not been established
Tooth-Sepal Dodder *Cuscuta denticulata* Engelm.	Monitor	Recently found in Benton County; parasitic on sagebrush; may occur in the vicinity of the 200-Areas

(a) Plants that are listed as "C" are candidates on the 1980 *Federal Register* Notice of Review and 1983 Supplement.

Definitions of special classifications of vascular plants in Washington and special terminology:

Endangered. A vascular plant taxon in danger of becoming extinct or extirpated in Washington within the near future if factors contributing to its decline continue. These are taxa whose populations are at critically low levels or whose habitats have been degraded or depleted to a significant degree.

Threatened. A vascular plant taxon likely to become endangered within the near future in Washington if factor contributing to its population decline or habitat degradation or loss continue.

Sensitive. A vascular plant taxon, with small populations or localized distribution within the state, that is not presently endangered or threatened, but whose populations and habitats will be jeopardized if current land use practices continue.

Monitor. A vascular plant taxon of potential concern because of uncertain taxonomic status or paucity of information concerning distribution; or a taxon that is actually more abundant or less threatened than previously thought.

Local endemic. A taxon restricted to a limited geographical area, usually within a single county or several adjacent counties.

Source: DOE 1987b

3.14.2 Animals

Predominant fauna of the sagebrush-grass community that potentially reside in or near the 200-Area are the cottontail rabbit, jackrabbit, Great Basin pocket mouse, horned lark, and the western meadowlark. Mule deer, coyotes, and various species of raptors forage in this habitat type (DOE 1987b).

Great numbers of waterfowl either inhabit the islands in the free-flowing reach of the Columbia River or use the river as a resting area during migration (ERDA 1975). More than 125 species of birds have been identified at the Hanford site (Rogers and Rickard 1977). The horned lark and western meadowlark are the most abundant nesting birds in the shrub-steppe. The Hanford site supports populations of chukar partridge, gray partridge, and sage grouse (PNL 1991).

Approximately 30 species of mammals have been identified on the Hanford site. Most are small and nocturnal. Of this group, the Great Basin pocket mouse is the most abundant. The coyote is the principal mammalian predator on the site. Larger mammals found include the mule deer and elk. The elk are centered almost entirely on the Arid Lands Ecology Reserve, a part of the Hanford site established as an environmental research study area in 1968. Mule deer are found mostly along the Columbia River and in the Rattlesnake Hills, although they move throughout the site (PNL 1991).

Approximately 16 species of amphibians and reptiles have been observed at the Hanford site (ERDA 1975). The side-blotched lizard, the most abundant reptile, can be found throughout the Hanford site. Short-horned lizards and sagebrush lizard are also common in selected habitats. The most common snakes are the gopher snake, the yellow-bellied racer, and the Pacific rattlesnake. Striped whipsnakes and desert night snakes are found only rarely on the Hanford site (PNL 1991).

More than 300 species of terrestrial and aquatic insects have been found on the Hanford Site. Insects are important in the food chain of local birds and mammals. Most species occur throughout the spring and autumn and are subject to wide annual variation in abundance (PNL 1991).

Two Federally designated endangered raptors, the peregrine falcon and the bald eagle, migrate across the area (Table 3-2). The Columbia River that flows through the Hanford site serves as a winter concentration area for bald eagles. The bald eagle is usually associated with the Columbia River where it feeds on spawning salmon. Peregrine falcons may occur in the Hanford area during spring and fall migration periods.

Federally designated endangered candidate bird species that nest at the Hanford site include the ferruginous hawk, long-billed curlew, and the western sage grouse (Gloman 1991). Other rare bird species occurring in the Hanford area, which do not have a designated status, include the American osprey and the western burrowing owl (ERDA 1975).

TABLE 3-2 Endangered, Threatened, and Sensitive Animals on the Hanford Site (Washington State 1983)

Taxa	Status[a]	Relationship to the 200-Areas
WASHINGTON STATE STATUS OF SPECIAL BIRD SPECIES		
Birds Associated with the Hanford Reach of the Columbia River but not Known to Nest on the Hanford Site		
Bald Eagle *Haliaeetus leucocephalus*	FT ST	A possible occasional forager of sagebrush-grass habitats and waste ponds in the 200-Areas; a regular winter visitor to the Columbia River on the Hanford Site
American White Pelican *Pelecanus erythrorhyncus*	SE	Unlikely foragers at waste ponds in the 200-Areas; mostly fall and winter use of the Columbia River
Birds Associated with the Hanford Reach of the Columbia River that Also Nest on the Hanford Site		
Great Blue Heron *Ardea herodias*	PM	Nest in trees along the Columbia River: an occasional forager at waste ponds in the 200-Areas; a year-round resident
Black-Crowned Night Heron *Nycticorax nycticorax*	PM	Nest in trees along the Columbia river; an occasional forager at waste ponds in the 200-Areas; a year-round resident
Birds Associated with Dryland Habitats of the Hanford Site but not Known to Nest on the Hanford Site		
Golden Eagle *Aquila chrysoaetes*	PS	Forages in sagebrush-grass habitats and at waste ponds in the 200-Areas; mostly a winter visitor
Birds that are Infrequent Visitors to the Hanford Site		
Peregrine Falcon *Falco peregrinus*	FE SE	An erratic visitor
Birds Associated with Sagebrush-Grass Habitats		
Ferruginous Hawk *Buteo regalis*	ST	An occasional forager in sagebrush-grass habitats; an occasional nester on the Arid Lands Ecology Reserve
Swainson's Hawk *Buteo swainsonii*	PS	Nests in planted trees near the 200-Areas; forages in sagebrush-grass habitats in spring and summer
Prairie Falcon *Falco mexicanus*	PS	Nests on basalt cliffs on Gable Butte; forages in sagebrush-grass habitats; a year-round resident
Burrowing Owl *Athene cunicularia*	PS	Nests in the vicinity of the 200-Areas; forages in sagebrush-grass habitats
Sage Thrasher *Oreoscoptes montanus*	PS	Not known to nest in the vicinity of the 200-Areas; a possible forager in sagebrush-grass habitats

TABLE 3-2 Endangered, Threatened, and Sensitive Animals on the Hanford Site (Washington State 1983) (Continued)

Taxa	Status[a]	Relationship to the 200-Areas
Long-Billed Curlew *Numenius americanus*	PM	Nests in dryland habitats in the vicinity of the 200-Areas, mostly in spring and summer; forages in sagebrush-grass habitats
Sage Sparrow *Amphispiza belli*	PM	Nests in desert shrubs in the vicinity of the 200-Areas; forages in sagebrush-grass habitats in spring and summer
Sage Grouse *Centrocercus urophasianus*	Undetermined	Not known to nest or forage in the vicinity of the 200-Areas; a small population inhabits the Arid Lands Ecology Reserve
WASHINGTON STATE STATUS OF SPECIAL MAMMAL SPECIES		
Pygmy Rabbit *Sylvilagus idahoensis*	ST	An unlikely inhabitant of sagebrush-grass habitats in the 200-Areas; known to inhabit the Arid Land Ecology Reserve
Merriam's Shrew *Sorex merriami*	PS	An unlikely inhabitant of sagebrush-grass habitats in the 200-Areas; known to inhabit the Arid Land Ecology Reserve
White-Tailed Jackrabbit *Lepus townsendii*	PS	An unlikely inhabitant of sagebrush-grass habitats in the 200-Areas; may be extirpated from the Hanford Site
Sagebrush Vole *Lagurus curtatus*	PM	An unlikely inhabitant of the sagebrush-grass habitats in the vicinity of the 200-Areas; more abundant on the Arid Lands Ecology Reserve
Northern Grasshopper Mouse *Onychomys leucogaster*	PM	Present in sagebrush-grass habitats in the vicinity of the 200-Areas
Ord Kangaroo Rat *Dipodomys ordii*	PM	Not known to inhabit the Hanford Site
Townsend Ground Squirrel *Spermophilus townsendii*	PM	Locally abundant in sagebrush-grass habitats in the vicinity of the 200-Areas

Several species of bats may inhabit caves or abandoned buildings in the 200-Areas. The Long-Eared Myotis (*Myotis evotis*) and Pallid Bat (*Antrozous pallidus*) are listed as Proposed Sensitive (PS). The Yuma Myotis (*Myotis yumanensis*) Fringed Myotis (*Myotis thysanoides*) Long-Legged Myotis (*Myotis volans*) Small-footed Myotis (*Myotis leibi*) and Western Pipistrelle (*Pipistrellus hesperus*) are listed as Proposed Monitor (PM).
The Townsend's Big-eared Bat (*Plecotus townsendii*) is listed as proposed Threatened (PT).

TABLE 3-2 Endangered, Threatened, and Sensitive Animals on the Hanford Site (Washington State 1983) (Continued)

Taxa	Status[a]	Relationship to the 200-Areas
WASHINGTON STATE STATUS OF SPECIAL REPTILE AND AMPHIBIAN SPECIES		
Sagebrush Lizard *Sceloporus graciosus*	PM	Known to inhabit sagebrush-grass habitats in the vicinity of the 200-Areas
Northern Desert Horned Lizard *Phrynosoma platyrhinos*	PM	Known to inhabit sagebrush-grass habitats in the vicinity of the 200-Areas
Striped Whipsnake *Masticophis taeniatus*	PM	May be present in sagebrush-grass habitats in the vicinity of the 200-Areas
Night Snake *Hypsiglena torquata*	PM	May be present in sagebrush-grass habitats in the vicinity of the 200-Areas
Woodhouse's Toad *Bufo woodhousei*	PM	May be present in the vicinity of the 200-Areas near waste ditches and ponds
WASHINGTON STATE STATUS OF SPECIAL INVERTEBRATE SPECIES		
Columbia River Tiger Beetle *Cincindela columbica*	PE	Believed to inhabit the sandy shore of the Columbia River
Columbia River Limpet *Lanx nuttalli*	PM	Believed to inhabit the Hanford Reach of the Columbia River
Columbia River Spire Snail *Lithoglyphus colombiana*	PM	Believed to inhabit the Hanford Reach of the Columbia River
Oregon Swallowtail Butterfly *Papilio oregonius*	PM	Inhabits sagebrush-grass habitats; ecological status in the vicinity of the 200-Areas is unknown

(a) FE = Federally designated endangered species
FT = Federally designated threatened species

Definitions of special classifications of animal species:

State Endangered (SE). A species which is seriously threatened with extirpation within the state of Washington. These are classified by the State Game Commission as endangered wildlife (WAC 232-12-014). Protected from taking due to damage (RCW 77.12.265), trafficking (RCW 77.16.040) and possession, control, or destruction of nests or eggs (RCW 77.16.120).

Proposed Endangered (PE). A species proposed for consideration for State Endangered classification.

State Threatened (ST). A species that could become endangered without management or removal of threats. These species are classified by the State Game Commission as protected wildlife (WAL 232-12-011). Protected from possession, control, or destruction of nests or eggs (RCW 77.16.120).

Proposed Threatened (PT). A species proposed for consideration for State Threatened classification.

TABLE 3-2 Endangered, Threatened, and Sensitive Animals on the Hanford Site (Washington State 1983) (Continued)

Taxa	Status[a]	Relationship to the 200-Areas

State Sensitive (SS). A species that could become Threatened if current water, land, and environmental practices continue. Classified by the State Game Commission as Protected Wildlife and protected from possession, control, or destruction of nests or eggs.

Proposed Sensitive (PS). A species proposed for consideration for State Sensitive classification.

Monitor Species (SM). A species of special interest because of public appeal, need for special habitats during a portion of their life cycle, status as indicators of environmental quality, population status that is mostly unknown, taxonomic status in need of further study, or justifiably removed from Endangered, Threatened or Sensitive classifications.

Proposed Monitor (PM). A species proposed for State Monitor classification.

Two Federally designated endangered candidate invertebrate species occurring in the Hanford reach of the Columbia River include the shortfaced lanx, also known as the giant Columbia River limpet, and the Columbia pebblesnail, also known as the great Columbia River Spire Snail (DOE 1987b).

3.15 Cultural Resources

The Yakima Indian Reservation west of the Hanford Reservation is home to several bands and tribes of native Americans. From prehistoric to contemporary times, cultural and natural resources have had importance for the Confederated Tribes and the Yakima Indian Nation (Yakima Indian Nation 1985). Environmental resources on and near the Hanford Reservation may have cultural and religious importance for the Yakima Indian people, and environmental degradation could have serious cultural consequences (Jim 1980; Carrel 1984).

There are 10 major historical properties on or adjoining the Hanford site. Most of these are located on the islands or shoreline of the Columbia River. The Hanford site encompasses 128 archaeological sites, including open camps, fishing stations, house pit sites, cemeteries and flaking floors. Five sites are located about 3.3 km (2 mi) north of the 200-Areas near Gable Mountain and Gable Butte, and four others lie on the western part of the site at Rattlesnake Springs and Snively Canyon; however, no such sites are known to be located within the 200-Areas or the 6-km (3.75-mi) by 13-km (8.1-mi) disposal site boundary that includes the 200-Areas (DOE 1987b).

An intensive cultural resource survey has not been conducted in the area of the candidate disposal site. Two cultural sites are located north of the 200-Areas near Gable Mountain and Gable Butte, and two others lie on the western part of the Hanford Reservation at Rattlesnake Springs and Snively Canyon. No known sites are located within the 200-Areas.

Nine archaeological properties on the Hanford site are listed in the National Register of Historic Places.

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