Public Health Assessment for

42601

HANFORD 1100-AREA (USDOE)
RICHLAND, BENTON COUNTY, WASHINGTON
CERCLIS NO. WA4890090075
NOVEMBER 20, 1995

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
Agency for Toxic Substances and Disease Registry

PUBLIC HEALTH ASSESSMENT

HANFORD 1100-AREA (USDOE)

RICHLAND, BENTON COUNTY, WASHINGTON

CERCLIS NO. WA4890090075

Energy Section
Federal Facilities Assessment Branch
Division of Health Assessment and Consultation
Agency for Toxic Substances and Disease Registry

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment was prepared by ATSDR pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6), and in accordance with our implementing regulations 42 C.F.R. Part 90). In preparing this document ATSDR has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate.

In addition, this document has previously been provided to EPA and the affected states in an initial release, as required by CERCLA section 104 (i)(6)(H) for their information and review. The revised document was released for a 30 day public comment period. Subsequent to the public comment period, ATSDR addressed all public comments and revised or appended the document as appropriate. The public health assessment has now been reissued. This concludes the public health assessment process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

Additional copies of this report are available from:
National Technical Information Service, Springfield, Virginia
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FOREWORD

The Agency for Toxic Substances and Disease Registry, ATSDR, is an agency of the U.S. Public Health Service. It was established by Congress in 1980 under the Comprehensive Environmental Response, Compensation, and Liability Act, also known as the *Superfund* law. This law set up a fund to identify and clean up our country's hazardous waste sites. The Environmental Protection Agency, EPA, and the individual states regulate the investigation and clean up of the sites.

Since 1986, ATSDR has been required by law to conduct a public health assessment at each of the sites on the EPA National Priorities List. The aim of these evaluations is to find out if people are being exposed to hazardous substances and, if so, whether that exposure is harmful and should be stopped or reduced. (The legal definition of a health assessment is included on the inside front cover.) If appropriate, ATSDR also conducts public health assessments when petitioned by concerned individuals. Public health assessments are carried out by environmental and health scientists from ATSDR and from the states with which ATSDR has cooperative agreements.

Exposure: As the first step in the evaluation, ATSDR scientists review environmental data to see how much contamination is at a site, where it is, and how people might come into contact with it. Generally, ATSDR does not collect its own environmental sampling data but reviews information provided by EPA, other government agencies, businesses, and the public. When there is not enough environmental information available, the report will indicate what further sampling data is needed.

Health Effects: If the review of the environmental data shows that people have or could come into contact with hazardous substances, ATSDR scientists then evaluate whether or not there will be any harmful effects from these exposures. The report focuses on public health, or the health impact on the community as a whole, rather than on individual risks. Again, ATSDR generally makes use of existing scientific information, which can include the results of medical, toxicologic and epidemiologic studies and the data collected in disease registries. The science of environmental health is still developing, and sometimes scientific information on the health effects of certain substances is not available. When this is so, the report will suggest what further research studies are needed.

Conclusions: The report presents conclusions about the level of health threat, if any, posed by a site and recommends ways to stop or reduce exposure in its public health action plan. ATSDR is primarily an advisory agency, so usually these reports identify what actions are appropriate to be undertaken by EPA, other responsible parties, or the research or education divisions of ATSDR. However, if there is an urgent health threat, ATSDR can issue a public health advisory warning people of the danger. ATSDR can also authorize health education or pilot studies of health effects, full-scale epidemiology studies, disease registries, surveillance studies or research on specific hazardous substances.

Interactive Process: The health assessment is an interactive process. ATSDR solicits and evaluates information from numerous city, state and federal agencies, the companies responsible for cleaning up the site, and the community. It then shares its conclusions with them. Agencies are asked to respond to an early version of the report to make sure that the data they have provided is accurate and current. When infomed of ATSDR's conclusions and recommendations, sometimes the agencies will begin to act on them before the final release of the report.

Community: ATSDR also needs to learn what people in the area know about the site and what concerns they may have about its impact on their health. Consequently, throughout the evaluation process, ATSDR actively gathers information and comments from the people who live or work near a site, including residents of the area, civic leaders, health professionals and community groups. To ensure that the report responds to the community's health concerns, an early version is also distributed to the public for their comments. All the comments received from the public are responded to in the final version of the report.

Comments: If, after reading this report, you have questions or comments, we encourage you to send them to us.

Letters should be addressed as follows:

Attention: Chief, Program Evaluation, Records, and Information Services Branch, Agency for Toxic Substances and Disease Registry, 1600 Clifton Road (E-56), Atlanta, GA 30333.

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ATSDR . . . Agency for Toxic Substances and Disease Registry
BW . . . . . . Body Weight
C . . . . Contaminant Concentration
CERCLA . . Comprehensive Environmental Response, Compensation, and Liability Act of 1980
Cr . . . . Chromium
CREG . . . . Cancer Risk Evaluation Guide
CSF . . . . . . Cancer Slope Factor
DEHP . . . . Di(2-ethylhexyl)phthalate
dl . . . . deciliter
DOE . . . . . Department of Energy
ED . . . . Exposure Dose
EF . . . . Exposure Factor
EM . . . . . . Equipment Maintenance
EMEG . . . . Environmental Media Evaluation Guide
EPA . . . . . . Environmental Protection Agency
FFS . . . . . . Focused Feasibility Study
FY . . . . Fiscal Year
HARP . . . . Health Activities Recommendation Panel
IARC . . . . . International Agency for Research on Cancer
IR . . . . Intake Rate
IQ . . . . Intelligence Quotient
IRIS . . . . . . Integrated Risk Information System
IU . . . . Isolated Unit
kg . . . . kilogram
L . . . . Liters
LFI . . . . . . Limited Field Study
log . . . . logarithm
m . . . . meter
m^3 . . . . cubic meter
MCL . . . . . Maximum Contaminant Level
mg . . . . milligram
mg/kg . . . . . milligram per kilogram
µg . . . . microgram
µg/dl . . . . . microgram per deciliter
$\mu g/m^3$ . . . . . microgram per cubic meter
MRL . . . . . Minimal Risk Level
NPL . . . . . . National Priorities List
NTIS . . . . . National Technical Information Service
NTP . . . . . . National Toxicology Program
OSHA . . . . Occupational Safety and Health Administration
PAHs . . . . . Polycyclic Aromatic Hydrocarbons
PCBs . . . . . Polychlorinated Biphenyls
PHAP . . . . . Public Health Action Plan
PMCL . . . . Proposed Maximum Contaminant Level

ppb ...... parts per billion
ppm ...... parts per million
RAC ..... Reasonably Assumed a Carcinogen
RCRA .... Resource Conservation and Recovery Act
RfC ...... Reference Concentration
RfD ...... Reference Dose
RMEG .... Reference Dose (or Concentration) Media Evaluation Guide
ROD ..... Record of Decision
SARA .... Superfund Amendments and Reauthorization Act
TCE ...... Trichloroethylene
TRI ...... Toxic (Chemical) Release Inventory
TMO ..... Tetramethyloxirane
USACE ... US Army Core of Engineers
VOCs ..... Volatile Organic Compounds
WADOE ... Washington State Department of Ecology

SUMMARY

The 1100-Area is one of four National Priorities List (NPL) sites designated at the Hanford Nuclear Reservation, a former production facility for weapons-grade plutonium. Because the 1100-Area is so close to Richland, Washington, the Department of Energy (DOE) has gathered more data about the 1100-Area than about the 100-Area, the 200-Area, and the 300-Area, the other NPL sites at Hanford. This availability of data has permitted the Agency for Toxic Substances and Disease Registry (ATSDR) to undertake public health assessment of the 1100-Area before assessment of the other NPL sites. This public health assessment document does not address exposures to contaminants from NPL sites other than the 1100-Area at the Hanford Nuclear Reservation. Exposures from other NPL sites and public health activities appropriate to them will be addressed as part of public health assessments and health consultations for those sites.

The 1.2-square-mile 1100-Area serves as a vehicle maintenance and general support area for DOE's 560-square-mile Hanford Reservation. The parts of the 1100-Area of concern in this document are those nearest to Richland in Benton County, Washington.

ATSDR has determined that the 1100-Area of the Hanford Reservation poses no apparent public health hazard from site-related contaminants because no one can come in contact with contaminants identified in surface soil, groundwater, or air. The contaminants identified on site were not found off site. There are no known completed past or current exposure pathways from the 1100-Area to the 32,000 people in Richland or the 95,000 people in the Tri-Cities, nor are completed exposure pathways likely in the near future. After the year 2018, future decisions to change land use might result in exposure of the public to 1100-Area contaminants. ATSDR would need additional qualitative and quantitative information about environmental contaminants for assessment of their public health implications at that time.

Community health concerns about Hanford relate mainly to radioactive releases from other areas at the Hanford Reservation and not to the 1100-Area, where radioactive contamination has not been detected.

ATSDR recommends actions to limit long-term access to or further characterize the 1100-Area before release of the 1100-Area for general public use.

This public health assessment was reviewed by the Agency's Health Activities Recommendation Panel (HARP). Follow-up health actions are not indicated at this time; however, if additional information becomes available, ATSDR will evaluate the data and determine whether any actions are needed.

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BACKGROUND

A. Site Description and History

Site History

In January 1943, the Hanford area in southeastern Washington state was selected as one of the sites for the Manhattan Project, a secret project conducted by the Army during World War II to produce plutonium for the atomic bomb, a new weapon that would bring a swift end to the war. The area was an excellent site for that undertaking because it was remote, yet near railroads, and it had abundant water for reactor cooling and plentiful electricity from hydroelectric dams. In the spring of 1943, 1,200 residents of Hanford, White Bluffs, and Richland were evacuated from a 640-square-mile area. A 560-square-mile portion of that area was later renamed the Hanford Nuclear Reservation (1).

Until recently, the reservation was used as a part of the DOE nuclear weapons complex to process spent nuclear fuel and to extract plutonium for national defense. With the nuclear arms reduction, the need for plutonium production activities lessened until the final reactor, N-reactor, went to cold-standby in 1988. The Hanford Nuclear Reservation is no longer used as part of the DOE nuclear weapons complex. The present stated DOE mission at Hanford is engineering and research programs, as well as defense waste research and applications (1).

In 1988, the Hanford Nuclear Reservation was placed on the National Priorities List (NPL) by the Environmental Protection Agency (EPA) as four separate NPL sites: the 100, 200, 300, and 1100 areas. The 1100-Area was placed on the NPL for the following reason:

> *On-site wells in the vicinity of the 1100-Area contain volatile organic compounds (VOCs) including trichloroethylene (TCE). Nitrates, sodium, and sulfate are present in Richland's well water. On-site soils are contaminated with heavy metals and polychlorinated biphenyls (PCBs). Possible exposure routes include direct contact with or accidental ingestion of contaminated groundwater and soil. The Yakima River borders the site and is a main fishing source for the Yakama Indian Reservation* (2).

The listing was finalized in 1989.

On May 15, 1989, representatives of the DOE, the Washington State Department of Ecology, and the EPA signed an agreement to clean up radioactive and chemical wastes at the Hanford Nuclear Reservation over the next 30 years. This agreement, known as the Hanford Federal Facility Agreement and Consent Order or the Tri-Party Agreement, organized the reservation into 78 operable units containing more than 1,100 areas of contamination. Four of the 78 operable units are within the 1100-Area.

The Hanford Nuclear Reservation is government (DOE)-owned and contractor-operated, with

Westinghouse Hanford Company as the prime contract operator (3). Battelle Pacific Northwest Laboratories is the principal research and development contractor for the reservation. The 1100-Area has provided vehicle service and maintenance, transportation, utilities, shipping, receiving, and warehousing for the reservation since the early 1950s.

ATSDR activity at the Hanford Nuclear Reservation began in 1989 with an initial site visit on April 17, 1989. Preliminary public health assessments for each of the four NPL sites, including the 1100-Area, were released in November 1989. Since then, additional information has been made available to this Agency by DOE. The present public health assessment document addresses the 1100-Area based on data made available since 1989.

This public health assessment is one of a series of documents, including health consultations and public health assessments, planned to address public health issues at the Hanford Nuclear Reservation. Parts or all of three of the four operable units in the 1100-Area are in close proximity to Richland. For this reason, DOE has carried the process mandated by the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), including data collection, further for the 1100-Area than for the 100, 200, and 300 areas, the other three NPL sites at the Hanford Nuclear Reservation. Because the 1100-Area is close to Richland and environmental data was made available sooner than for the other areas, public health assessment of the 1100-Area was undertaken sooner than assessments of the other areas.

The ATSDR Division of Health Studies is considering health studies concerning past radionuclide exposures from areas of the Hanford Nuclear Reservation other than the 1100-Area. However, health studies are not planned for any health effects that could be related to releases of nonradioactive substances from the 1100-Area. Studies relevant to the other NPL sites of Hanford will be discussed in ATSDR documents about those NPL sites or in ATSDR documents that address the Hanford Nuclear Reservation as a whole.

Site Description

The Hanford Nuclear Reservation is in southeastern Washington state. The Columbia River borders the reservation on the north and east. To the south is the city of Richland, and to the west are the Rattlesnake Hills. The reservation includes portions of Benton, Grant, Franklin, and Adams counties. The area of the reservation is 560 square miles (Figure 1).

Most of the 768 acres (1.2 square miles) in the 1100-Area is near Richland in Benton County on the southern boundary of the Hanford Nuclear Reservation. The area is on a plateau about 400 feet above mean sea level and some 60 feet above the Columbia River. The river lies about one mile to the east (see Figure 2). The 1100-Area also includes a former Nike base in the Rattlesnake Hills 15 miles west-northwest of Richland (see Figure 1 and Figure 2).

The 1100-Area has been in operation for vehicle service and other support functions for about 40 years. DOE plans to retain the 1100-Area for the foreseeable future for use as a maintenance and support facility for the remediation and restoration effort as well as for

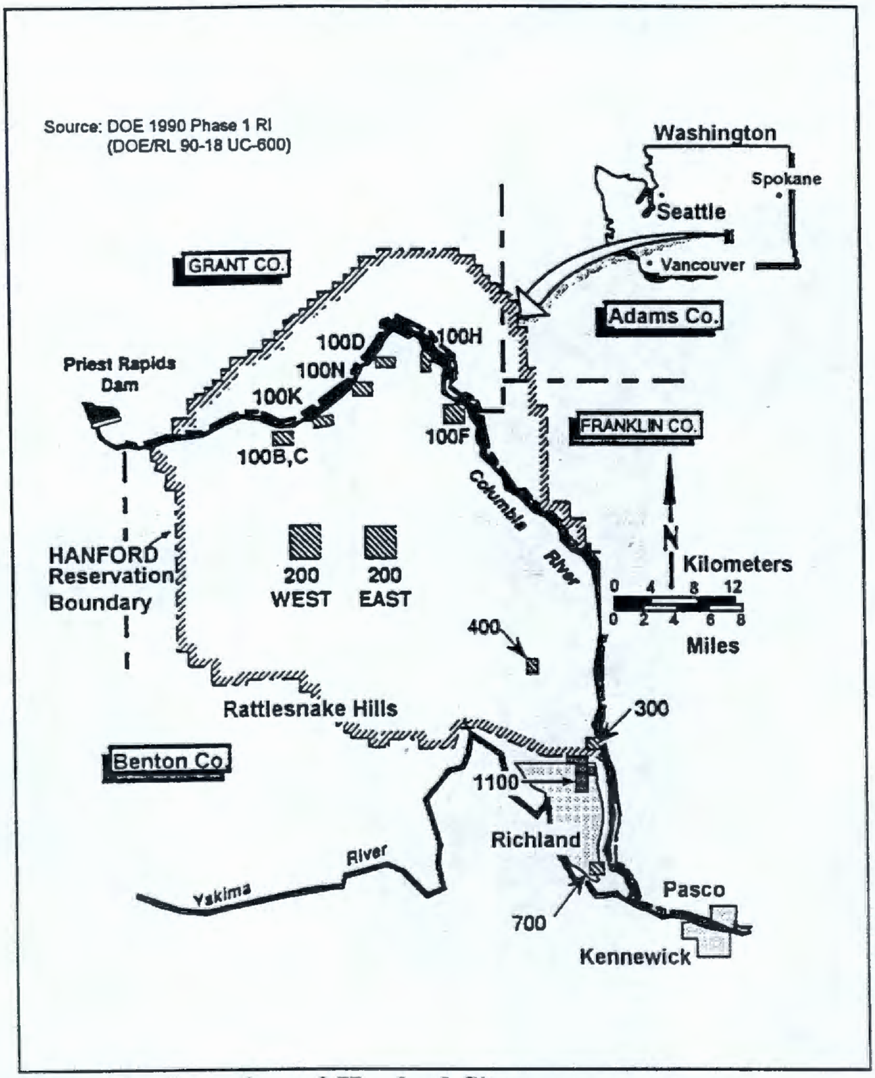

Figure 1. Location of Hanford Site.

research activities at the Hanford Nuclear Reservation (4). On September 8, 1992, the Richland City Council resolved to annex 3.8 square miles of Hanford, including the 1100-Area (5). The time frame for release of DOE's Hanford property extends to the year 2018 (6). The future use of all of the Hanford Nuclear Reservation is under community debate, with some hoping for unrestricted use of the 1100-Area beyond 2018 (6). A DOE representative has stated that the 1100-Area is to remain zoned industrial in the future but has not formally committed to restrict future land use, e.g., by deeds restrictions (see Appendix A) (7).

DOE's remediation of the 1100-Area is being treated as four operable units. Three (EM-1, EM-2, and EM-3) are in or near the city of Richland, and an outlying, isolated operable unit, 1100-IU-1, is in the Arid Lands Ecology Reserve approximately 15 miles away. These designations indicate the equipment maintenance (EM) units and an isolated unit (IU) to be remediated. Remediation plans, rather than geography, define the operable units of this NPL site. The EM-1 Operable Unit is further subdivided into suboperable units. The operable and

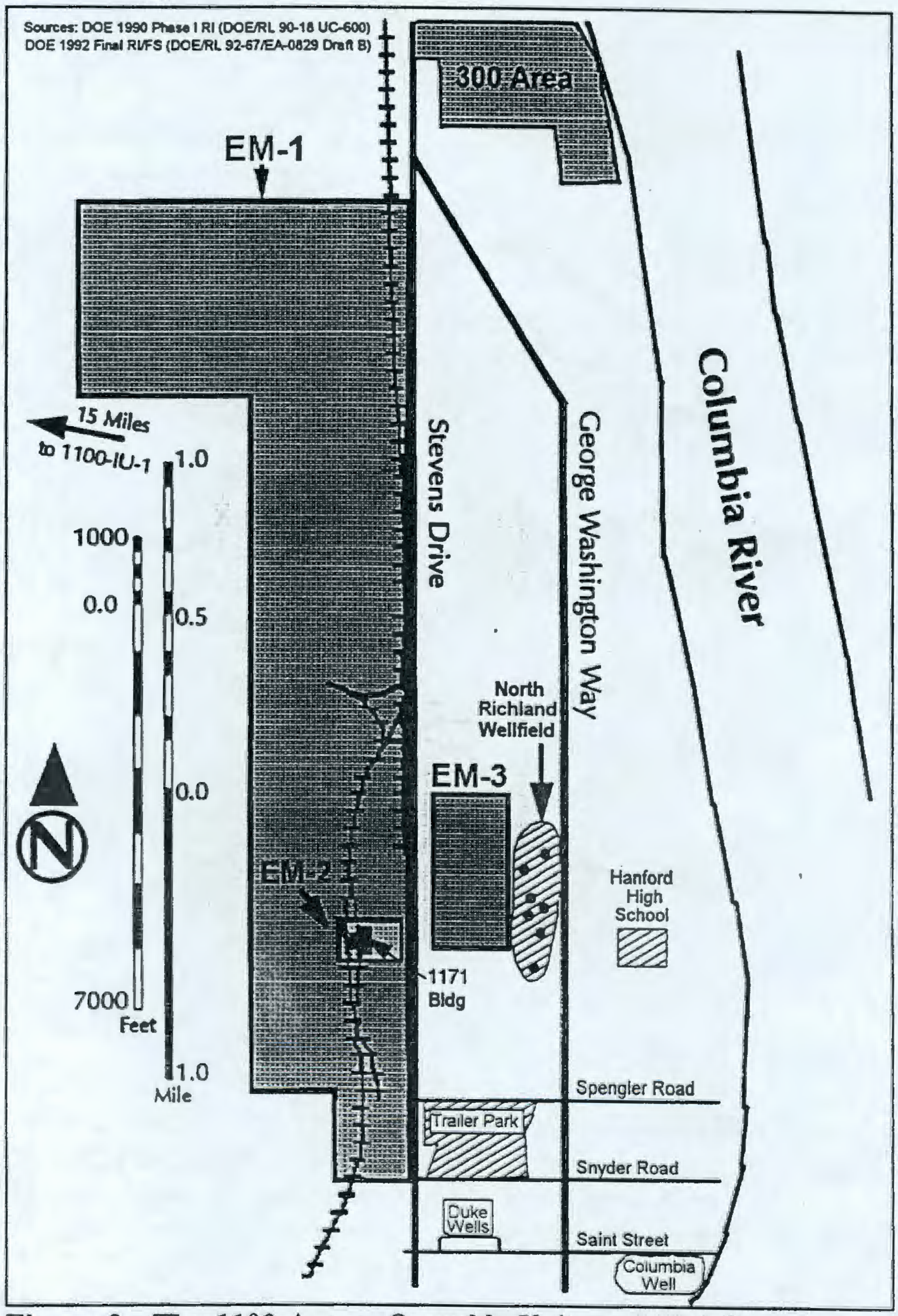

Figure 2. The 1100 Area: Operable Units and Vicinity.

suboperable units of the 1100-Area are summarized in Table 1.

Representatives of the Washington State Department of Ecology, DOE, and EPA agreed to document and authorize the remediation of operable units EM-1, EM-2, EM-3, and IU-1 in a record of decision signed in September 1993 (9). Operable Unit EM-1 consists of six suboperable units, a rainwater pool that collects runoff from a parking lot, and one plume of contaminated groundwater that DOE investigators believe originates at Siemens Power Corporation (also known as Advanced Nuclear Fuels), an off-site facility (Figure 3) (3).

Table 1 Operable and Suboperable Units of the 1100 Area

Operable Unit	Sub-operable Unit	Waste Type	Remarks
EM-1	1100-1	Battery acid pit	Used 1954 until backfilled in 1977; lead now in backfill
	1100-2	Paint & solvent pit	Used 1954-85; near rail line
	1100-3	Antifreeze & degreaser pit	Used 1979-85; 250 ft. wide
	1100-4	Antifreeze storage tank	Tank removed 1978; covered by Bldg. 1171. No leaks
	1100-5 (discontinued)	1962 spill of short-lived radionuclides	No radioactivity detected with repeated testing
	1100-6	Discolored soil (organic chemical spill)	Near rail line; 0.4 acre
	Rainwater Pool	Parking lot runoff, unknown spill	Near rail line
	Horn Rapids Landfill (HRL)	Wastes from offices, construction, septic tanks, fly ash, asbestos, solvents, PCBs	Used 1940s to 1970; 50 acres
	HRL groundwater	Nitrates, trichloroethylene	DOE states plume came from Siemens (Advanced Nuclear Fuel)
EM-2		Used oil storage tanks	
		Steam pad and hoist ram storage tanks	hoist ram storage tanks removed prior to 1991
		Underground antifreeze tank	Tank removed 1986
EM-3		Buried gasoline tanks	Tanks removed; soil remediated
		Waste staging & storage areas	
		Underground oil storage tank	
		Stored contaminated soil	
		Underground fuel storage tanks	Removed in 1991
IU-1		Septic system from old antiaircraft facility and support	Chemicals may be in soil, groundwater

Sources: Prepared from references 3, 4, & 8.

Siemens is southwest of the Horn Rapids Landfill (Figure 3). Five of the suboperable units are defined by soil contamination from spills. The sixth suboperable unit is a landfill/disposal site, the Horn Rapids Landfill, that is used for commercial and industrial wastes but not for household wastes (4).

Suboperable Unit 1100-1 is a 6-foot-wide pit used for battery acid disposal. This pit was used from 1954 to 1977 and lies near a maintenance facility within the 1100-Area (4).

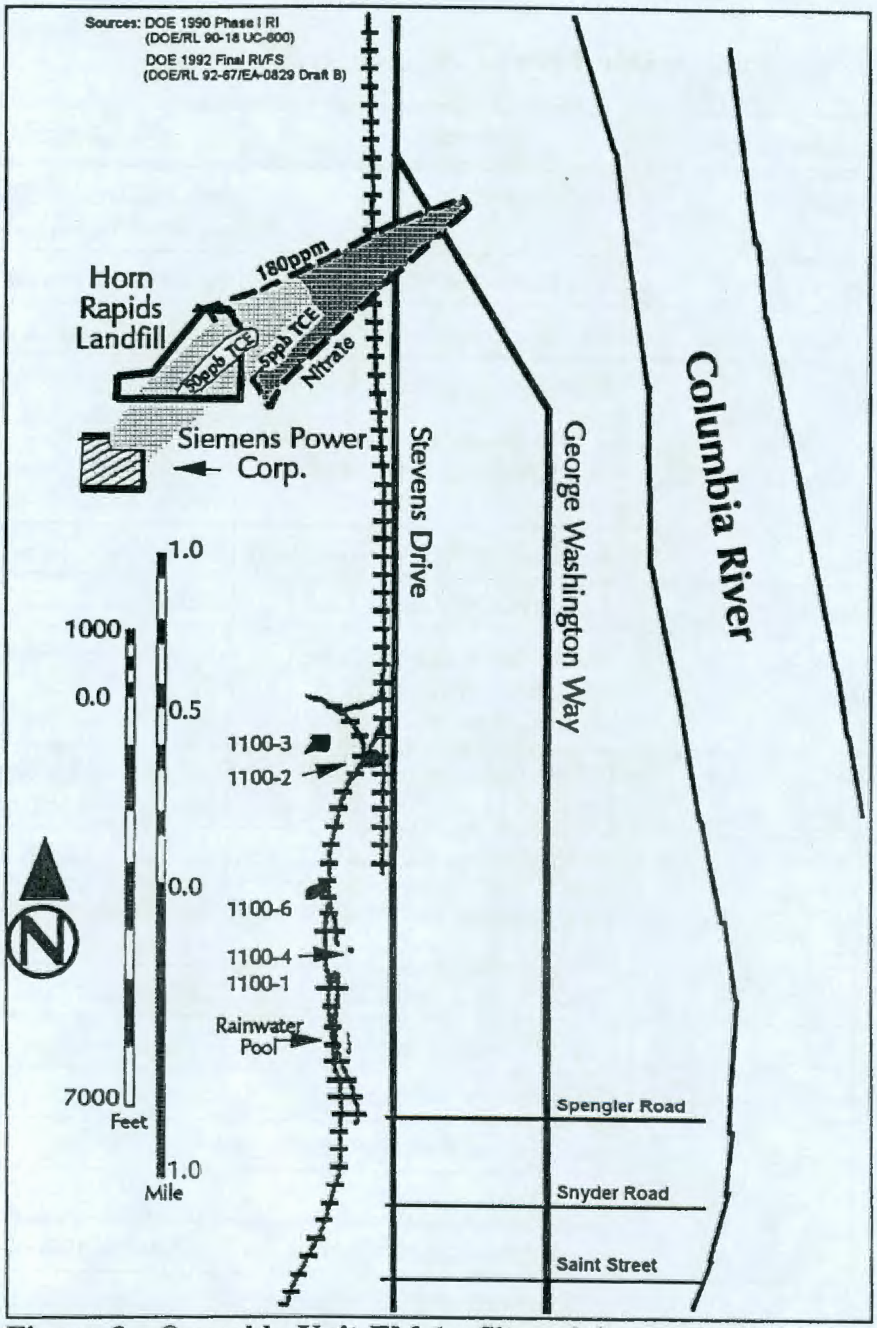

Figure 3. Operable Unit EM-1: Sites of Contamination.

Suboperable Unit 1100-2 is a 350-foot-wide pit used from 1954 to 1985 for disposal of paint and solvents. This pit lies near a rail line passing through the 1100-Area (4).

Suboperable Unit 1100-3 is a pit used from 1979 to 1985 for disposal of antifreeze and degreasing agents. The pit is approximately 250 feet in diameter (4).

Suboperable Unit 1100-4 was a 5,000 gallon underground tank used to store antifreeze until 1978. The tank was removed in 1986, and the location is now covered by the concrete floor of Building 1171. DOE reported that no evidence of leakage was found (4).

Suboperable Unit 1100-5 was a 1962 spill of water from a barrel of radioactive metals onto the bed of a truck parked on a lot near Building 1171. The trailer bed was contaminated with several radioisotopes with half-lives of less than 12 days. Repeated testing of the parking lot surface failed to reveal radioactive contamination. The DOE eliminated this suboperable unit from further study (3,4).

Suboperable Unit 1100-6 is a 0.4-acre spill of organics, also near the rail line (4). This suboperable unit was selected for remediation in the record of decision (9).

The rainwater pool is a depression 20 feet wide and 650 feet long near the rail line in the vehicle maintenance area used to collect runoff from the parking area (3). It was contaminated by unknown spills of organic substances (4). This suboperable unit was also selected for remediation in the record of decision (9).

The largest suboperable unit, Horn Rapids Landfill, was used for industrial wastes from the 1940s until about 1970. The landfill covers about 50 acres. Horn Rapids Landfill wastes include office and construction waste, septic tank waste, fly ash, asbestos, and various solvents. No household or food wastes or other methanogenic substances are present. The Horn Rapids Landfill is about 550 feet northeast of the Siemens facility (Advanced Nuclear Fuels), the nearest building, and about 2 miles from the nearest residence. A chain link fence and locked gates restrict access to the landfill (4). The landfill was selected for partial remediation in the record of decision (9).

DOE representatives believe most of the groundwater contamination within the 1100-Area is in a plume originating at the nearby Siemens facility (Advanced Nuclear Fuels) (3). This facility manufactures fuel for commercial nuclear power plants. The major contaminants in the plume are trichloroethylene and nitrate. Siemens (shown in Figure 3) is southwest of the landfill (4). According to the record of decision, contamination will be monitored to follow the progress of its natural attenuation as the plume extends toward the Columbia River (9).

The EM-2 Operable Unit surrounds a vehicle maintenance and repair facility (Building 1171) constructed in the early 1950s and regulated by the EPA, under the Underground Storage Tank and Resource Conservation and Recovery Act (RCRA) programs. Waste areas within this operable unit consist of several used oil storage tanks, a hazardous waste storage area, a steam pad, and several hoist ram storage tanks. The storage tanks collect effluent from steam cleaning operations that are part of equipment and vehicle maintenance. An underground antifreeze storage tank was removed in 1986. As shown in Figure 2, all of EM-2 is contained within EM-1, within 400 feet of Suboperable Unit 1100-4 (8). According to the record of decision, this operable unit will be remediated by a limited field investigation/focused feasibility study (LFI/FFS), an expedited version of the CERCLA process (9).

EM-3 was the site of buried gasoline tanks. The tanks were removed in 1991, and the surrounding soils, primarily sand and gravel, were remediated under the EPA Underground Storage Tank Regulatory Program. As shown in Figure 2, EM-3 is between EM-1 on the west and the North Richland Wellfield on the east. This operable unit, once called the 3000-

Area, has about 20 permanent structures, some built as early as 1950, for general maintenance and service support for the Hanford Nuclear Reservation. The foci of contamination are several hazardous waste staging and storage areas and a used underground oil storage tank. The contamination is regulated by the EPA under the Underground Storage Tank and RCRA programs (8). As with EM-2, EM-3 will be remediated by the LFI/FFS process (9).

Operable units EM-1, EM-2, and EM-3 are on-site units in this public health assessment. They are the portions of the 1100-Area that are closest to residential areas of the city of Richland in Benton County, Washington. Public access to these areas is restricted, as it is to all of the Hanford Nuclear Reservation. The public cannot come into direct contact with on-site contamination in the equipment maintenance units. DOE investigators have monitored the potential for indirect contact with water under the ground (groundwater) from on-site contamination, and this public health assessment contains a review of the monitoring results.

The remaining operable unit, IU-1, situated in the Rattlesnake Hills about 15 miles west of the 1100-Area, consists of abandoned antiaircraft emplacement and support facilities. This operable unit contained several military installations involved in air defense of the Hanford Nuclear Reservation. The installations have been inactive since the early 1960s. IU-1 consisted of antiaircraft artillery and Nike missile emplacements, missile storage and maintenance facilities, and motor pools (4). The primary concern at IU-1 is chemicals discharged into the soil through a septic system (4,8). Contamination was probably within 25 feet of the surface, above bedrock (8). Public access is restricted. Preliminary indications are that groundwater in the unconfined aquifer of Rattlesnake Hills is entirely within bedrock, sometimes 990 feet below the surface (8). The direction of underground groundwater movement generally follows the downward slope of ground surface. The surface of the downward slope of the Rattlesnake Hills at the Nike sites is toward the east-northeast past the 400-Area toward the Columbia River 18 miles away (see Figure 1). Contamination in IU-1 is also being addressed through the LFI/FFS process.

The record of decision directs that, if the LFI/FFS process reveals that soil and debris from operable units EM-2, EM-3, and IU-1 are contaminated, the contaminated soil and debris will be disposed off site (9).

Environmental monitoring information for the Hanford Nuclear Reservation is collected annually (10). The current environmental monitoring network includes soil, surface water, groundwater, and biota. No permanent surface water or ephemeral (seasonal) streams are present within EM-1 through EM-3, although there may be ephemeral streams in IU-1 (8). Until recently, monitoring activities focused entirely on radiological monitoring. No radiological contamination has been found within the 1100-Area. Remedial investigation sampling and analysis activities have expanded this monitoring network. Testing now also includes the target chemicals EPA monitors at NPL sites.

B. Site Visit

Formal site visits were made to the 1100-Area during the weeks of April 17, 1989; January 27, 1992; and April 18, 1994. The most recent of these visits was conducted by Dr. Jo A. Freedman, a toxicologist, and Dr. Paul Charp, a health physicist, from the Energy Facilities Assessment Section, Division of Health Assessment and Consultation, ATSDR.

Security measures at the 1100-Area consist of foot and ground vehicle patrols. All workers and visitors are required to display identification badges. Any person on the premises without security clearance is required to be escorted by cleared personnel; therefore, the likelihood of current or past public access is not great.

C. Demographics, Land Use, and Natural Resource Use

Demographics

The reservations of the Coeur d'Alene Tribe, Colville Confederated Tribes, Confederated Tribes of the Umatilla Indian Reservation, Confederated Tribes of the Warm Springs Reservation of Oregon, Kalispel Tribe, Kootenai Tribe of Idaho, Nez Perce Tribe, Spokane Tribe, and Yakama Indian Nation are dispersed in Washington, Idaho, and Oregon around Hanford. The reservations and the largest population centers for most of the tribes are more than 100 miles from the 1100-Area. Umatilla and Yakama are two exceptions. The 1100-Area is 50 miles northwest of Umatilla's reservation and 20 miles east of Yakama's reservation. The Yakima River, on which Yakama Nation has fishing rights, is upstream from the 1100-Area except for parts of the river 5 miles west and 8 miles south of the 1100-Area that will be discussed later in this document. Hanford (including the 1100 Area) contains lands some of the tribes ceded to the U.S. government in the nineteenth and twentieth centuries. Because the tribes traditionally hunt, fish, and gather food and medicines on and near the Columbia River or its tributaries, tribal leaders are concerned that their people's health may have been harmed by releases from other NPL sites of Hanford. No tribal representatives expressed concern to ATSDR that their people's health was harmed by 1100-Area releases.

The Hanford Nuclear Reservation is on the banks of the Columbia River in southeastern Washington; it covers parts of Benton, Grant, Franklin, and Adams counties. Grant and Adams counties are more than 25 miles north of the 1100-Area. Benton County contains the 1100-Area and the cities of Richland and Kennewick. Across the Columbia River from the 1100-Area and the city of Richland is Franklin County, containing the city of Pasco. Richland, Kennewick, and Pasco are collectively called the Tri-Cities. The following discussion about the people in the counties containing or bordering on the 1100-Area and cities near the 1100-Area is based on the tables listed in Appendix B. The tables are extracted from the 1990 Census of Population and Housing Data for Benton County, Franklin County, and the Tri-Cities. Of the two counties, Benton has more people and a greater population density. Franklin has a total area of 1,242 square miles. Nearly one-third of the population in Franklin County is of Hispanic origin (Table B-1).

Relative to Benton County, Franklin County also shows a high percentage of children under age 10, nearly 20%, and a large number of persons per household, 3.0 (Table B-2).

One-half to two-thirds of the housing units in Benton and Franklin counties were owner-occupied. The median value of owner-occupied housing units in Benton County is nearly $10,000 greater than that of owner-occupied homes in Franklin County.

The 1100-Area is the southernmost part of the Hanford Nuclear Reservation, partly within the city of Richland. For this reason, the people within the Tri-Cities having the greatest proximity to the 1100-Area are those in Richland. In Richland, off-site land use south and southeast of the 1100-Area is mostly residential. The closest residence is 100 feet from the boundary of Operable Unit EM-1 but more than 15 miles from Operable Unit IU-1 of the 1100-Area. The 1990 population of Richland was 32,315 (Table B-3). Richland's population was 93% white; 1.4% black; 0.7% American Indian, Eskimo, or Aleut; and 4.9% other races.

In Richland, there were 13,162 households and an average of 2.44 persons per household (Table B-4). Sixty-two percent of all households are owner-occupied. The median value for owner-occupied homes was $69,200.

The other Tri-Cities are Kennewick and Pasco (see Table B-3 and Table B-4). Kennewick and Pasco are on the banks of the Columbia River approximately 12 miles downstream and southeast of the 1100-Area. The 1990 population of Kennewick was 42,155, of whom 89.9% were white. Slightly more than 50% of the 16,074 households were owner-occupied. The median value was $64,800, which was near the median for Benton County.

Pasco's population was 20,337. Nearly 60% of the people were white; 5.6% were black; 0.9% were American Indian, Eskimo, or Aleut; and 33.6% were of other races. Relative to Richland and Kennewick, Pasco showed a high percentage of people of Hispanic origin, 40.8%. Some 47.4% of the 6,842 housing units were owner-occupied. The median value of owner-occupied homes was $44,100, and the median monthly apartment rent was $228. These figures are lower than the medians for Franklin County and the other Tri-Cities.

Information concerning the proportion of Tri-Cities residents specifically employed in the 1100-Area (as opposed to the Hanford Nuclear Reservation in general) was not available.

Land Use

Across Stevens Drive, east of the 1100-Area, are several research, manufacturing, and utility firms, including contractors for the Hanford Nuclear Reservation, the Port of Benton, and the Washington Public Power Supply System. West of the 1100-Area, land use is industrial and commercial, including light industry, the Richland Airport, the Siemens (Advanced Nuclear Fuels) facility, and the Richland sanitary landfill. The Siemens Facility is 550 feet from the boundary of the EM-1 Operable Unit of the 1100-Area (compare Figure 2 to Figure 3). Large undeveloped tracts are east and west of the 1100-Area. Within one-half mile to the east of the 1100-Area are residential neighborhoods, consisting of single-family dwellings and mobile home parks. The nearest residences include mobile homes in one of the parks and are across Stevens Drive (about 100 feet) from the 1100-Area's eastern boundary (see Figure 2). Hanford High School (see Figure 2) is about 1,800 feet from the EM-2 Operable Unit. The school and residences are south and southeast of the 1100-Area (4).

Natural Resource Use

About 70% of the water used by the city of Richland for domestic purposes comes directly from the Columbia River. Several pumps on an intake structure (due east of the southern boundary of the trailer park -- see Figure 2) draw drinking water from the Columbia River, which is about 1 mile east of the equipment maintenance units and about 18 miles east of the isolated unit of the 1100-Area (11). In addition, water from the Columbia River is pumped into the unconfined aquifer reservoir at the North Richland Wellfield. The municipal aquifer recharge wells are on the eastern border of the EM-3 operable unit of the 1100-Area (see Figure 2). About 15% of Richland's water is supplied from the North Richland Wellfield. Other water sources that add into the city's general water supply include Columbia Well 1100B (5-10% of Richland's water), Duke Fields (3-5% of Richland's water), and, until it was taken out for maintenance at the start of 1993, Wellsian Field. As can be seen from comparison of Figure 2 to Figure 3, the municipal wells are not in the path of migration of the plume under the Horn Rapids Landfill. The potential for municipal water drawn from the Columbia River to be contaminated by this plume or for the municipal wells to be contaminated by the rainwater pool and suboperable units 1100-1 through 1100-6 will be discussed in the sections on Environmental Contamination and Pathways later in this document. Water used by the Hanford 1100-Area is supplied by the city of Richland (5,12).

In 1985, the city of Richland enacted an ordinance requiring all city residents to use city water for human consumption. According to a 1990 inventory by Washington Department of Ecology (3), 10 residential wells predate the 1985 ordinance and may be used for domestic water supply. Additional wells are to the south of the southern boundary of 1100-Area, across the Yakima River (13.14). A further search of Washington State Department of Ecology's Richland well permitting records revealed 12 wells drilled for domestic use between 1974 and 1985 (15). On the basis of their street addresses, ATSDR located these wells within a triangular region bounded on the north by Snyder Street (shown in Figure 2 and Figure 3) and extending 6,500 feet south (15). In addition, within the city of Richland are about 100 households considered part of Benton County and not incorporated into the city (16). These households do not use city water but draw water from the subdivision's private well (12,16). This subdivision is due south of the 1100-Area, across the Yakima River (16).

Figure 4 shows major surface water features near the 1100-Area. The Yakima River passes 5 miles to the west and 8 miles to the south of the equipment maintenance units of the 1100-Area. From where the Yakima River is 5 miles to the west of the equipment maintenance units, the flow of groundwater under these operable units of the 1100-Area is eastward from the Yakima to the Columbia River. As the Yakima River flows farther to the south, it is out of the path of groundwater passing eastward under these operable units. The Yakima river also flows south of the Rattlesnake Hills, not in the east-northeast path of groundwater

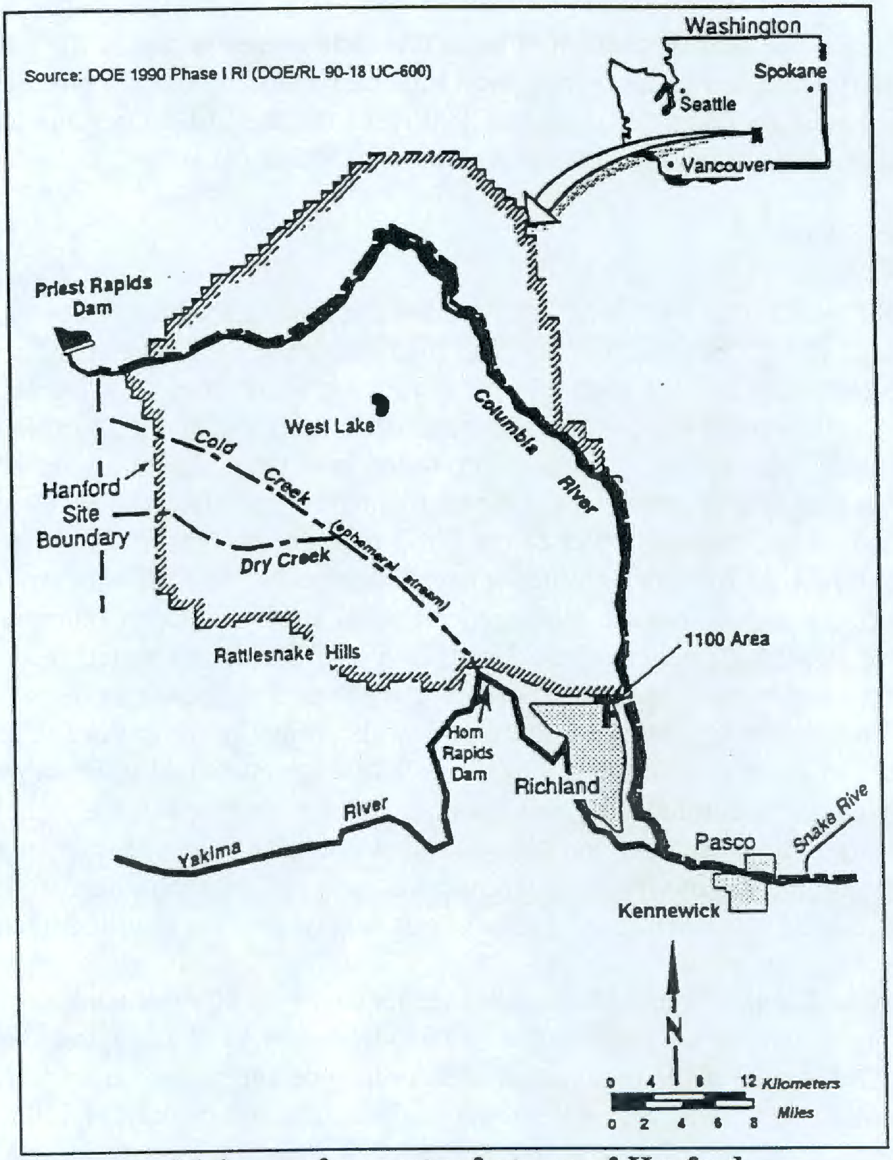

Figure 4. Major surface water features of Hanford.

flowing under Operable Unit IU-1 of the 1100-Area. The Yakima River's proximity to the 1100-Area and its use for subsistence fishing by the Yakama Indian Nation were a cause for placement of the 1100-Area on the NPL (2), but no part of the Yakima River is downgradient from any part of the 1100-Area. The Columbia River is downgradient from the 1100-Area, within a mile of the equipment maintenance operable units, and about 18 miles from IU-1. The Columbia River was discussed above as a drinking water source for the city of Richland. The city of Pasco also draws water from the Columbia River. The Pasco facility is about 9 miles downriver from the 1100-Area. The city of Kennewick uses water from infiltration wells farther downstream and adjacent to the Columbia River. Both the Pasco and Kennewick systems are downstream from the Columbia River's confluence with the Yakima River (Figure 4). The rate of flow of the Columbia River averages 120,000 cubic feet per second (ft^3/sec) (17).

The state of Washington has designated the Columbia River (from Grand Coulee Dam to the Oregon border) as a Class A (excellent) water system. This area includes the Hanford Reach, which is the free-flowing stretch of river between the Priest Rapids Dam and the McNary Dam. The Columbia River is used for drinking, industrial process, irrigation, recreation, fishing industries, and hunting by people living in or visiting Washington and Oregon.

The Hanford Nuclear Reservation is located in the south central region of the state of Washington. Predominant westerly winds blowing from the Pacific Ocean deposit most of their moisture in western Washington, windward of the Cascade Mountains. When these air masses reach central Washington, they are quite dry. Hanford is in a semidesert region. The average annual rainfall for the period 1912-1980 was 6.3 inches (4). The surrounding area supports agricultural activities by the use of a state-run underground water distribution system drawing from the Columbia River at the Grand Coulee Dam. The soil at the Hanford Nuclear Reservation itself is not irrigated. This soil is composed primarily of layers of sand and gravel with little organic matter or clay to retard movement of soil gases or undissolved matter suspended in groundwater. These layers can be seen in the drilling logs for monitoring wells and soil borings drilled for environmental sampling (3,4).

D. State and Local Health Data

Health data were not reviewed because the surrounding public was not found to be exposed to contaminants originating in the 1100-Area, and people living nearby did not express concern about being made ill by the nonradioactive contaminants specific to the 1100-Area. Health data for adverse effects that could result from exposures to contaminants originating in the other NPL sites of the Hanford Nuclear Reservation will be addressed in public health assessments and health consultations for those sites.

COMMUNITY HEALTH CONCERNS

Discussions with local government and health officials and representatives of citizen groups and American Indian tribes during 1992-1994 indicated in general that health concerns are reservation-wide. This is because the public and local governments view Hanford as an aggregate of all reservation facilities rather than as four NPL sites, of which the 1100-Area is one site. As is the case with other DOE facilities, public concern tends to focus on radiological hazards. The absence of radiological contamination in the 1100-Area may explain the lack of public focus on this NPL site. ATSDR representatives were unable to identify any community health concerns specifically associated with the nonradiological contaminants of the 1100-Area. Community health concerns associated with contaminants originating in the other NPL sites of the Hanford Nuclear Reservation will be addressed in public health assessments and health consultations for those sites.

ENVIRONMENTAL CONTAMINATION AND OTHER HAZARDS

The tables in this section list the contaminants of concern. ATSDR's evaluations of these contaminants and determinations of whether exposure to them has public health significance appear in the subsequent sections of this public health assessment. The Agency selects and discusses these contaminants based upon the following factors:

1. concentrations of contaminants on and off the site;

2. field data quality, laboratory data quality, and sample design;

3. comparison of on-site and off-site concentrations with health assessment comparison values for (1) noncarcinogenic and (2) carcinogenic endpoints; and

4. community health concerns.

In the data tables that follow under the On-site Contamination subsection and the Off-site Contamination subsection, listing of a contaminant does not mean that it will cause adverse health effects from exposures. Instead, the list indicates which contaminants will be evaluated further in the public health assessment.

The data tables include the following abbreviations and acronyms:

- **CREG** = Cancer Risk Evaluation Guide
- **EMEG** = Environmental Media Evaluation Guide
- **MCL** = Maximum Contaminant Level
- **PMCL** = Proposed Maximum Contaminant Level
- **ppb** = parts per billion
- **ppm** = parts per million
- **RfC** = Reference Concentration
- **RfD** = Reference Dose
- **RMEG** = Reference Dose (or Concentration) Media Evaluation Guide

Comparison values for public health assessment are contaminant concentrations in specific media that are used to select contaminants for further evaluation. These values include Environmental Media Evaluation Guides (EMEGs), Cancer Risk Evaluation Guides (CREGs), and other relevant guidelines. CREGs are estimated contaminant concentrations based on one excess cancer in a million persons exposed over a lifetime. CREGs are calculated from EPA's cancer slope factors. EPA's Maximum Contaminant Levels (MCLs) represent contaminant concentrations that EPA deems protective of public health (considering the availability and economics of water treatment technology) over a lifetime (70 years) at an exposure rate of 2 liters of water per day. Proposed Maximum Contaminant Levels (PMCLs) are MCLs that are being proposed. MCLs are regulatory concentrations. EPA's Reference Dose (RfD) and Reference Concentration (RfC) are estimates of the daily exposure to a contaminant that is unlikely to cause adverse health effects. Reference Dose (or Concentration) Media Evaluation Guides (RMEGs) are based on EPA's RfDs and RfCs.

A. On-Site Contamination

For the purpose of this document, "on-site" will refer to the three equipment maintenance operable units -- EM-1, EM-2, and EM-3. The isolated unit, Operable Unit IU-1, is off site.

The EM-1 Operable Unit of the 1100-Area has been the subject of extensive study during remedial investigation. Phase I of the Remedial Investigation for Operable Unit EM-1 was completed in August 1990 (3). Phase II was completed in December 1992 (4). The remaining three operable units (EM-2, EM-3, and IU-1) were addressed as a limited field investigation (LFI) and focused feasibility study (FFS) in an addendum to the Phase II Remedial Investigation and Feasibility Study of the EM-1 Operable Unit, completed in April 1993 (8). The LFI/FFS approach differs from the usual CERCLA process. Rather than taking place as an initial detailed evaluation of media contamination, sampling and establishment of media-specific goals take place during the remediation process (8).

EM-1 is the only 1100-Area operable unit for which both soil and groundwater data are available. Because of the area's past use, DOE representatives believe that soil in EM-2 could be contaminated with trichloroethane, chlordane, and polychlorinated biphenyls (PCBs). Soil in EM-3 could be contaminated with nitrates, lead, carbon tetrachloride, and PCBs. Soil in 1100-IU-1 could be contaminated by fuel spillage and leakage of hydraulic fluid and solvents at the Nike sites (8). Quantitative soil data for these operable units were not given in the remedial investigation/feasibility study, in the LFI/FFS, or in a record of decision signed in September 1993 (3,4,8,9). Groundwater data are available from monitoring wells in EM-2 (located entirely within EM-1) and EM-3 (once called the 3,000-Area, between EM-1 and the North Richland Wellfield), but not for 1100-IU-1 (15 miles west of EM-1) (8).

The EM-1 Operable Unit is shown in Figure 2. Contamination known to originate in Operable Unit EM-1 is limited to six suboperable units, a rainwater pool, and one groundwater plume (see Figure 3). The reported contaminants in EM-1 are motor and hydraulic oils, battery acid, ethylene glycol (antifreeze), solvents and degreasers, paints and paint thinner, and asbestos.

A DOE document suggests the groundwater plume originated at Siemens (Advanced Nuclear Fuels) just outside the border of the operable unit (compare Figure 2 to Figure 3) (3).

Trichloroethene (TCE) and nitrate are the primary contaminants (3,4). This plume is moving northeast under the Horn Rapids Landfill and toward the Columbia River (Figure 3). Siemens Power Corporation, through its contractor, Geraghty and Miller, Inc., began a remedial investigation/feasibility study under the Washington State Model Toxics Control Act (4). Sampling and analysis that supplied data for this public health assessment were conducted by or under the direction of DOE's contractor, Westinghouse Hanford Company (3).

Soil

Soil was sampled either 0-6 inches deep or at the subsurface (more than 6 inches deep) (3). Sampling was not random throughout the operable units but was restricted to areas that DOE investigators believed were likely to be contaminated by waste disposal or vehicle maintenance activity. Sampling took place from July through October 1989 (18).

Samples were analyzed for contaminants on the EPA target analyte and target compound lists and were tested for ethylene glycol in suboperable units 1100-3 and 1100-4 (3,19). The sample ethylene glycol content was indistinguishable from blanks -- less than 2,000 ppm. ATSDR's comparison values (EMEGs) for soil contaminated with ethylene glycol are 1,000,000 ppm for adults, 100,000 ppm for most children, and 4,000 ppm for children exhibiting pica behavior (ingestion of non-nutritive substances). None of the samples showed ethylene glycol in amounts sufficient to justify further evaluation in this public health assessment (19).

The suboperable units 1100-1 and 1100-4 were not surface-sampled because they had been backfilled with sand and gravel; 1100-1 after it ceased to be a designated battery acid disposal site in 1977 and 1100-4 after tank removal in 1986 (3,4). The location of 1100-4 has since been covered with concrete. It is under the floor of Building 1171, an indoor vehicle maintenance facility (compare Figure 2 to Figure 3).

Table 2 below lists substances reported in the Phase I Remedial Investigation (3) at concentrations exceeding ATSDR's comparison values. These substances will be evaluated further in the assessment to determine whether they could be of public health concern.

Arsenic is not a product or byproduct of any human activities know to have occurred in the 1100-Area; it is an expected constituent of soil of basaltic origin. Variability of basaltic content in soil may account for variability in soil arsenic content. Arsenic is listed in the table, although ATSDR does not assume it to be a contaminant generated by DOE, and its concentration is similar to that expected in regional soil. It was found in the soil at concentrations high enough to justify further evaluation in this assessment.

Tetramethyloxirane (TMO) was ***tentatively*** identified 10-22 feet below the surface. TMO could be migrating towards the groundwater from the paint and solvent pit. TMO may be hazardous by analogy to oxirane (ethylene oxide).

Lead is present near the surface (2-4 feet down) of the battery acid pit (1100-1) at levels that

Table 2 Range of Contaminant Concentrations in On-site Soil Samples

Substance	Operable Subunit	Concentration Range[a] (ppm) Surface (0-0.5 ft.)	Concentration Range[a] (ppm) Subsurface	Concentration Range[a] (ppm) Subsurface Depth (ft.)	Cancer[b] Class and Comparison Values (ppm)	Source	Range[c] in Washington soil (ppm) Range Arithm.Mean±Dev N
Arsenic	Background	0.15-1.6	0.64-2.7	0.5-21	Adult 200 Child 20 Pica[d] 0.6 0.4 A KC	RMEG CREG EPA NTP	0.4-8.6 4.5±2.6 N=22
	1100-1 battery acid pit	Not reported	0.94-3.2	1.5-20			
	1100-2 paint & solvent pit	1.4-2.3	0.65-1.9	0.5-40			
	1100-3 antifreeze & degreaser pit	1.1-3.4	0.69-1.5	1-10			
	1100-4	Not reported	2.1-2.6	1.2-16.5			
	Rainwater pool	1.8-2.6	Not reported	Not applicable			
	1100-6 discolored soil	1.7-2.7	Not reported	Not applicable			
	Horn Rapids Landfill	0.62-3.6	0.37[e]-4.2[e]	0-27			
Chromium (Environmental Cr^{VI} persistence unlikely)	Background	7.9-2.0[e]	7.3-18.3	1.5-21	Cr^{VI}:Pica[d]Chld10; Chld300; Adlt4,000 Cr^{III}: Pica[d] Child 2,000; Child 50,000; Adult 700,000	RMEG	15-150 67±44 N=22
	Horn Rapids Landfill	0.51-17.1	4.0[e]-1250	0-27			
Lead	Background	6.2-8.1	4.3-6.5 4.5 2.1-2.8	0.5-2 8-10 11.5-21	No slope factor B-2 RAC	EPA NTP	ND[h]-30 12±9.5 N=22
	1100-1	Not reported	266 126-191 132 35.3 2-4	1.5-2 2.2-4.2 5.3-6.1 8.8-9.6 11-20			
	1100-2	3.3-84.4	1.3-94.6	0.5-40			
	1100-3	4.8-26.4	2.1-5.2	1-34			
	1100-4	Not reported	4.4-5.0	1.2-16.5			
	Rainwater pool	35[f]-54.2[f]	Not reported	Not applicable			
	1100-6	5.0-22.1	Not reported	Not applicable			
	Horn Rapids Landfill	0.38[e,g]-482[e]	0.12[e,g]-854[e,i]	0-27			
Trichloroethylene (TCE)	1100-1	Not reported	0.0075[e]-0.016[e]	2-4	60 B2-C 3	CREG(comp.val) EPA (class) IARC (class)	
	1100-2	0.006	Not reported	Not applicable			
	Horn Rapids Landfill	0.005[e]	0.005[g]	0-25			
Aldrin-R	1100-2	0.001[e]-3.7[e]	Not reported	0.0-0.5	0.04 (B2)	CREG (EPA)	

Hanford 1100-Area (USDOE)

Substance	Operable Subunit	Concentration Range[a] (ppm)			Cancer[b] Class and Comparison Values (ppm)	Source	Range[c] in Washington soil (ppm)
		Surface (0-0.5 ft.)	Subsurface	Subsurface Depth (ft.)			Range Arithm.Mean±Dev N
Di(2-ethylhexyl)phthalate (DEHP)	1100-6	4500[e]-25000[e]	Not reported	Not applicable	50 B2	CREG EPA	
Total PCBs[j]	1100-1	Not reported	0.299[e]	1.5-2	0.09 B2 RAC Adult 4 Child 0.3 Pica[d] 0.01	CREG EPA NTP RMEG	
	1100-3	0.15[e]	Not reported	Not applicable			
	1100-4	Not reported	0.33[g]-0.34[g]	1.2-16.5			
	Rainwater pool	0.3[e]-42[i]	Not reported	Not applicable			
	Horn Rapids Landfill	0.1[g]-3.2[e]	95 0.09[g]-49.6[i]	0-2 5.4-25.1			
Tetramethyloxirane (tentatively identified, based on retention time)	1100-3	Not reported	220[e]-280[e]	10-22 (4 samples in borehole DP8)	RAC (for oxirane or ethylene oxide) 2A	NTP IARC	

a Data from reference 3 unless otherwise stated.

b EPA cancer classes: A, human carcinogen; B2, probable human carcinogen with inadequate human studies; C, possible human carcinogen. NTP cancer classes: KC, known carcinogen; RAC, reasonably assumed a carcinogen. IARC: 2A, reasonably assumed a carcinogen with limited human studies.

c Expected levels of elements in soil from reference 20.

d A child who exhibits pica behavior -- ingests non-nutritive substances such as soil.

e Estimated.

f Spiked sample not within control limits.

g The limit of detection.

h ND = not detected.

i Data from reference (4).

j eg Aroclor-1248, -1254, -1260; 2,4',6-trichloro-1,1'-biphenyl; 2,3, 3',6'-tetra..., 2,2',3,5'-tetra...; 2,2',3, 4-tetra...; 2,2', 4,5'-tetra...; 2,3',4', 5-tetra...; 2,2',6,6'-tetra...; 2,2', 3,5,5'-penta...; 2,3,3',4',6-penta...; 2,2',3,4',5'-penta...; 2,2',3,3',6'-penta...; 2,3',4, 4',5-penta...; 2,3',4,5,5'-penta...

increase sharply as the surface is approached. The proximity to the surface of high levels of lead in the backfill is evidence that the site may have been contaminated with more lead after it had been backfilled. For this reason, absence of surface sampling at the battery acid pit could be a significant data gap. DOE suggests that the concentration gradient is evidence that the lead is unlikely to be a groundwater contaminant in the near future (3).

Scattered about the Horn Rapids Landfill were depressions in which lead was found in surface or subsurface sampling. Most (>80%) had lead at levels below 30 ppm. In the sparsely sampled northeastern corner of the landfill, there were two adjacent surface hits, one at 102 ppm and one estimated at 482 ppm. A boring from this region contained lead estimated at 854 ppm 4 feet below the surface. According to the record of decision, soil in this portion of the landfill is not slated for removal but will be covered by a cap of 24 inches of soil (9).

Polychlorinated biphenyls (PCBs) were reported at concentrations sufficient to justify further evaluation at the rainwater pool and in 8 of 10 samples taken 0-1.5 feet below the surface in the south-central Horn Rapids Landfill (4). Based on comparison of the retention time to that of standards, DOE identified the mixture of PCBs as Aroclor 1248 (3,4). However, identification of the specific chemicals classed as PCBs is not always straightforward (see references cited in the section on Toxicological Implications). PCB-contaminated soil at both the landfill and the rainwater pool will be removed to off-site disposal facilities before the landfill is capped with soil (9).

Friable asbestos was reported, but not quantitated, at the landfill. During remediation, a layer of 24 inches of soil will be applied to the landfill to prevent dispersal of asbestos fibers as fugitive dust (9).

There was no analysis of the soil samples for nitrate, a contaminant in groundwater.

Although the 1100-Area is currently under DOE's controlled access and will remain so until the year 2018, future use is under debate (6). Some of the public advocates unrestricted use for the 1100-Area (6). DOE representatives prefer that the 1100-Area remain zoned industrial in the future but did not formally commit to restrict future land use (see Appendix A) (p 7-40 in ref. 4, 7). Multiple comparison values were chosen to reflect potential exposure levels that could occur depending on whether the area is developed for residential use or remains industrial.

Surface Water and Sediment

No permanent surface waters or seasonal streams are within EM-1, EM-2, or EM-3, although there may be some seasonal streams in IU-1.

Groundwater - Monitoring Wells

Groundwater information is available for the on-site operable units EM-1, EM-2, and EM-3, but not for IU-1 (4,8). Information for operable unit IU-1 was addressed as a LFI/FFS in an addendum to the Remedial Investigation and Feasibility Study of the EM-1 Operable Unit in the third quarter of FY 1993 (8). The addendum and the record of decision, signed in September 1993, gave no groundwater data for IU-1 (8,9). The potential for the public to come in contact with contaminants that might be in groundwater under the operable units of the 1100-Area will be addressed in the Pathways section of this document. For the present, it is sufficient to point out that groundwater under Operable Unit IU-1 or under the Horn Rapids Landfill of Operable Unit EM-1 is not moving towards sources of potable water used by the public.

The local unconfined (lower) and confined (upper) aquifers within and near EM-1 were sampled from 16 wells and analyzed during the Phase I Remedial Investigation. During the Phase II Remedial Investigation (1991-2), seven more wells were drilled and sampled (4).

Figure 5 shows the locations of the monitoring wells. Comparing Figure 5 with Figure 2 shows that wells number 1 and 3 are within Operable Unit EM-2, and Well Number 17 is within Operable Unit EM-3. Thus, there are data for all groundwater moving toward Richland.

Data from the Final Remedial Investigation/Feasibility Study summarized six sampling rounds from March 1991 through March 1992. The samples were analyzed for Washington State primary and relevant secondary drinking water standards, RCRA groundwater monitoring parameters, general chemistry parameters, Contract Laboratory Program organic and inorganic parameters, coliform bacteria, and radiochemical parameters (4).

Results of the sampling and analyses are shown in Table 3. Soluble arsenic (with similar concentrations in filtered and unfiltered samples) was detected throughout the lower, unconfined aquifer, especially near 1100-2 and 1100-3. Arsenic is not a product or byproduct of current or past activities on the Hanford Nuclear Reservation. The EPA suggests that its presence in the groundwater is likely due to leaching from the basaltic soil because the soil contains too little iron to bind the arsenic (21). Arsenic is listed in this table although ATSDR does not assume it to be a contaminant generated by DOE. It was found at levels sufficiently high in groundwater to justify further evaluation in this assessment.

Lead was present, although not above its MCL, near 1100-2, 1100-3, and the Horn Rapids Landfill. Trichloroethylene and nitrate were at the boundary of Horn Rapids Landfill. Neither substance was detected above comparison value in groundwater moving toward sources of potable water used by the public. Antimony and manganese were widely distributed but not in concentrations sufficient to justify further evaluation in this health assessment.

Chromium, primarily insoluble, was at a sufficient concentration in samples (Monitoring Wells Numbered 20 and 21) from the plume from Siemens (Advanced Nuclear Fuels) and the Horn Rapids Landfill to justify further evaluation in this assessment (4). At another location, well upgradient of the plume under the landfill, a sample taken in the summer of 1992 from

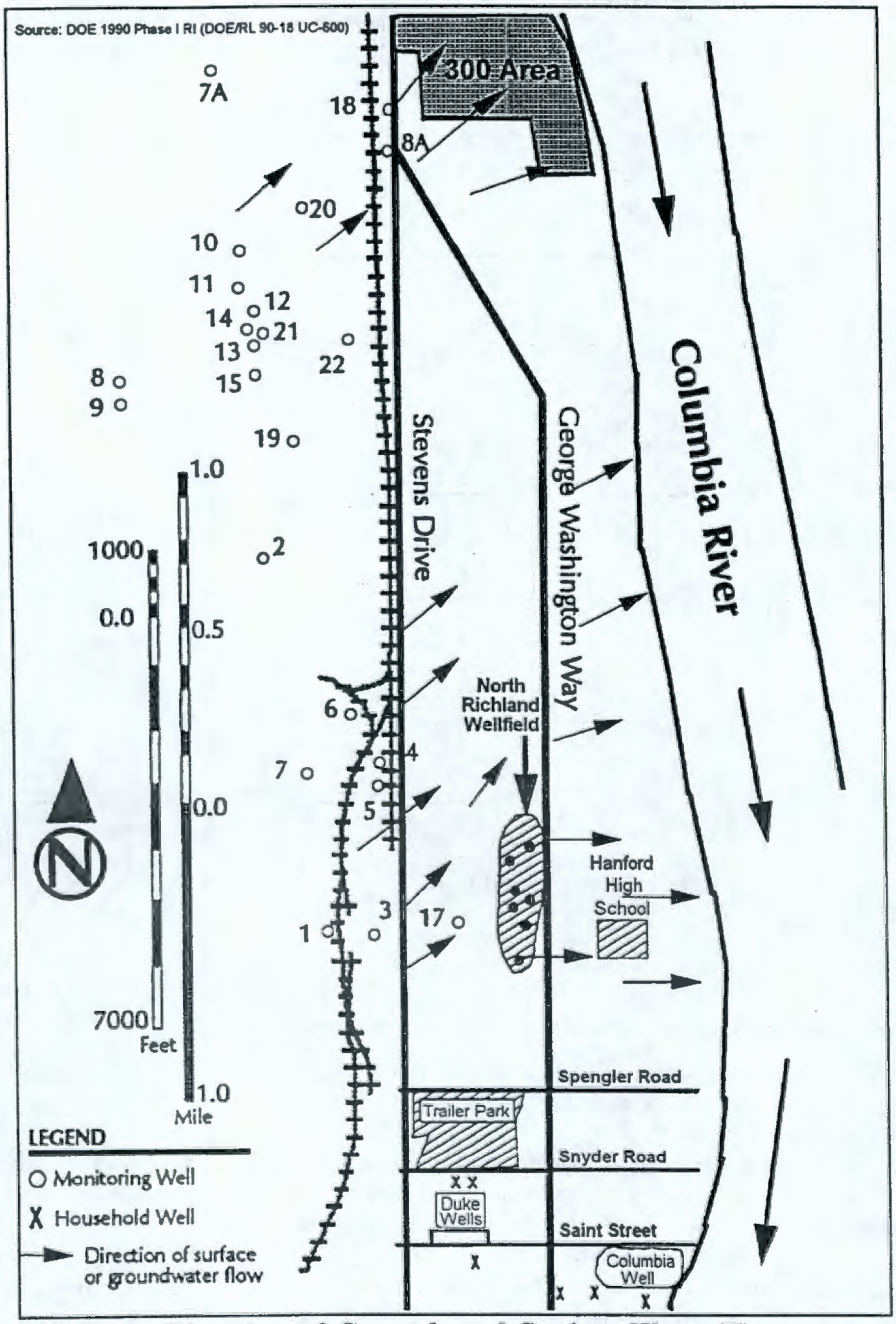

Figure 5. Direction of Ground- and Surface Water Flow.

Monitoring Well Number 3 (near 1100-1 and 1100-4) contained 2,810 ppb chromium (22). The level of chromium downgradient of this well, in Well Number 17 (under EM-3) did not indicate migration of chromium contamination toward municipal water at levels substantially above comparison values. The chromium oxidation state was not reported for either location, although the high proportion of insoluble chromium and the neutral pH of the water suggests the metal is predominantly in the chromium-III rather than chromium-VI oxidation state. The public health significance of the chromium oxidation state will be discussed in the section on toxicological implications.

Table 3 Contaminant Concentration in On-site Groundwater Monitoring Wells

Contaminant	Well Nos.[a]	Concentration (ppb)[b]	Date	Cancer Class and Comparison Values (ppb)	Source
Trichloroethylene (TCE)	12,13,14,15	56-82	3/91-3/92	3.0 (B2[c], EPA)	CREG
Aldrin	All wells	0.05[d]-0.06[d]	3/91-3/92	0.002 (B2, EPA)	CREG
Di(2-ethylhexyl)phthalate (DEHP)	All wells	10[d]-40[d]	3/91-3/92	3 (B2, EPA) (RAC, NTP)	CREG
Total PCBs[e]	All wells	4.5[d]	3/91-3/92	0.005 (B2, EPA) (RAC, NTP)	CREG
Arsenic	All but #21 1-4,8A,10,13,15,17 19,20,22,S29E12 5-8, 12, 18 6	1.3[f,g]-15[f,g] ≤3.2-5.0 ≤3.2-4.8 5.6-7.9 ≤15	3/91-11/91 3,6,8,9,11/91 6,9,11/91 6&9/91 11/91	0.02 (A, EPA)	CREG
Chromium[h,i]	3 17 20 21	2810[j] 57.5 53.3 55.7	6/92 6/91 11/91 11/91	Cr^{VI},Child:50 Cr^{VI},Adult:200 Cr^{III},Child:10,000 Cr^{III},Adult:30,000	RMEG RMEG
Lead	4 6 8 10 18 20 S3015A	4 3.4 21 5.3 3.7 4.6 6.2	6/91 11/91 6/91 9/91 6/91 9/91 6/91	None (B2, EPA) 50	MCL
Nitrate	8A 10 11 12 13 14 15	18,000 47,000 49,000 52,000 46,000 50,700 36,000	6/91 8/91 3/92 9/91 6/91 3/92 9/91	10,000	MCL (to protect infants)
Sulfate	18	3,300,000[k]	3/91	400,000	PMCL

a Wells 9 and 21 tapped the upper, confined aquifer; water level in well 17, said to tap the confined aquifer, fluctuated with the level of the unconfined aquifer; all others tapped the lower, unconfined aquifer.

b Data from reference 4 unless otherwise stated.

c EPA considers the weight of evidence for carcinogenicity of TCE is between C (possible human carcinogen) and B-2 (probable human carcinogen). TCE caused cancer in rodents, but evidence for human carcinogenicity is equivocal.

d The limit of detection.

e Aroclor-1016, -1221, -1232, -1242, -1248, -1254, -1260.

f Unfiltered samples are not consistently higher than filtered samples (much of substance is dissolved).

g Contract-required detection limit > reported value > instrument detection limit.

h Environmental Cr^{VI} persistence is unlikely.

i Unfiltered samples had levels several times those of filtered samples (much of substance is insoluble).

j From reference 22.

k Sample pH was 1.6.

Ethylene glycol was assayed in monitoring wells near 1100-3 and 1100-4, but the detected concentrations do not justify further evaluation in this public health assessment.

Groundwater contamination is mainly near the landfill. Except for chromium in Monitoring Well Number 3 (but not in Number 17) and naturally occurring arsenic, substances detected near Richland municipal wells are below or marginally above comparison values (Table 3).

Ambient Air

Air samples were collected April 11, 1990 upwind and downwind of suboperable units 1100-1, 1100-3, and the Horn Rapids landfill. Tetrachloroethylene, 1,1,1-trichloroethane, carbon tetrachloride, trichloroethylene, toluene, and octane were found downwind at concentrations the same as or lower than those upwind (3). Total polycyclic aromatic hydrocarbons (PAHs) were found at 6 micrograms per cubic meter ($\mu g/m^3$) downwind of 1100-3, twice the concentration of those found upwind (3). The Occupational Safety and Health Administration (OSHA) permissible exposure limit for coal tar pitch volatiles, including PAHs, is 200 $\mu g/m^3$ (23). ATSDR derived a comparison value of 5 $\mu g/m^3$ for general public exposure by adjusting OSHA's permissible exposure limit for the greater duration and frequency of nonoccupational exposure and applying an uncertainty factor of 10 to allow for possible increased sensitivity of the general public relative to healthy workers. Because total airborne PAHs near 1100-3 exceeded this comparison value, they will be further evaluated in this assessment.

B. Off-Site Contamination

Few environmental data are available for off-site contamination related to the 1100-Area.

Soil

No data were available on contaminants that may be in surface or subsurface soil off site.

Surface Water and Sediment

The potential for contaminants from the 1100-Area to reach the Columbia River will be discussed in the Pathways section of this document.

Groundwater - Municipal and Private Wells

ATSDR scientists reviewed Richland city well data for contaminants from the 1100-Area. Analyses of composite samples taken in 1987 and 1988 from the North Richland Wellfield were available prior to the remedial investigation (18). The results of analyses of samples taken from the North Richland and Duke wellfields from 1991 through 1994 were made available to ATSDR in 1994 (24,25).

Although the presence of "nitrates, sodium, and sulfate . . . in Richland's well water" was a cause for placement of the 1100-Area on the NPL (2), the concentrations of these substances in the North Richland and Duke wellfields were insufficient to justify further evaluation in this public health assessment (18,24,25). Nitrate was detected in Duke Wellfield, 1 mile south southeast of the 1100-Area boundary, at 8,000 ppb, and in the North Richland Wellfield at 200 ppb (24,25). Both concentrations are below the comparison value of 10,000 ppb, selected by ATSDR to protect infants. The North Richland and Duke wellfield supply 15% and 3-7%, respectively, of Richland's water. Nitrate is below the 200 ppb limit of detection in the Columbia River, which supplies 70% of Richland's water (25).

Sulfate was not detected in either wellfield, and sodium was 23 and 5 ppm in the North Richland and Duke wellfields, respectively (24,25). The 1100-Area groundwater contaminants, trichloroethylene, lead, arsenic, and chromium, were reported less than 0.5 and 2, 10, and 10 ppb, respectively, in both wellfields (24,25).

Twelve private wells used for domestic consumption are south of the 1100-Area and within 3,000 feet of the wells in the Duke Wellfield (15). The six northernmost wells are shown in Figure 5. Other private wells tapped for household use were located in two regions within the city of Richland. Both of them are at least 8 miles south of the 1100-Area and across the Yakima River (12,16). Groundwater flow under the 1100-Area is eastward and northeastward toward the Columbia River, not south to the Yakima River. ATSDR investigators believe these southern private wells unlikely to be contaminated by substances in 1100-Area groundwater.

Ambient Air

No data were available on levels of any contaminants in the ambient air off site. In the absence of data, ATSDR performed worst-case modeling. Agency scientists estimated the maximal off-site concentration of PAHs to be less than 0.4 $\mu g/m^3$. As described in the section on ambient air contaminants on site, ATSDR derived a comparison value of 5 $\mu g/m^3$ for general public exposure to PAHs.

The downwind station that detected 6 $\mu g/m^3$ PAHs on site was 250 feet from the presumed source of air contamination, 1100-3 (3). As the volume of an airborne contamination plume expands, the concentration of contaminants will be reduced proportionately. For example, if the PAH plume's width, height, and length all doubled, the concentration would be reduced to 1/2 X 1/2 X 1/2 X 6 $\mu g/m^3$, or 0.8 $\mu g/m^3$. The nearest access to the public downwind and off site is about 4,000 feet farther away from the downwind station (immediately outside the EM-3 Operable Unit's eastern border) (3). If the plume lengthened by 4,000 feet but did not increase in width or height the PAH concentration at that point could maximally reach 250/(4,000+250) X 6 $\mu g/m^3$, or 0.4 $\mu g/m^3$. Because the lengthening plume would probably also expand in width and height, the PAH concentration 4,000 feet from the downwind station would probably be lower than 0.4 $\mu g/m^3$.

Using the derived comparison value, ATSDR investigators do not consider the level of contamination of off-site ambient air likely to be sufficient to justify further evaluation.

Toxic Chemical Release Inventory

Under Section 313 of the Emergency Planning and Community Right-to-Know Act (SARA, Title III), manufacturers are required to report to the EPA annually if they have released into the environment (routinely or accidentally) any of more than 300 toxic chemicals. Section 313 authorizes EPA to maintain the data in a computerized database known as the Toxic Chemical Release Inventory. Manufacturing facilities (as defined in the Standard Industrial Classification codes 20-39) that have 10 or more full-time employees *and* that manufacture or use a Title III-listed chemical in an amount greater than its specified threshold for manufacture, import, processing, or other use during any calendar year are required to estimate their annual releases of such toxic chemicals into the air, water, and land. The database is available to federal and state government officials as well as to the public.

ATSDR investigators searched the Toxic Chemical Release Inventory database for toxic chemical releases to the soil, water, and air from facilities in Benton County, Washington, including the Hanford Nuclear Reservation, for the reporting years 1987 through 1990. The Hanford Nuclear Reservation was listed as a single entity, but ATSDR used information from DOE to distinguish among the releases from four NPL sites (26). In particular, releases from the 1100-Area could be identified. Table C-1 through Table C-4 summarize reported releases greater than one pound. Table C-1 lists releases to soil from DOE and industries of Benton County. None of the releases to land reported by DOE originated from the 1100-Area. From 1987-1990, the DOE released from Hanford's other NPL sites an assortment of chemicals, including a total of approximately 2,300 tons of sulfuric acid, sodium hydroxide, and their salt (sodium sulfate) to the soil. Approximately 2.3 tons of nitric acid was reported during this period. Sodium hydroxide was also released by other industries in Benton County. Other releases to soil included fertilizer components, such as ammonia and ammonium nitrate.

Smaller releases of sodium hydroxide and sodium sulfate from the Hanford Nuclear Reservation into surface water were reported during this period, but none from the 1100-Area (Table C-2). The largest chemical release to surface water from private industry in Benton County was 8 tons of sodium hydroxide during 1987.

In 1987, the 1100-Area was the source of 1 pound of acetone, 7 pounds of methyl ethyl ketone, 2 pounds of sulfuric acid, and 13 pounds of 1,1,1-trichloroethane released into the air (see the shaded rows in Table C-3). Of the air releases reported for the remainder of Hanford, the largest, more than 8 tons of carbon tetrachloride from the 200-Area, took place over the course of 1987. Hanford Nuclear Reservation also was the source of about 5 tons of other volatile organic solvents, including acetone, methyl ethyl ketone, tetrachloroethylene, Freon-113, and 1,1,1-trichloroethane, during 1987. Nine to 10 tons of ammonia were released during 1987 and 1989, and a ton and a half of chlorine was released during 1987. The largest recent release was about 23.5 tons of nitric acid during 1990.

The Hanford Nuclear Reservation was not the largest source of chlorine and ammonia released to the air in Benton County -- during the reporting period, other sources released 15 tons of chlorine and more than 2,500 tons of ammonia. But all other Benton County industries reported less nitric acid and volatile organic compounds than the Hanford Nuclear Reservation released into the air during 1987 through 1990 (see Table C-4).

The Toxic Chemical Release Inventory may not be the best way to accurately represent contributors to contamination of the Hanford region. Limitations of the Toxic Chemical Release Inventory database include unreported or unknown releases or spills, contamination prior to 1987, sources not required by law to report releases, and inaccurate estimations.

C. Quality Assurance and Quality Control

Quality assurance procedures for soil sampling and analysis were outlined by Westinghouse Hanford Company in the DOE Work Plan for the Phase I Remedial Investigation (18). ATSDR investigators were unable to find data quality reports for soil analysis data. The Westinghouse Hanford Company Office of Sample Management provided validated results for groundwater sampling round 5 (March 1991) and partially validated results for round 6 (June 1991). The remaining groundwater analytical data were validated by the U.S. Army Corps of Engineers using current EPA Contract Laboratory Program guidelines (4,27).

Because soil sampling at EM-1 was nonrandom, but chosen from locations DOE believed most likely to be contaminated by vehicle maintenance or waste disposal activity, ATSDR cannot assume the data in Table 2 are representative of overall on-site contamination. Given the basis of sample selection, the sampled areas probably represent higher than typical soil contamination -- i.e., they may be hot spots.

As discussed in the references for the Toxicological Implications section of this document, technical details in the standard methods used for PCBs may result in some uncertainty regarding their identification. The soil concentrations and the limits of detection for PCBs listed in Table 2 are for the total of all PCB species and mixtures determined in a sample. For example, if the limit of detection for Aroclor-1248, Aroclor-1254, and Aroclor-1260 was 0.09 ppm for each of the commercial mixtures reported in a sample, than the total concentration of these PCBs which could have escaped detection in the sample would have been 0.27 ppm.

As in the case of soil, groundwater concentrations and limits of detection were listed in Table 3 for *total* PCBs. Because the limit of detection for each of the commercial mixtures was above ATSDR's CREG, the total that could have escaped detection is almost 1,000 times the CREG. The detection limits for aldrin and DEHP were also above comparison values in groundwater.

Sulfate at 3,300,000 ppb appeared once at pH 1.6 in Well Number 18. This concentration of sulfate was at least 50 times higher than the concentration in any other sample. The combination of a high concentration of sulfate with a low pH is essentially sulfuric acid, used by DOE to pretreat sample bottles when a preservative was needed. Such a low pH, if representative of local groundwater, would have leached alkaline earth metals (magnesium, calcium, and the like) from the soil. The result was found in only one round out of six in this well, and not in any of the six rounds in nearby Well 8A. The presence of normally low levels of alkaline earth metals in the 1 high sulfate sample out of 12 from 2 adjacent wells strongly suggests that the high sulfate concentration resulted from sample contamination, probably due to inadvertent use of a preservative-treated bottle (22).

With those exceptions, ATSDR relied on information provided by DOE and its contractor, Westinghouse Hanford Company, and assumed that adequate quality assurance and quality control measures were followed with regard to chain of custody, laboratory procedures, and data reporting. The validity of the analysis and conclusions drawn in this public health assessment depend on the completeness and reliability of the referenced information.

D. Physical and Other Hazards

No physical hazards were observed within the 1100-Area other than those associated with normal operations of a maintenance area. Sites of potential contamination were well delineated and posted. Areas of potential soil contamination were marked with chains.

ATSDR investigators have not found contaminants in 1100-Area soil that could present an explosion hazard to DOE visitors or employees in the present or to the public in the event of future commercial or residential development. At EM-3, gasoline tanks were removed and the soil was remediated in 1991. The Horn Rapids Landfill was used for construction and industrial wastes, not household wastes; no methanogenic substances were buried in this landfill. In addition, ATSDR scientists observed that wastes are buried by coarse soil of a texture between sand and gravel and containing little or no organic matter. This soil is unlikely to trap lighter-than-air substances such as methane. The landfill was extensively monitored for soil gases to delimit the groundwater plume migrating beneath. The process used an organic vapor monitor. The only positive readings were near paint cans. No explosive levels of any substance were found. No methane gas was found (4).

The 1100-Area is currently patrolled by the DOE-contracted security force, and access is well controlled. While portions of the 1100-Area are not completely restricted, the sites of concern are not located in areas where casual trespassing would be a likely problem.

PATHWAYS ANALYSES

To determine whether humans are exposed to contaminants migrating from a site, ATSDR staff members evaluate the environmental and human components that lead to human exposure. This evaluation or pathways analysis consists of five elements: source of contamination; environmental medium in which contaminants may be present or into which they may migrate; point of human exposure such as a private well; route of human exposure such as ingestion, inhalation or dermal contact; and receptor population (people who are exposed or potentially exposed).

ATSDR identifies exposure pathways as completed or potential. For a completed pathway to exist, all of the five elements must be present to provide evidence that exposure to a contaminant has occurred in the past, is occurring, or will occur in the foreseeable future. A potential pathway indicates that at least one of the five elements is missing but could exist.

Potential pathways indicate that exposure to a contaminant could have occurred, could be occurring, or could occur in the future. Pathways are eliminated when at least one of the five elements is missing and will never be present.

Past, present, and future exposure pathways that may present public health hazards are discussed in this section.

A. Completed Exposure Pathways

There was no identification of completed exposure pathways at the 1100-Area by which contaminants in soil or groundwater could reach the public.

Soil Pathways

Because security measures restrict public access to EM-1, including the suboperable units 1100-1 through 1100-4, 1100-6, the Horn Rapids Landfill, EM-2, and EM-3, the public has not previously had and does not currently have opportunity for contact with soil contamination on site. Similarly, the public does not have access to Operable Unit IU-1. This restricted access will continue as long as the property remains under DOE control. The time frame for remediation and release of DOE's Hanford property extends to the year 2018 (6). Although DOE stated "The 1100-Area . . . is to remain zoned industrial in the future," there is no formal commitment to restrict land use beyond the year 2018 (see Appendix A) (p 7-40 in ref. 4, 7). There are some among the public that prefer unrestricted use after that time (6).

ATSDR found no evidence of completed pathways for worker exposure in the 1100-Area. Because the mission of the 1100-Area is support and vehicle maintenance activities, there is little need for DOE employees and contractors working in the 1100-Area to engage in frequent contact with contaminated soil in the course of their duties. During remediation, ATSDR assumes that proper OSHA procedures will be used.

Groundwater Pathways

The flow of ground- and surface water from contaminated parts of the 1100-Area equipment maintenance units is illustrated in Figure 5.

There is no completed pathway by which the public could have come in contact with nitrate- and TCE-contaminated groundwater migrating under the Horn Rapids Landfill in the past or by which the public could come in contact with such water now. There are no known private or municipal wells that are or have been used to supply drinking water (3,4). As for the near future, there are no plans for municipal or private drinking water wells that might intercept the plume of contamination to the east and northeast of the landfill as the plume extends to the Columbia River in the region of the 300-Area. The 300-Area, another NPL site of the Hanford Nuclear Reservation, does not draw drinking water from on-site wells. Drinking water for the 300-Area comes from the Columbia River (11,28). The 1100-Area itself is supplied potable and fire-control water by the city of Richland (5,12). Richland's municipal wells are 2 miles south-southeast of the landfill, out of the migration path of this plume (3,4).

No completed pathway exposes the public using Richland's municipal water system to any contaminants in the southern portion of the EM-1 Operable Unit, including 1100-1 through 1100-6; the EM-2 Operable Unit; and the EM-3 Operable Unit. The Duke and Columbia wells are on Saint Street, a Richland street that passes a half mile south of the 1100-Area and extends due east to the Columbia River (see Figure 5). Contaminants in the 1100-Area were not found at concentrations of concern in water from the Duke Wellfield. This may be because the wells are too far south to be in the migration paths of contaminants under EM-1, EM-2 or EM-3. The North Richland Wellfield is due east of these sources of contamination and could be in the migration paths. However, water from the Columbia River is pumped into the wellfield faster than the city of Richland pumps water out for municipal use (25). These relative rates of pumping probably explain why the nitrate concentration in the water from these wells resembles that in the Columbia River more than that in the groundwater from the Duke wells (25). Moreover, 70% of Richland's gravity feed water distribution system is supplied directly from the Columbia River, further diluting groundwater drawn from the wells before it reaches the public (12).

No completed pathway exposes Richland's residents using water from private wells for domestic purposes to contaminants in the southern portion of the EM-1 Operable Unit, including 1100-1 through 1100-6; the EM-2 Operable Unit, and the EM-3 Operable Unit. Twelve private wells are within an area with its north side 4,000 feet south of 1100-1 (15). Six of these are shown in Figure 5 near the Duke and Columbia wells. The absence of 1100-Area contaminants in Duke wells may be because the wells are too far south to be in the pathway of contaminated groundwater movement. The same logic applies to the six private wells shown in Figure 5. The other six wells are still farther south, out of range of the map.

Other private wells tapped for household use were located in two regions within the city of Richland. Both of them are at least 8 miles due south of the 1100-Area's operable units and across the Yakima River (12,16). The flow of groundwater under the 1100-Area is eastward toward the Columbia River, not southward to this part of the Yakima River. ATSDR does not consider that these wells could form part of a completed pathway by which the public is likely to be exposed to 1100-Area contaminants.

Under federal ownership, the land on the Hanford Nuclear Reservation is not used for residential or agricultural purposes, and domestic wells are not tapping groundwater in the vicinity of Operable Unit IU-1. This situation is unlikely to change before the year 2018. Because the movement of water underground (groundwater flow) tends to be downhill, people living or farming on the other side of the Rattlesnake Hills are unlikely to draw groundwater that might be contaminated by IU-1 soil. The downhill slope on the IU-1 side of the hills extends approximately in the direction of the 400-Area (shown in Figure 1). Groundwater flow from under IU-1 is unlikely to pass close to sources of potable water used by Richland. Thus, although environmental data were not available for Operable Unit IU-1, pathway considerations make exposure of the public to any IU-1 groundwater contaminants unlikely as long as control remains under DOE. DOE has not committed to formal restrictions in its transfer of property after the year 2018 (p 7-40 in ref. 4, 7).

B. Potential Exposure Pathways

Soil Pathway

The selected remediation alternative will treat three types of contaminated soil. Soil contaminated with PCBs (at the Rainwater Pool and the south central part of the Horn Rapids Landfill) will be disposed of off site (9). Discolored soil at 1100-6 will be incinerated off site (9). The surface of the Horn Rapids Landfill, including the part contaminated with lead, will be covered with 24 inches of soil to prevent friable asbestos from becoming airborne (9). The cleanup standards in the record of decision are chosen assuming industrial use at the Horn Rapids Landfill and possible residential use at the Discolored Soil Site (1100-6), the Rainwater Pool, and other operable and suboperable units that are not selected for remediation (9). A DOE representative believes that in the future, the 1100-Area is likely to be used for offices, research facilities, or industry (7). Some people in the community want the 1100-Area to become available for unrestricted use in the year 2018 (6). DOE is currently not considering deed and excavation restrictions to prevent residential development (p 7-40 in ref. 4).

Disturbance of soil during development after 2018 could blur the distinction between surface and subsurface contaminants. Excavation could cause all soil to have the potential of becoming surface soil. For example, as building foundations are laid in the years beyond 2018, clumps of soil containing lead at 266 ppm (now 1.5-2.0 feet below the surface at 1100-1) or 854 ppm (now 4 feet below the surface in the northeastern corner of the Horn Rapids Landfill), could be gouged out and used to level surfaces for parking areas, roads, parks, and possibly houses (3,4). Those exposed by ingestion, inhalation, or dermal contact with the soil after the year 2018 could include unknown numbers of construction workers, office park employees, and possibly residents working and living in the area during and after development of the 1100-Area. Thus, after 2018, workers may be exposed by ingestion, inhalation, and dermal contact as they excavate and construct office buildings and landscape parks and yards. After 2018, potential office and laboratory personnel could be exposed by inhalation and ingestion to windborne soil when commuting or eating outdoors. In the decades to come, in the absence of land use restrictions, resident families could be exposed as they garden or play in backyard soil. The first row of Table 4 summarizes the potential for this type of pathway.

Groundwater Pathways

ATSDR considered two pathways by which contaminated groundwater might potentially reach water taken in by the public through ingestion, inhalation, and dermal contact (see Figure 5).

Table 4 Potential Exposure Pathways Considered by ATSDR

PATHWAY NAME	EXPOSURE PATHWAY ELEMENTS					TIME
	SOURCES	ENVIRON-MENTAL MEDIA	POINTS OF EXPOSURE	ROUTES OF EXPOSURE	ESTIMATED EXPOSED POPULATION	
Surface Soil	Equipment Maintenance (EM) and Isolated (IU) Operable Units	Soil	Development for Urban, Commercial, Possible Residential Use	Ingestion, Inhalation, Dermal Contact	Unknown Number of Construction & Office Workers, Possible Residents Unless Development Restricted	After 2018 (During & after Development)
Groundwater Southeast	EM Operable Units, not including Horn Rapids Landfill	Groundwater	North Richland Wellfield	Ingestion Inhalation, Dermal Contact	32,000 in Richland	Unlikely Because Richland Dilutes Groundwater with River Water
Groundwater Northeast	Groundwater under Horn Rapids Landfill	Groundwater to Columbia River	Richland, Pasco, & Kennewick Water Supplies	Ingestion Inhalation, Dermal Contact	95,000 Tri-Cities Residents & Workers	Unlikely Because of Columbia River Flow Rate & Volume
Air	Paint & Solvent Pit	Air	Development for Possible Residential Use	Inhalation	Unknown Numbers of Possible Residents	After 2018 (If Unrestricted Development)

Groundwater Southeast

First, ATSDR scientists considered whether groundwater contaminants from the EM-1 suboperable units in the southern half of the 1100-Area and from the operable units EM-2 and EM-3 could migrate eastward to the North Richland Wellfield and expose Richland residents (Groundwater southeast in Table 4). Exposure to hazardous concentrations of contaminants by this pathway is unlikely because contaminants in groundwater migrating toward this wellfield are diluted by the river twice. The first dilution occurs when water from the Columbia River is pumped into the wellfield, and a second dilution occurs when 15 volumes of water from the wellfield are mixed in Richland's distribution system with 70 volumes of water from the river and an additional 15 volumes from other sources. ATSDR scientists considered whether this pathway could become a health threat in the future if the operators of Richland's water system should cease to pump water into the North Richland Wellfield from the Columbia River faster than the system would draw water from the wellfield for municipal use, thus inadequately diluting groundwater with river water. This could happen if municipal demand increases due, for example, to a population increase or to increased demand from parts of Hanford released by DOE.

The nitrate concentration in the wellfield could serve as a warning indicator in such a case. The present concentration of nitrate in water from the North Richland Wellfield more closely resembles the nitrate concentration in the Columbia River than that of wells further south that draw groundwater (and that are below the comparison value selected by ATSDR to protect infants). A rising nitrate concentration in the North Richland Wellfield would indicate that a falling proportion of Columbia River water in the wellfield might be insufficient by itself to dilute contaminants that might be in groundwater.

ATSDR investigators then considered groundwater chromium, found in Well Number 3, could potentially reach the public by this pathway. The chromium plume has been diluted almost fiftyfold as it spread from Well Number 3 to Well Number 17 (see Table 3 and Figure 5). As discussed above, the chromium would be further diluted by river water pumped into the North Richland Wellfield and by water from the river and other sources mixed with wellfield water in the city distribution system. Moreover, as will be explained in the Toxicological Implications section, environmental chromium is unlikely to persist in a hazardous form.

Groundwater Northeast

ATSDR scientists consider it highly unlikely that the second pathway (Groundwater Northeast in Table 4) will present a hazard. By this pathway, groundwater contaminants migrating under the Horn Rapids Landfill would reach the Columbia River and thence the city water supplies for Richland, Pasco, and Kennewick. The flow of the Columbia River averages 120,000 cubic feet per second (17). Should groundwater contaminants under the Horn Rapids Landfill reach the Columbia River, they would be quickly diluted by the river's rapid flow. The contaminants (from under the Horn Rapids Landfill) are unlikely to be detectable more than a few yards from their point of entry into the river. They are unlikely to threaten the river's current Class A (excellent) status.

Air Pathway

If after the year 2018, land near the paint and solvent pit (Suboperable Unit 1100-3 of EM-1, which is not selected for remediation in the record of decision) is developed for residential use, persons who then build houses within 500 feet of that site could be exposed to concentrations of PAHs above the comparison value developed by ATSDR. Past, current, or future employees of the DOE or its contractors would have been or would be exposed below the OSHA permissible exposure levels for occupational exposure and so are not included in this pathway. This potential pathway could be completed only if, in the absence of restrictions on land transfers that could take place in the year 2018, the current equipment maintenance areas are developed for residential use.

PUBLIC HEALTH IMPLICATIONS

A tripartite approach is used to assess the public health implications associated with a site. First, ATSDR scientists address the toxicological implications in a discussion of health effects that *might* occur in people exposed to specific contaminants. Second, they evaluate state and local health databases for evidence that such health effects *have* occurred. And finally, the Agency addresses the community's *concerns* about site-related health issues. ATSDR staff members believe that all three approaches are important to the eventual development of acceptable solutions to site-specific public health problems.

A. Toxicological Implications

Introduction

A release of a hazardous waste does not always result in exposure. People are exposed to a nonradiological contaminant such as those identified in the 1100-Area only if they come in contact with it; exposure may occur by breathing, eating, or drinking a substance containing the contaminant or by skin contact with a substance containing the contaminant. Several factors determine the type and severity of health effects associated with exposure to a contaminant. Such factors include the exposure concentration (how much); the frequency and/or duration of exposure (how long); the route of exposure (breathing, eating, drinking, or skin contact); and the multiplicity of exposure (combination of contaminants). Moreover, people can be exposed to an environmental contaminant by more than one route of exposure. Once exposure takes place, characteristics such as age, sex, nutritional status, genetics, lifestyle, and health status of the exposed individual influence how the individual absorbs, distributes, metabolizes, and excretes the contaminant. Together, those factors and characteristics determine the health effects that may result from exposure to a contaminant.

ATSDR scientists consider the previously described physical and biologic characteristics when developing health guidelines. Toxicological profiles prepared by the Agency's scientists summarize chemical-specific toxicologic and adverse health effects information. Health guidelines, such as ATSDR's minimal risk level (MRL) and EPA's reference dose (RfD) and cancer slope factor (CSF) are included in the toxicological profiles. Those guidelines are used by ATSDR public health professionals to determine an individual's potential for developing adverse noncancer health effects and/or cancer from exposure to a hazardous substance.

Health guidelines provide a basis for comparing estimated exposures with concentrations of contaminants in environmental media (soil, air, water, and food) depending on who might be exposed and the length of the exposure. An MRL is defined as an estimate of the daily human exposure to a contaminant that is likely to be without an appreciable risk of adverse noncancer health effects over a specified duration of exposure (acute, <15 days; intermediate, 15-365 days; chronic >365 days). Oral MRLs are expressed in units of milligrams per kilogram per day (mg/kg/day). MRLs are not derived for dermal exposure. The method for deriving MRLs does not include information about cancer; therefore, an MRL does not imply anything about the presence, absence, or level of cancer risk. An EPA RfD is an estimate of the daily exposure of the human population, including sensitive subpopulations, that is unlikely to cause adverse noncancer health effects during a lifetime (70 years). Noncancer health guidelines are adjusted downward using uncertainty factors to make them adequately protective of the public health. Therefore, the health guidelines should not be viewed as a strict boundary between what level is toxic and what level is nontoxic. For cancer-causing substances, EPA has established the CSF as a health guideline. The CSF is used to estimate the number of excess cancers maximally expected from exposure to a contaminant.

To link a site's human exposure potential with health effects that may occur under site-specific conditions, ATSDR investigators estimate human exposure to site contaminants from ingestion and/or inhalation of different environmental media. The following relationship is used to determine the estimated exposure to the site contaminant:

$$ED = (C \times IR \times EF) / BW$$

ED = exposure dose (mg/kg/day)
C = contaminant concentration
IR = intake rate
EF = exposure factor
BW = body weight

ATSDR uses standard intake rates for ingestion of water and soil. The intake rate for drinking water is 2 liters per day (L/day) for adults and 1 L/day for children. For incidental ingestion of soil, the intake rate is 100 mg/day for adults, 200 mg/day for children, and 5,000 mg/day for children with pica behavior (repeated ingestion of non-nutritive substances). Standard body weights for adults and children are 70 kg and 10 kg, respectively. The maximum contaminant concentration detected in a specific medium at a site is used to determine the estimated exposure; use of the maximum concentration results in an evaluation that is most protective of human health. When unknown, the biological absorption from environmental media (soil, water, etc.) is assumed to be 100%.

People may be exposed to more than one contaminant from a site. Data on the health effects of exposure to multiple contaminants are very limited. Those effects can be additive, synergistic (greater than the sum of the single contaminant exposures), or antagonistic (less than the sum of the single contaminant exposures). Also, simultaneous exposure to contaminants that are known or probable human carcinogens could increase the risk of developing cancer. In most cases, there is insufficient information about the effect of mixtures of contaminants. ATSDR's evaluation of exposures in this public health assessment is limited to individual contaminant exposures; multiple exposures have not been evaluated.

Sometimes several potential pathways exist by which site contaminants in could reach the public. Multiple pathways may complicate the assessment of potential health effects because they could increase an individual's exposure to substances.

At the 1100-Area of Hanford, the limiting factor affecting exposures that could have toxicological implications is the existence of or the potential for a pathway by which people could come in contact with contaminants. For this reason, some pathway-specific information previously discussed in the Pathway Analyses section of this document will be repeated here in cases where such information could aid in the understanding of toxicological implications.

Past, Current, and Future Implications to the Year 2018

No adverse health effects are expected from past, current, or future exposures to 1100-Area air or soil contaminants through the year 2018. This is because no families live or have lived in this area since the beginning of activities that resulted in the present contamination. Thus, no resident family is or has been exposed to any air or soil contaminants. This situation is likely to continue until the federal government transfers the land in the year 2018. Given the nature of work performed by 1100-Area employees (vehicle maintenance and other support functions), it has been and continues to be unlikely for employees to have frequent and lengthy contact with soil. Workers are unlikely to be at risk from air contaminants because contaminants were not identified at concentrations above OSHA standards (23). Remediation workers could have greater exposure to soil contaminants. ATSDR assumes OSHA requirements for worker protection against contaminated media will be met during remediation.

Future Implications of an 1100-Area Redeveloped After the Year 2018

The future uses of the 1100-Area are currently under debate, and this area may be open to public uses beyond the year 2018 (6). Although DOE stated "The 1100-Area . . . is to remain zoned industrial in the future," there is no formal commitment to restrict future land use (see Appendix A) (p 7-40 ref. 7). There are some among the public that prefer unrestricted use (6). To be protective of public health, ATSDR has reviewed the toxicological implications that would exist if this area were developed for residential, commercial, and industrial use by the public.

Chemical-Specific Implications

Lead -- ATSDR does not have a comparison value for lead. Under current and past nonresidential land use, the concentration of lead in soil on site (as high as 482 ppm in the top 6 inches or 854 ppm 4 feet below the surface at the northeastern corner of the Horn Rapids Landfill and 266 ppm 2 feet below the surface at the battery acid pit) is not harmful to public health because the public did not and does not come in contact with the soil (3,4). As long as nonresidential use continues, no harm to public health can come from lead-related data shortcomings. Two examples of such data inadequacies are (1) estimated values for two high lead concentrations in the sparsely sampled northeastern Horn Rapids Landfill and (2) absence of surface sampling at the battery acid pit despite a sharp increase in soil lead concentration as the surface is approached. Additional sampling could determine whether the estimated soil concentrations (at the Horn Rapids Landfill and the Battery Acid Pit) reflect widespread lead contamination. Such widespread contamination by lead in the soil could be harmful for people if they moved into an 1100-Area developed for residential use after the year 2018 (29,30). The relationship between soil lead concentration and the concentration of lead in the blood of children living in an area depends on factors discussed in Appendix D. Under worst-case conditions, if families who may move into a newly developed 1100-Area have very young children whose average background blood lead concentration is 5 or 6 micrograms per deciliter (µg/dl) -- not considered to be lead-poisoned -- an increase of 6-7 µg/dl to 11-13 µg/dl could be sufficient to depress the children's hearing, growth rate, and average IQ (30). If they resided in such a community, middle-aged men might have a higher average blood pressure (29,30). Office or industrial employees, who would spend less time in the area and have little contact with the soil, would not be at risk. For additional information about the toxicological implications of lead-contaminated soil, see Appendix D.

Polychlorinated Biphenyls (PCBs) -- PCBs in the 1100-Area will not present a threat to the public when the 1100-Area is released in the future. In the record of decision, soil contaminated with PCBs in the Horn Rapids Landfill and the Rainwater Pool will be disposed of off site (9). PCBs are a class of many chemicals. Some of these chemicals are hazardous. The standard analyses used by DOE may not be adequate to determine whether the PCBs detected in the 1100-Area are the particular chemicals that could cause cancer or harm the immune system, adrenal glands, thyroid glands, central nervous system, skin, eyes, reproductive systems, developing fetuses, and livers of future residents (31,32,33). Removal of the contaminated soil will protect the public health regardless of the identity of the PCBs present.

Polycyclic Aromatic Hydrocarbons (PAHs) -- ATSDR does not have a comparison value for airborne PAHs because the toxicity of inhaled environmental PAHs has not been adequately characterized. OSHA has set a permissible exposure limit of 200 $\mu g/m^3$ to protect healthy adult workers exposed for 8-hour periods (23). These chemicals were identified at the paint and solvent pit once at 6 $\mu g/m^3$, which is below the OSHA standard, and therefore not at a concentration sufficient to threaten the health of 1100-Area employees or employees of future industrial and commercial concerns (3,23). Should the 1100-Area become available for residential development after the year 2018, future residents could include infants, children, the elderly, and the ill, some of whom could be at home more than 8 hours per day. ATSDR cannot determine from published toxicity data whether the airborne PAH concentrations would be sufficient to harm people who might build their homes within a few feet of this site after the year 2018. People currently living off site are unlikely to be exposed to sufficient concentrations of airborne PAHs to put them at risk of illness.

Di(2-ethylhexyl)phthalate (DEHP) -- DEHP does not pose a threat to the public health now and will not in the future. DEHP-contaminated soil will be incinerated off site, so future residents will not be exposed to DEHP in the soil (9). The public will not be at risk if remediation is delayed or incomplete. In the quantities of soil to which the public might conceivably be exposed orally, by inhalation, and transdermally, DEHP is not likely to cause harmful effects to anyone who might build or live in a home in the 1100-Area in the future. DEHP was found only at a surficially stained area of soil (1100-6). Its concentration at this suboperable unit was as high as 2.5%, which is much higher than its comparison value (3). It should be noted, however, that DEHP is a commonly used plasticizer that occurs at concentrations as high as 40% in frequently encountered clothing and household items (e.g., rainwear, footwear, upholstery, imitation leather, waterproof gloves, tablecloths, shower curtains, food packaging, floor tiles, and paint) (34). Small children could suck or chew on such objects. DEHP also is used to plasticize containers for transfusible blood (34), to which the public is exposed intravenously upon receiving transfusions. Aside from gastrointestinal distress from ingestion of 143 but not 71 mg DEHP/kg (which is more than a pica child might ingest daily for a week playing in the soil at 1100-6), DEHP has not caused adverse health effects in people (34).

Chromium (Cr) -- The 1250 ppm chromium 14-16 feet below the surface at the Horn Rapids Landfill (3,4) is not now a threat to the public health and is unlikely to become a threat even if the land does become residential. There are two reasons for this. First, unless the land is used for multistory apartment and office buildings with basement and subbasements, people could not come in contact with the contamination now or in the future. It is unlikely to be disturbed by human activities -- people probably would not dig 14-16 feet in a closed landfill. Second, environmental chromium occurs primarily in two chemical states: chromium-III (Cr-III) and chromium-VI (Cr-VI). The first, Cr-III (comparison values of 2,000 ppm or more), which is environmentally very stable, is nutritionally essential for health, and not harmful at soil concentrations double that maximally reported at the landfill. Even if all the chromium released by DOE to the soil were the second form (Cr-VI -- comparison values of 10-4,000 ppm -- is much more toxic, especially if inhaled), in deep, airless soil this form is readily reduced to Cr-III by sulfur (II) and iron (II) present in the soil; aerobic reduction (in the presence of oxygen) is possible only when organic substances are present (35-37). In the semidesert climate of eastern Washington, the organic content of nonirrigated soil tends to be low. This concentration of chromium in the soil below the site could be of concern after excavation only in the highly unlikely possibility that nearly all the chromium had persisted in the environment as Cr-VI for 20-50 years.

The 2,810 ppb chromium reported in the groundwater under operable unit EM-2 is not now a threat to public health and is unlikely to become a threat in the future. As discussed in the sections on off-site groundwater contamination and groundwater pathways, groundwater contaminants in the southern part of the 1100-Area are not migrating towards municipal and private wells drawing groundwater rather than river water; analyses of the Duke and Columbia wells have not shown these contaminants above comparison values.

Monitoring well data suggest that contamination in groundwater substantially decreases as it moves towards the North Richland Wellfield. The concentration of chromium diminished from 2,810 to 57.5 ppb in the 600 feet from wells number 3 to 17 (see Figure 5 and Table 3). At that rate, as the plume extends an additional 260 feet to the western edge of the North Richland Wellfield, its concentration would drop to about 40 ppb, below all chromium comparison values for drinking water. In this wellfield, its concentration would be further diluted by water pumped from the Columbia River. River and groundwater mixed in the wellfield are further diluted in the Richland distribution system. The final concentration of chromium in Richland tapwater is unlikely to become detectable.

Moreover, the 2,810 ppb chromium would probably be primarily in the more stable, less toxic Cr-III (comparison values of 10,000 ppm or more) oxidation state (see above), and therefore below its comparison value. Table 3 indicates that where data were given for both filtered and unfiltered samples, unfiltered samples had much more chromium -- i.e., the chromium was primarily insoluble. Insoluble chromium is more likely to be Cr-III than Cr-VI. Poorly soluble Cr-III tends to have low mobility in ordinary soil because it is adsorbed to clay. Hanford soil is not clay-like; it is multiple layers of sand and gravel. Suspended Cr-III can be carried along by the flow of groundwater. Although this does not definitively establish most of the chromium as Cr-III, the absence of current chromium contamination and the unlikelihood of future chromium contamination in supplies of potable water makes it unnecessary to have definitive information about the chromium oxidation state to protect public health.

Arsenic -- People are unlikely to be made ill by ingestion of arsenic, which is present in the 1100-Area in soil at concentrations up to 4.2 ppm and in groundwater at concentrations up to 15 ppb arsenic. Arsenic in both media is present above its comparison values (3,4). A potential future 1100-Area resident who drank groundwater for a lifetime could maximally average 30 μg arsenic per day, and a child with pica behavior could maximally ingest 21 μg arsenic per day from the soil. Oral arsenic intake as high as 420 μg/day does not cause noncancer effects in humans, and human cancer has only been observed in studies where prolonged arsenic intake exceeded 630 μg/day (38). For more information about the toxicity of arsenic, see Appendix D.

Aldrin -- Aldrin was tentatively identified at concentrations sufficient to generate a low increased cancer risk to potential future residents of the 1100-Area in 4 of 23 soil samples taken from the surface of the southern and southwestern parts of the paint and solvent pit (1100-2) (3). This suboperable unit was not selected for remediation (9). Concentrations ranging from 0.3 to 3.7 ppm (about 100 times its comparison value) would be unusually high levels of aldrin contamination if the tentative identification should be confirmed and could present a threat to the public health if the area should be developed for residential use after the year 2018 (39). Further information about the toxicity of aldrin is in Appendix D.

Trichloroethylene (TCE) -- TCE at levels reported in 1100-Area soil and groundwater is not a likely threat to the health of future residents. In soil samples from the 1100-Area, TCE was found at levels well below that of concern for public health (3). A TCE-contaminated plume is currently migrating northeast towards the Columbia River from the region of the Horn Rapids Landfill (3,4). This plume will be monitored to confirm that the concentration of TCE in the groundwater is attenuating (or decreasing) as DOE's modeling predicts (9). If attenuation is less rapid than predicted, and if the 1100-Area should be open to public use in the future, TCE in this plume could be of concern if people drilled wells into the TCE-contaminated plume but not if their water were taken from the river after the plume had reached the Columbia River. TCE is too volatile to persist in surface water long enough to present a health threat, especially given dilution by the high flow rate of the Columbia River (40). If wells are drilled in the future, data from animal studies (but not human studies) suggest the possibility that people drinking the water for their entire lifetimes might have a very low increased cancer incidence (31). Because TCE is volatile, showering and bathing in the well water for their lifetimes might also slightly increase their incidence of cancer (31). However, the city of Richland has proposed to supply water to a future redeveloped 1100-Area, making such lifetime exposures to water from future wells unlikely (5).

Nitrate -- Nitrate in 1100-Area groundwater is unlikely to cause adverse health effects. Nitrate is present at 8 ppm in municipal wells drawing groundwater. This is below the comparison value of 10 ppm selected by ATSDR to protect infants from methemoglobinemia. This ailment, the oxidation of the oxygen-carrying pigment of the blood, is the critical effect of nitrate ingestion by those most sensitive among the public -- babies weighing less than 4 kilograms (8 pounds, 13 ounces) (31). Methemoglobinemia has not been observed as a result of drinking water containing less than 10 ppm nitrate (31). Some 70% of the water in Richland's municipal distribution system derives from the Columbia River, which contains less than 0.2 ppm nitrate (the level of detection). The considerations that would protect the public (regardless of future land use) from exposure to as much as 52 ppm nitrate in the groundwater under the Horn Rapids Landfill have been discussed in the Pathway section of this document. Briefly, the groundwater moving under the landfill is not being tapped for potable water now, since the 1100-Area is being supplied by the city of Richland. The area will continue to be so supplied after transfer of the land from federal control (5). When the nitrate-contaminated groundwater plume extends to the Columbia River, nitrate will quickly be diluted to undetectable levels by the 120,000 cubic feet per second flow of water (17).

Tetramethyloxirane (TMO) -- ATSDR has no comparison value for TMO. TMO was tentatively identified in 4 samples in borehole DP8 some 10 to 22 feet below the surface at the antifreeze and degreaser pit (1100-3) (3). Unless it was injected at that depth, it has been migrating downward toward the groundwater at an unknown rate. How this could affect the public health, and when, is uncertain in the absence of confirmation of its identity, additional sampling to quantify rate of movement, and possible research (in the event of confirmed identification) on its toxicity. For a discussion of possible toxicological implications of exposure to TMO, see Appendix D.

Implications of Exposure of People in Richland and Rural Benton County

At present, the public is not exposed to 1100-Area contaminants *via* the Groundwater southeast pathway (see Table 4). Municipal and private wells are either too far south to be in the path of migration of contaminated groundwater or the well water is sufficiently diluted with Columbia River water to prevent a health threat. The protective effect of mixing, shown by wellfield nitrate concentrations closer to those of the Columbia River than to the groundwater taken from Duke wells, may result from water from the Columbia River being pumped into the North Richland Wellfield faster than it is drawn from the wellfield for municipal use.

Implications of Exposure of People in the Tri-Cities Area

No one in this area has been or is being exposed to nitrates, trichloroethylene, or chromium from 1100-Area groundwater contaminants in the plume moving northeast from the Horn Rapids Landfill because this plume has not yet reached the Columbia River. As discussed above, the highly volatile trichloroethylene is unlikely to persist in surface water until it reaches a water supply intake. Nitrate in the plume is in high enough concentration to be of concern if the water is ingested by infants. However, there are no drinking water wells that tap the plume, and any future residents would drink city water. In the future, the plume could eventually deposit the contaminants in the river, where they would be diluted, most likely below the level of detection, before they reach water intakes for the cities.

B. Health Outcome Data Evaluation

Health data were not reviewed because the surrounding public was not found to be exposed to contaminants originating in the 1100-Area, and people living nearby did not express concern about being made ill by the nonradioactive contaminants specific to the 1100-Area. Health effects that could result from exposures to contaminants specific to other Hanford NPL sites will be addressed as part of the public health assessments of those sites.

C. Community Health Concerns Evaluation

Discussions with local government and health officials and representatives of citizen groups and American Indian tribes during 1992-1994 indicated that health concerns are generally reservation-wide. This is true because the public and local governments view Hanford as an aggregate of all reservation facilities rather than as four NPL sites of which the 1100-Area is one site. As with other DOE facilities, public concern tends to focus on radiological hazards. The absence of radiological contamination in the 1100-Area may explain the lack of public focus on this NPL site. ATSDR representatives were unable to identify any community health concerns specifically associated with the contaminants of the 1100-Area. Community health concerns specifically associated with the contaminants of the other Hanford NPL sites will be addressed as part of the public health assessments of those sites.

CONCLUSIONS

The 1100-Area of the Hanford Nuclear Reservation poses no apparent public health hazard from currently known site-related contaminants. No one can come into contact with the contaminants identified in surface soil or groundwater.

Available environmental data and current land use indicate that no one is exposed, has been exposed, or is about to be exposed in the near future to 1100-Area contaminants at levels of health concern.

ATSDR investigators found that, depending on decisions yet to be made about land use, future exposures could take place in decades to come (after the year 2018). Because exposure is not imminent, data inadequacies do not affect the conclusion that there is currently no apparent hazard. Additional information could help to evaluate the future public health significance of the following data gaps:

1. Although the public does not now have access to the 1100-Area, transfers of parts of the reservation to the public are under consideration (6). DOE representatives have stated, "The 1100-Area . . . is to remain zoned industrial in the future," but there is no formal commitment to restrict future land use (see Appendix A, ref. 7, and p 7-40, ref. 4). Some people prefer unrestricted use (6). Thus, it is not clear how the public would use the transferred areas.

2. In the absence of a formal commitment to restrict future use of the 1100-Area, ATSDR investigators will need to evaluate data that are either unavailable or qualitatively or quantitatively inadequate. Following are examples of such data:

   - post-remediation soil data for operable units EM-2, EM-3, and IU-1;
   - post-remediation groundwater data for Operable Unit IU-1;
   - quantitation of lead at the battery acid pit surface (top 3 inches);
   - quality and quantity of soil lead analyses at the northeast corner of the Horn Rapids Landfill;
   - unconfirmed identification of aldrin at the paint and solvent pit; and
   - unconfirmed identification of TMO at the antifreeze and degreaser pit.

RECOMMENDATIONS

1. If portions of the 1100-Area are transferred from DOE to the public, the transfer should include sufficient safeguards (e.g. institutional controls should be considered to protect public health) to protect the public from exposure to unremediated sites and to guard against the breaching of barriers created in the course of remediation (e.g., caps). In the absence of safeguards, remediation plans should protect the public in case of residential use. For example, remediation of the Horn Rapids Landfill should address remaining concentrations of lead before the land is made available for use which could be residential.

2. In the absence of limited access, the following specific additional information should be supplied:

   - post-remediation soil data for operable units EM-2, EM-3, and IU-1;
   - post-remediation groundwater data for Operable Unit IU-1;
   - the concentration of lead at the surface of the battery acid pit;
   - reliable additional data confirming or refuting high estimated lead concentrations in the northeastern corner of the Horn Rapids Landfill subsurface and at 0-3 inches deep; and
   - the identities and quantities of the substances tentatively identified as aldrin at the paint and solvent pit and as TMO at the antifreeze and degreaser pit.

3. Substance-specific research on TMO should be initiated if its identity is confirmed at the antifreeze and degreaser pit and it is not removed.

4. If the existence of completed or potential pathways is indicated by additional data, ATSDR investigators should conduct site reviews and updates, health consultations, and exposure assessments when resources are available.

Health Activities Recommendation Panel (HARP) Recommendations

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended, requires ATSDR to perform public health actions needed at hazardous waste sites. To determine whether public health actions are needed, the data and information developed in the Hanford 1100-Area Public Health Assessment were evaluated by the ATSDR Health Activities Recommendation Panel (HARP) for follow-up health actions. Because people have not been exposed to Hanford 1100-Area contaminants at levels of health concern in the past, are not currently being so exposed, are unlikely to be so exposed for more than 20 years into the future, and it is not practical to plan public health activities that far in advance, no follow-up health actions related to the 1100-Area are indicated at this time. Exposures to contaminants from other Hanford NPL sites (e.g., the 100, 200, and 300 areas) and public health activities appropriate to those exposures will be addressed as part of public health assessments and health consultations for those sites.

Public Health Action Plan

The Public Health Action Plan for the Hanford 1100-Area NPL Site contains a description of actions to be taken by ATSDR and other government agencies at and in the vicinity of the site after the completion of this public health assessment. The purpose of this public health action plan is to ensure that this public health assessment not only identifies public health hazards but also provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment.

ATSDR's staff will conduct the following public health actions:

1. Based on the determinations of the ATSDR Health Activities Recommendation Panel, the 1100-Area is not being considered for follow-up public health actions at this time.

   Exposures to contaminants from other Hanford NPL sites (e.g., the 100, 200, and 300 areas) and public health activities appropriate to those exposures will be addressed as part of public health assessments and health consultations for those sites.

2. To protect public health after DOE releases the 1100-Area for development, ATSDR representatives have recommended that formal steps, such as deed restrictions, be taken to restrict public access to the 1100-Area for the long term or that additional information be provided for all four operable units. For EM-1, more information is needed about lead in soil and to confirm the identities of aldrin and tetramethyloxirane. For EM-2 and EM-3, information is needed about post-remediation soil contamination. For IU-1, information is needed about post-remediation soil and groundwater contamination. When these data are provided, ATSDR representatives will review the data to determine whether actions are needed to protect the public from exposure to 1100-Area contaminants.

The Record of Decision for the Hanford 1100-Area was signed by representatives of the U.S. Department of Energy, the U. S. Environmental Protection Agency, and the Washington Department of Ecology in September 1993 (9). The ROD presents the selected remedies for operable units EM-1, EM-2, EM-3, and IU-1.

DOE personnel and contractors will initiate the following actions in accordance with the ROD and the subsequent U.S. Department of Energy Remediation Design and Remedial Action Plan (9,41).

1. DOE's proposed plans for remediating the contaminated areas in operable unit EM-1 are as follows:

   a) off-site incineration of Discolored Soil Site (1100-6) soil that has a DEHP concentration greater than 71 ppm;
   b) off-site disposal of Rainwater Pool soil that has a total PCB concentration greater than 1 ppm;
   c) off-site disposal of Horn Rapids Landfill soil that has a total PCB concentration greater than 5 ppm;
   d) capping of the Horn Rapids Landfill with 24 inches of uncontaminated soil to prevent inhalation of fugitive dust contaminated by friable asbestos;
   e) monitoring of groundwater migrating under the Horn Rapids Landfill to ensure natural attenuation of its TCE concentration to 5 ppb before the year 2018 or before the groundwater reaches the Columbia River.

2) DOE will conduct Limited Field Investigations and Focused Feasibility Studies of EM-2, EM-3, and IU-1. Solid wastes and contaminated media will be remediated to the regulatory values of the Environmental Protection Agency and Washington State (8).

DOE plans to relinquish control of parts of Hanford, including the 1100-Area, after the year 2018. DOE plans no formal restriction on land use as part of the transfer (4,6,7).

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APPENDIX

APPENDIX A. Letter from J. Monhart, Director of Richland Operations, DOE

Department of Energy
Washington, DC 20585

ATSDR/DHAC/OD

93 NOV -8 PM 2:39

OCT 29 1993

Dr. Mark Bashor
Associate Administrator
Office of Federal Programs
Agency for Toxic Substance and Disease Registry
1600 Clifton Road
Atlanta, Georgia 30333

Dear Dr. Bashor:

This letter is in response to your preliminary examination comments offered in your letter dated September 1, 1993, on the "Hanford 1100 Area Remedial Investigation and Proposed Plan for the Cleanup of the 1100 Area Superfund Site" (DOE-RL-92-74).

In general, we find these comments out of context for the remedial measures proposed in regards to the current and future land use in the 1100 Area. In the Remedial Investigation/Feasibility Study we performed risk assessments on two different scenarios, industrial and residential, at the request of the U.S. Environmental Protection Agency (EPA) for comparison purposes. The residential scenario was not intended to be used for cleanup goals. The 1100 Area is currently in an industrial area and is to remain zoned industrial in the future.

Your specific comments regarding lead at HRL-1 and the Battery Acid Pit are also a point of concern. We screened at 500 mg/kg in Phase I and dropped lead as a potential contaminant of concern for those areas below that concentration. However, at EPA's request, the Department of Energy (DOE) Richland Operations Office performed an analysis using their UPTAKE/BIOKINETIC MODEL FOR LEAD (UBK) for the maximum concentration of lead detected at Horn Rapids (854 mg/kg) for the residential scenario. Based on the maximum concentration of lead detected and the conservative UBK model parameters, the geometric mean and geometric standard deviation of the predicted blood lead levels indicate that approximately five percent of the exposed children would be expected to have a blood level greater than 10 ug/dl. Approximately 95 percent of the children would be expected to have a blood lead level less than 10 ug/dl. The scenario of 1100-EM-1 being residential is highly unlikely based on its industrial setting and future land use considerations.

The proposed alternative for HRL-1 does not include removal of soil in the areas containing concentrations of lead between 102 and 482 ppm. However, the proposal does call for the placement of a two-foot soil cap designed for asbestos abatement on the landfill including those areas containing lead. It is highly unlikely that this landfill will ever be remediated to support residential use.

Please consider reassessment of your comments based on the above information. In addition, the "abbreviated" form of the health consultation does not provide sufficient information for a thorough review by DOE. Background information is missing (e.g., what scenarios were used in your assessments) that would have provided a basis for additional comments. DOE would appreciate that the Agency for Toxic Substances and Disease Registry consider discussing the health consultations with the appropriate operations offices before sending out formal comments.

Sincerely,

Jane L. Monhart

Jane L. Monhart
Director
Richland Operations Division
Office of Northwestern Area Programs
Environmental Restoration

cc:
W. Wisenbaker, EM-43
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B. Stewart, DOE-RL
S. Wisness, DOE-RL
R. Williams. ATSDR

APPENDIX B. Demographic Data

Table B-1 Population Data: By Counties

Variable	Benton County	Franklin County
Total persons	112,560	37,473
Total area, square miles	1,703	1,242
Persons per square mile	66.1	30.2
% Male	49.4	51.3
% Female	50.6	48.7
% White	91.4	71.8
% Black	1.0	3.5
% American Indian, Eskimo, or Aleut	0.8	0.7
% Asian or Pacific Islander	2.0	2.3
% Other races	4.9	21.6
% Hispanic origin	7.7	30.2
% Under age 10	17.2	19.9
% Age 65 and older	10.1	10.0

Source: 1990 Census of Population and Housing, Summary Tape File 1 (Washington). Prepared by the Bureau of the Census, Washington, DC, 1991.

Table B-2 Housing Data: By Counties

Variable	Benton County	Franklin County
Households*	42,227	12,196
Persons per household	2.65	3.03
% Households owner-occupied	63.1	59.7
% Households renter-occupied	36.9	40.3
% Households mobile homes	9.3	12.3
% Persons in group quarters	0.5	1.2
Median value, owner-occupied households, $	66,200	56,000
Median rent, renter-occupied households, $	283	234

* A household is an occupied housing unit, not including group quarters, e.g., college dormitories, fraternity and sorority houses, prisons, nursing homes, or hospitals.

Source: 1990 Census of Population and Housing, Summary Tape File 1 (Washington). Prepared by the Bureau of the Census, Washington, DC, 1991.

Table B-3 Population Data: Tri-Cities

Variable	Kennewick	Pasco	Richland
Total persons	42,155	20,337	32,315
Total area, square miles	20.1	22.8	32.0
Persons per square mile	2,095	892	1,008
% Male	49.0	51.2	48.8
% Female	51.0	48.8	51.2
% White	89.9	59.9	93.0
% Black	1.1	5.6	1.4
% American Indian, Eskimo, or Aleut	0.8	0.9	0.7
% Asian or Pacific Islander	2.0	2.5	3.3
% Other races	6.2	31.1	1.6
% Hispanic origin	8.7	40.8	3.0
% Under age 10	18.7	20.9	15.2
% Age 65 and older	9.1	11.2	12.6

Source: 1990 Census of Population and Housing, Summary Tape File 1 (Washington). Prepared by the Bureau of the Census, Washington, DC, 1991.

Table B-4 Housing Data: Tri-Cities

Variable	Kennewick	Pasco	Richland
Households*	16,074	6,842	13,162
Persons per household	2.61	2.91	2.44
% Households owner-occupied	53.1	47.4	62.0
% Households renter-occupied	46.9	52.6	38.0
% Households mobile homes	6.5	10.4	2.7
% Persons in group quarters	0.6	2.1	0.4
Median value, owner-occupied households	$64,800	$44,100	$69,200
Median rent paid, renter-occupied households	279	228	293

* A household is an occupied housing unit, but does not include group quarters such as college dormitories, fraternity and sorority houses, prisons, nursing homes, or hospitals.

Source: 1990 Census of Population and Housing, Summary Tape File 1 (Washington). Prepared by the Bureau of the Census, Washington, DC, 1991.

APPENDIX C. Toxic Chemical Release Inventory (TRI) Data

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Table C-1 Releases to Land, Benton County, Washington State

Chemical	County	Facility	Pounds released to the Soil			
			1987	1988	1989	1990
Aluminum Oxide	Benton	DOE Hanford 300 Area	666	--	--	--
Ammonia	Benton	Chevron East End	0	304	200	5
Ammonia	Benton	Chevron Kennewick	0	0	3,400	0
Ammonia	Benton	DOE Hanford 200 Area	--	--	8,075	--
Ammonium Nitrate	Benton	Chevron Kennewick	750	750	750	250
Ammonium Nitrate	Benton	Chevron Finley	--	25,709	8,700	26
Ammonium Nitrate	Benton	Columbia Crest	--	--	--	88,000
Ammonium Nitrate	Benton	DOE Hanford 200 Area	785	--	--	--
Chlorine	Benton	DOE Hanford 100 Area	--	--	--	8,000
Chlorine	Benton	DOE Hanford 200 Area	--	--	--	880
Chlorine	Benton	Lamb Weston	--	--	16,000	22,000
Copper	Benton	DOE Hanford 200 Area	150	--	--	--
Ethylene Glycol	Benton	DOE Hanford 200 Area	--	75	--	--
Hydrazine	Benton	DOE Hanford 100 Area	20	--	55	--
Hydrazine	Benton	DOE Hanford 200 Area	1	--	--	--
Hydrochloric Acid	Benton	DOE Hanford 200 Area	7	--	--	--
Hydrochloric Acid	Benton	DOE Hanford 300 Area	113	--	--	--
Hydroquinone	Benton	DOE Hanford 100 Area	146	--	--	--
Hydroquinone	Benton	DOE Hanford 200 Area	803	--	--	--
Hydroquinone	Benton	DOE Hanford 300 Area	377	--	--	--
Lead	Benton	DOE Hanford 200 Area	507	--	--	--
Nitric Acid	Benton	DOE Hanford 200 Area	3,496	--	12	--
Nitric Acid	Benton	DOE Hanford 300 Area	1,012	14	15	12
Phosphoric Acid	Benton	Lamb Weston	--	16,100	--	--
Sodium Hydroxide	Benton	Lamb Weston	0	148,000	10,443	7,328
Sodium Hydroxide	Benton	DOE Hanford 100 Area	500,000	430,000	--	--
Sodium Hydroxide	Benton	DOE Hanford 200 Area	49,760	14,706	--	--
Sodium Hydroxide	Benton	DOE Hanford 300 Area	468	209	--	--
Sodium Hydroxide	Benton	Seneca Foods	131,742	0	--	--
Sodium Sulfate	Benton	DOE Hanford 100 Area	890,000	900,000	--	--
Sodium Sulfate	Benton	DOE Hanford 200 Area	--	28,635	--	--
Sulfuric Acid	Benton	DOE Hanford 100 Area	1,000,000	644,000	--	130,000
Sulfuric Acid	Benton	DOE Hanford 200 Area	16,181	10,916	2	6
Sulfuric Acid	Benton	DOE Hanford 300 Area	45	9	7	7

Table C-2 Releases to Surface Water, Benton County, Washington State

Chemical	County	Facility	Pounds Released into Water			
			1987	1988	1989	1990
Ammonia	Benton	Chevron East End	3,996	7,985	0	9,327
Ammonia Nitrate	Benton	Chevron Kennewick	10,347	10,777	0	6,800
Sodium Hydroxide	Benton	Chevron East End	15,860	2,790	10,443	7,328
Sodium Hydroxide	Benton	DOE Hanford 100 Area	--	53	--	--
Sodium Sulfate	Benton	DOE Hanford 100 Area	--	350	--	--

Table C-3 Releases to Air by the Department of Energy, Benton County, WA

Chemical	County	Facility	Pounds Released into the Air			
			1987	1988	1989	1990
Acetone	Benton	DOE Hanford 1100 Area	1	--	--	--
Methyl Ethyl Ketone	Benton	DOE Hanford 1100 Area	7	--	--	--
Sulfuric Acid	Benton	DOE Hanford 1100 Area	2	0	--	--
1,1,1 Trichloroethane	Benton	DOE Hanford 1100 Area	13	--	--	--
Acetone	Benton	DOE Hanford 100 Area	513	--	--	--
Ammonia	Benton	DOE Hanford 100 Area	1,200	--	--	--
Freon 113	Benton	DOE Hanford 100 Area	16	--	--	--
Methyl Ethyl Ketone	Benton	DOE Hanford 100 Area	923	--	--	--
Tetrachloroethylene	Benton	DOE Hanford 100 Area	127	--	--	--
1,1,1 Trichloroethane	Benton	DOE Hanford 100 Area	528	--	--	--
Acetone	Benton	DOE Hanford 200 Area	3,068	--	--	--
Ammonia	Benton	DOE Hanford 200 Area	18,150	--	18,874	
Carbon Tetrachloride	Benton	DOE Hanford 200 Area	17,140	--	--	--
Copper	Benton	DOE Hanford 200 Area	10	--	--	--
Ethylene Glycol	Benton	DOE Hanford 200 Area	2	--	--	--
Freon 113	Benton	DOE Hanford 200 Area	202	--	--	--
Hydrochloric Acid	Benton	DOE Hanford 200 Area	20	--	--	--
Hydrogen Fluoride	Benton	DOE Hanford 200 Area	16	--	--	--
Lead	Benton	DOE Hanford 200 Area	10	--	--	--
Methyl Ethyl Ketone	Benton	DOE Hanford 200 Area	12	35	--	--
Nitric Acid	Benton	DOE Hanford 200 Area	87	23	0	47,002
Sulfuric Acid	Benton	DOE Hanford 200 Area	10	0	0	0
1,1,1 Trichloroethane	Benton	DOE Hanford 200 Area	1013	--	--	--
Acetone	Benton	DOE Hanford 300 Area	9	--	--	--
Ammonia	Benton	DOE Hanford 300 Area	6	--	--	
Ammonium Nitrate	Benton	DOE Hanford 300 Area	73[a]	0	--	--
Ethylene Glycol	Benton	DOE Hanford 300 Area	--	5	--	
Lead	Benton	DOE Hanford 300 Area	4	--	--	--
Methyl Ethyl Ketone	Benton	DOE Hanford 300 Area	187	542	--	--
Nitric Acid	Benton	DOE Hanford 300 Area	98	91	0	--
Tetrachloroethylene	Benton	DOE Hanford 300 Area	760	--	--	--
1,1,1 Trichloroethane	Benton	DOE Hanford 300 Area	47[a]	--	--	--
Chlorine	Benton	DOE Hanford[b]	3,000	0	0	0
Methyl Ethyl Ketone	Benton	Unknown Hanford Areas	2,555	--	--	--

a. An unknown proportion of this quantity was released in the 700 Area (in downtown Richland).

b. Released throughout Hanford at water distribution points; the proportion released at each NPL site was not available.

c. Releases from the 1100 Area are indicated by shading.

Table C-4 Releases to Air by Other than the Department of Energy, Benton County, WA

Chemical	County	Facility	Pounds Released into the Air			
			1987	1988	1989	1990
Ammonia	Benton	Chevron - Finley	235,128	172,368	159,400	147,275
Ammonia	Benton	Chevron - Bowie	1,109,639	1,137,448	1,537,780	1,498,879
Ammonia	Benton	Kerley Ag. Products	1,645	1,719	1,839	22,751
Ammonia	Benton	Seneca Foods	--	--	1,300	1,600
Chlorine	Benton	Lamb Weston	--	--	20,000	--
Chlorine	Benton	Columbia Crest	11,550	9,750	4,050	5,250
Nitric Acid	Benton	Chevron - Bowie	1,000	1,641	1,742	1,817

APPENDIX D. Toxicological Information

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Lead -- Children who may in the future live on residential lots on the northeast corner of a redeveloped Horn Rapids Landfill could play in soil containing as much as 482-854 parts per million (ppm) lead (1,2). This compares to background soil concentrations in the 1100-Area and the State of Washington that range up to 8.1 and 30 ppm, respectively (3). The exact relationship between the lead concentration in soil and that in children's blood is in dispute among scientists. According to one theory, the average concentration of lead in their blood could be increased by 6 micrograms (µg) lead per deciliter (dl) of blood to 12.3 µg/dl, depending on many factors, such as the chemical form of the lead, the soil particle size, and the nutritional state of the children (4). In one case, this increase was calculated using the relationship reported between soil and blood lead concentrations observed in Helena Valley in Montana and Silver Valley in Idaho (4). The following equation was derived:

$$\text{Natural log (blood lead in } \mu g/dl) = 0.879 + 0.241 \text{ X Natural log (soil lead in ppm)}$$

Some factors (soil particle size, chemical species of lead, nonsoil lead sources, population demographics such as age and distribution of wealth, nutritional status, etc.) upon which a soil-lead relationship depends are site-specific. By varying assumptions about these and other factors, it is possible to draw different conclusions about the future potential for lead-induced harm. Similarly, different conclusions would be drawn if lead hot spots were remediated.

Young children are at risk from lead ingestion during ages 2-4, the years in which they are prone to pica behavior (ingestion of nonnutritive substances, such as soil). Their ingestion of small amounts of lead is associated with depressed IQ scores, slow growth, and hearing deficits (5). Middle-aged men may become hypertensive from small increases in their blood lead levels (5).

Environmental Protection Agency (EPA) scientists point out that the health effects of lead, especially those on "children's neurobehavioral development, may occur at blood lead levels so low as to be essentially without a threshold" and considers it inappropriate to derive an RfD for oral exposure to lead (6). Since a population's blood lead concentration is directly related to the local soil lead concentration (4), it seems inadvisable to use any soil comparison values or standards.

Arsenic -- Arsenic occurs in the environment in both inorganic and organic forms. In the absence of specific information about the form of arsenic in the soil and groundwater, it is prudent to make the conservative assumption that all arsenic found on site in groundwater and soil is in the much more toxic inorganic form. Chronic human ingestion of as little as 0.01 to 0.06 milligrams per kilogram per day (mg/kg/day) of *inorganic* arsenic has been associated with evidence of impaired circulation in the extremities, such as significantly increased incidence of Blackfoot disease and Raynaud's Syndrome (8). Other noncancer effects of low-level human oral exposure to the inorganic form included abdominal pain, diarrhea, liver damage (hepatomegaly, portal hypertension), skin lesions (melanosis, keratosis), and mild peripheral neuropathy (8). No effects were seen consequent to oral intake of as much as 0.006 mg inorganic arsenic/kg/day (8). Human ingestion of 0.009 to 0.04 mg inorganic arsenic /kg/day for 12 to 60 years has been associated with increased incidence of cancer of the skin, lungs, and liver (8). Although EPA declined to verify an oral slope factor for inorganic arsenic, that agency did derive a unit risk in water of 0.00005 per microgram per liter (µg/L) (6). As chemical carcinogenesis is assumed by EPA to be without a threshold, the derived value suggests lifetime exposure to drinking water containing as little as 0.2 parts per billion (ppb) arsenic or soil containing as little as 4 ppm inorganic arsenic might result in a slightly increased cancer rate in the exposed public.

Ingestion of less than 250 μg/day (0.004 mg/kg/day) does not affect blood arsenic concentration (9). If intake must exceed 250 μg/day (0.004 mg/kg/day) to raise blood levels, the implication is that elimination mechanisms are adequate at this level of intake. This fits with findings that oral intake as high as 0.006 mg/kg/day (420 μg/day) does not cause noncancer effects in humans and that human cancer has been observed only in studies where prolonged intake exceeded 0.009 mg/kg/day (630 μg/day) (8). A growing body of evidence suggests that arsenic carcinogenicity may result from mechanisms consistent with such a threshold (10). It follows that adverse public health effects from arsenic ingestion would be not be expected from inorganic arsenic concentrations less than 120 ppb in drinking water or 2,400 ppm in soil (or an equivalent combination, e.g., 140 ppb in groundwater plus 500 ppm in soil, which concentrations are 10 to 100 times those maximally found or estimated at the 1100-Area).

Aldrin -- Aldrin and dieldrin, its metabolite, are chlorinated cyclodienes formerly used as insecticides (11). Oral or dermal exposure to aldrin is neurotoxic to people, often causing convulsions well before less dramatic effects become evident (12). Repeated exposure to dieldrin caused immune hemolytic anemia in humans, and reproductive, developmental, and carcinogenic effects in rodents in addition to those seen in people (6,11,12). Aldrin's potential for carcinogenicity is of special concern to this Agency as well as to EPA (6,11). Lifetime exposure to the soil concentrations of 4 ppm reported for the 1100-2 Suboperable Unit could result in a low increased cancer incidence (6).

Tetramethyloxirane (TMO) -- ATSDR investigators did not locate toxicological information on tetramethyloxirane (TMO) -- tetramethylethylene oxide. This chemical is a derivative of oxirane, which is also known as ethylene oxide. Ethylene oxide itself is a volatile, unstable chemical that is used primarily in the manufacture of other synthetic chemicals, such as those in antifreeze. A small fraction is used as a sterilant for dry foods and for surgical instruments and supplies. Its volatility and instability result in a short environmental half-life, so that exposure is more likely to be occupational than environmental. It may be anticipated on the basis of general chemical principals that the tetramethyl derivative would be less volatile and more stabile than ethylene oxide. These differences would increase the time the derivative could persist in the environment and the probability of exposure of people in a pathway. It is not clear how substitution of the four hydrogens of ethylene oxide with methyl groups to form TMO might affect the toxicological properties of the parent compound. These properties of the parent compound, ethylene oxide, are briefly reviewed below (13).

In animals, the noncancer effects of subchronic inhalation exposure to ethylene oxide include effects on the developmental, reproductive, respiratory, hematological, renal, immunological, and neurological systems, of which the last is the most sensitive. For humans, chronic inhalation leads to poor hand/eye coordination (3 ppm) and peripheral neuropathy (10 ppm) as well as nasal irritation at the higher level. There is suggestive evidence of reproductive and developmental toxicity among people occupationally exposed, but exposure levels are uncertain. Ethylene oxide produced malignancies in animals at multiple sites, including the brain, uterus, lung, mononuclear cells, mesothelium, and mammary glands in rodents. Association with occupational exposure (mostly inhalation) in humans, though suggestive, is inconclusive. Oral exposure of rats produced cancer of the stomach, consistent with an increased incidence of stomach cancer in Swedish ethylene oxide factory workers who followed production by tasting the reaction mixture. Ethylene oxide is ranked as a probable human carcinogen: Weight-of-Evidence group B1 carcinogen by the EPA, and group 2A by the International Agency for Research in Cancer (IARC), both because there is adequate evidence in animal studies and limited evidence in humans (6,13,14).

References for Appendix D

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5. Agency for Toxic Substances and Disease Registry. Toxicological profile for lead. Atlanta: US Department of Health and Human Services, Public Health Service; 1990 June. Report No.: TP-88-17.

6. Integrated Risk Information System. On-line. Cincinnati, OH: US Environmental Protection Agency, Health and Environmental Assessment Office, Environmental Criteria and Assessment Office, 1993.

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APPENDIX E. Public Comments on the Hanford 1100-Area (USDOE) Public Health Assessment

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PUBLIC COMMENTS on the HANFORD 1100-AREA (USDOE) PUBLIC HEALTH ASSESSMENT

The following comments were received by ATSDR in response to the public comment period for the Hanford 1100-Area (USDOE) Public Health Assessment.

#	Page, Paragraph	Comment Summary	Response
1.	pp.4 & 36	Two commenters expressed concern that DOE's assumption of future industrial or commercial use of the Horn Rapids Landfill and other parts of the 1100-Area is not to be formally incorporated in deeds restrictions. One tribal commenter also indicated that future use is a critical issue.	ATSDR agrees and recommended on page 42 that "transfers ["of portions of the 1100-Area . . . from DOE to the public"] should include sufficient safeguards to protect the public from exposure". ATSDR policy does not permit specific risk management recommendations, such as invoking deed restriction. However, ATSDR can recommend institutional controls be considered to protect public health (see page 42). Comments concerning deed restrictions have been forwarded to EPA and DOE.
2.	p.14, last para.	Why is so much time and effort being spent on the 1100-Area although this area is the one for which the community has the least concern about health effects.	No changes. The Summary on page 1 and the second full paragraph, page 3 explain the 1100-Area was the first Hanford NPL site for which ATSDR had enough data to complete a public health assessment. Public health assessments for the other NPL sites are in progress.
3.	p.21, para. 7 p.22, Fig. 5	Wells 3 and 17 are upgradient of the plume from Siemens Power Corp. (Advanced Nuclear Fuels) and Horn Rapids Landfill (HRL). It is not correct to discuss contamination in these wells in the context of the Siemens/HRL plume.	The discussion was modified. See pages 21 and 22.
4.	No page listed.	A search of DOE fact sheets found no reference to preliminary geophysical exploration of Hanford. Were land-based non-invasive geophysical techniques used prior to drilling?	No changes. Yes, non-invasive geophysical surveys were used. See References 3 and 18.
5.	p.22, fig. 5	What is the source and date for the indicated direction of groundwater flow?	No changes. Source is indicated in the upper left corner of the figure as Reference 3, 1990.
6.	p.13, fig. 4 and text.	The report states "no part of the Yakima River is downgradient from any part of the 1100-Area," but Fig. 4 shows the confluence of the Columbia and Yakima Rivers near the 1100-Area, and the Yakima River south of the Horn Rapids Dam appears downgradient of the 1100-Area.	No changes. "Down*gradient*" means a downward trend in groundwater potential; i.e., the direction of water movement underground. The direction of groundwater moving under the 1100-Area is shown in Figure 5 to be towards east and northeast, away from the Yakima River and towards the Columbia River. Surface water (with no 1100-Area contaminants at levels of health concern -- see pages 24 and 25) in the Columbia River is moving down*stream* towards its confluence with the Yakima River; it would be incorrect and misleading to state the Yakima River is downgradient of the site.

#	Page, Paragraph	Comment Summary	Response
7.	p.22, fig. 5	Why are the monitor wells in Fig. 5 in a narrow north-south line parallel to the Columbia River? Are they deep enough to evaluate the fluid flow into the underlying basalt?	No changes. Comparison of Figs. 3 and 4 show that monitoring wells are placed near contamination sources to track contaminant movement. These wells do not reach to the underlying basalt. Most of the wells tap the unconfined aquifer (page 21). ATSDR examined well drilling logs for Richland private wells, and obtained depth information for municipal wells. These wells are screened for the unconfined aquifer; they do not draw water from fissures in the underlying basalt.
8.	p.20, para. 2 p.20, para. 3 p.42, para. 1 p.44, 1d	What does it mean to try and place a "cap" on an open system? Your method does not hold water.	No changes. The "cap of 24 inches of soil" (page 20, paragraph 2 and 3) was applied to the landfill "to prevent dispersal of asbestos fibers as fugitive dust" (page 20, paragraph 4; also see page 44 part 1d), not to prevent rainfall from washing contaminants in the vadose zone into groundwater.
9.	p.18-19	What geological layer is referred to in the "soil" contaminant data?	No changes. Soil depths are given in Table 2 on pages 18 and 19. The depths of vadose zone soil contamination of primary concern for public health are those which are accessible to people in activities such as gardening, sandlot play, and excavation for building construction. See pages 28-33.
10.	p.4-9	The public health assessment states the 1100-EM-1, -EM-2, and -EM3 operable units contain contaminated facilities such as the HEW bus lot, vehicle maintenance and repair facility, storage tanks, etc. since the early '50s. Would there not also be contamination in the original bus lot and garage that was located west of the present Chief Joseph School?	No changes. Contamination in the HEW bus lot was not discussed in the public health assessment. No contaminants were reported there at levels of concern for human health. ATSDR has no information about soil contamination in Richland south of the current 1100-Area boundary. ATSDR will be happy to receive and review data on contamination of additional 1100-Area facilities for public health implications.
11.	No page listed.	The land use based cleanup goal is designated as unrestricted for groundwater and soil for most of the 1100-Area in the Proposed Plan, but the land use based cleanup goal for the Horn Rapids Landfill is restricted. This should be stated in the public health assessment.	No change. This distinction is explained in the first full paragraph on page 31.
12.	No page listed.	The public health implications of not remediating the groundwater plume from Siemens should be explained.	No change. The pathway for exposure of people to this plume is "Groundwater Northeast". This pathway is discussed in Table 4 on page 32, and in the second full paragraph on page 33. The public health implications of the major contaminants in the plume are discussed in the paragraphs on TCE and nitrate on pages 39 and 40.

#	Page, Paragraph	Comment Summary	Response
13.	p.10, para. 3	The public health assessment fails to recognize the unique status of Tribal governments under CERCLA and federal Indian law. This failure translates into deficiencies in the section on Background, Section C, "Demographics, Land Use, and Natural Resource Use." Little or no direct government-to-government consultation between ATSDR and the tribes has occurred. The interests of the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) were not identified.	The discussion was modified. See page 10. ATSDR has attended meetings of the Intertribal Council on Hanford Health Projects (ITCHHP -- formerly the Native American Working Group) to learn tribal concerns about ATSDR health activities, including public health assessments. ATSDR received the Scoping report: Nuclear Risks in Tribal Communities at a presentation by Umatilla Special Sciences and Resources Program staff representatives April, 1995. In May 1992 and June 1995, ATSDR sent letters to tribal chairpersons and ITCHHP liaisons formally requesting meetings with tribal representatives and members to learn their concerns. ATSDR will schedule meetings when responses to those letters are received.
14.	p.1, para 1	The public health assessment should be a "stand alone" analysis--especially at Hanford which host 78 CERCLA-operable units with Records of Decision spanning generations. The public health assessment does not address the large number of substances released from Hanford in 50 years of operation.	No change. The purpose of the document was to be a stand-alone analysis for the 1100 area. Substances released from Hanford's other NPL sites will be addressed in public health assessments for those sites.
15.	p.22, fig. 5	The public health assessment relies heavily on DOE sponsored documentation and does not present information from non-DOE sources. For example, groundwater isopleths are displayed as arrows indicating direction, but not magnitude. Consultation with CTUIR could have alleviated the inadequate illustration.	No change. The arrows were ATSDR summaries of the public health significance of numerous groundwater potential maps drawn from data at different dates. The arrows indicate the absence of pathways for contaminants at levels of concern to drinking water sources. Technical data not of public health significance are not discussed in the public health assessment, although they can be found in the list of references by interested readers who wish additional background information. ATSDR will receive and review any additional information of public health significance from any and all concerned parties.
16.	p.25-27 Appendix C	Information in the section on "Toxic Chemical Release Inventory" and Appendix C may lead readers to dismiss the four chemicals released to the air from the 1100-Area as the *only* amounts ever released. Non-1100-Area releases are not shown in their true relationship to the 1100-Area.	Table C-3 in Appendix C is regrouped to show the relationship of reported releases from the 1100-Area to those from other DOE NPL sites. Readers' attention is called to the unchanged last paragraph in the "Toxic Chemical Release Inventory" section (page 27), which discusses the limitations of the database.
17.	p.6, Table 1 p.18, Table 2 p.23, Table 3	The public health assessment approaches the 1100-Area as a "service station", ignoring spills during the site's use as a point-of-exchange for off-site shipments of materials.	No change. ATSDR reviewed an abundance of soil and groundwater analysis data and listed values which could have public health significance in Tables 2 and 3. Table 1 lists 4 spills that lead to soil or groundwater characterization. They are named 1100-5, 1100-6, the Rainwater pool, and the Horn Rapids Landfill (HRL) groundwater plume.

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18.	No page listed.	The public health assessment does not contain complete geologic characterization and hydrogeologic modeling of the 1100-Area. This could show the effect of pumping drinking water in an aquifer that may have a carcinogenic contaminant such as TCE.	No change. Historical information on the TCE plume was reviewed by ATSDR; the concentration of TCE in the plume is attenuating, and TCE will be further diluted and volatilized as it reaches the Columbia River and before it reaches water intakes. Detailed geological characterization and hydrogeological modeling are of public health significance when historical plume information is lacking and when there are completed or potential pathways consistent with current or proposed future land use. There is no proposed future land use permitting a completed pathway from well use in the current or future plume area. Please see discussions on the groundwater northeast pathway (Table 4, page 32 and text on page 33) and the toxicological implications of TCE (page 39).
19.	No page listed.	ATSDR is required to complete public health assessments before the remedial investigations cited in the References section. The record of decision, based on those remedial investigations, was signed in September, 1993, and the public comment version of this public health assessment was released in July 1995. What caused the delay?	No change. Preliminary public health assessments for all Hanford NPL sites were released for data validation in October 1989, before the record of decision was signed. This public health assessment addresses additional data provided to ATSDR on 1100-Area soil and groundwater contamination levels and locations when the remedial investigations and limited field investigations were completed in 1993.
20.	p.41	ATSDR concludes that no one is or has been exposed. Table C-3 indicates releases to the air in 1987. The public health assessment does not provide air pathway data.	No change. The quotation in context is "no one is exposed, has been exposed, or is about to be exposed in the near future to 1100-Area contaminants ***at levels of health concern***" [emphasis added]. Ambient air concentrations (pages 24-25) and pathway analysis (page 33) indicated that the levels are below health concern.
21.	p.41	The public health assessment fails to present a "comparison of existing morbidity and mortality data on diseases that may be associated with the observed levels of exposure." -- CERCLA 104(i)(6)(F)	No change. In the absence of completed pathways (pages 29-31) there are no "diseases that may be associated with observed levels of exposure."