DOE/EIS-0245D

DRAFT ENVIRONMENTAL IMPACT STATEMENT

Management of Spent Nuclear Fuel from the K Basins at the Hanford Site, Richland, Washington

October 1995

U.S. DEPARTMENT OF ENERGY
RICHLAND, WASHINGTON 99352

DOE/EIS-0245D

Draft Environmental Impact Statement

Management of Spent Nuclear Fuel from the K Basins at the Hanford Site, Richland, Washington

October 1995

U.S. Department of Energy
Richland, Washington 99352

COVER SHEET

Responsible Agency: U.S. Department of Energy (DOE)

Title: Draft Environmental Impact Statement on the Management of Spent Nuclear Fuel from the K Basins at the Hanford Site, Richland, Benton County, Washington

Contact: For further information on this EIS, to request copies of the EIS, or to present comments on the EIS, contact:

Dr. P. G. Loscoe; (509) 376-7434
U.S. Department of Energy, Richland Operations Office
P.O. Box 550, MS S7-41
Richland, WA 99352

For general information on DOE's National Environmental Policy Act (NEPA) process, call the DOE's NEPA Information Line at 1-800-472-2756 to leave a message, or contact:

Carol Borgstrom, Director; (202) 586-4600
Office of NEPA Project Assistance (EH-42), U.S. Department of Energy
1000 Independence Avenue SW
Washington, D.C. 20585

Abstract: The purpose of this draft environmental impact statement (DEIS) is to provide environmental information to assist the U.S. Department of Energy (DOE) in the selection of an alternative for the management and storage (up to approximately 40 years) of spent nuclear fuel (SNF) currently located in the K Basins at the Hanford Site. Management and storage/disposal of sludge, debris, and water in the K Basins are also included in the DEIS. Alternatives considered include 1) no action, 2) enhanced K Basin storage, 3) new wet storage, 4) drying/passivation (conditioning) with dry storage (the preferred alternative), 5) calcination with dry storage, 6) onsite processing, and 7) foreign processing.

Public Comments: To provide comments to DOE on the DEIS, either send written comments to Dr. P. G. Loscoe at the above address, or present comments orally or in writing at the scheduled public hearing(s). Time(s) and location(s) of the hearing(s) will be announced in local newspapers or may be obtained from Dr. Loscoe at the above telephone number or from the DOE toll-free number 1-800-472-2756. To be assured of consideration, comments must be received within 45 days after the notice of availability is published in the Federal Register.

SUMMARY

The purpose of this draft environmental impact statement (DEIS) is to provide information on the potential environmental impacts of managing spent nuclear fuel (SNF) located in the K East (KE) and K West (KW) SNF storage basins at the Hanford Site. These basins are attached to the retired KE and KW Reactors. Approximately 2100 metric tons (2315 tons) of SNF are currently located in these two storage basins. The SNF is in the form of metallic uranium, plutonium, and fission products and is, for the most part, fuel from the operation of N Reactor. Small amounts of SNF remain from operation of reactors older than N Reactor. The fuel was never processed to remove uranium and plutonium, and has been stored for periods ranging from 8 to 24 years. Much of the SNF stored in KE Basin is visibly damaged, has deteriorated, and continues to deteriorate. Because the SNF in KW Basin is stored in sealed canisters, its condition is uncertain.

The KE and KW Reactors and their associated fuel storage basins were constructed in the early 1950s and are located in the 100-K Area as close as 420 m (1,380 ft) to the Columbia River. The basins are unlined concrete, 4.9-million-L (1.3-million-gal) water pools with an asphaltic membrane beneath each pool. The interior of the KW Basin has been coated with epoxy. The KE Basin has leaked water in the past and may still be leaking small quantities of water contaminated with radionuclides. The K Basins are not suitable for continued long-term storage of SNF.

Purpose of and Need for Action

The purpose of and need for DOE's action is to reduce risks to public health and the environment, specifically 1) to prevent the release of radioactive materials into the air or the soil surrounding the K Basins and the potential migration of radionuclides through the soil column to the nearby Columbia River, 2) to reduce occupational radiation exposure, and 3) to eliminate risks to the public and to workers from the continued deterioration of SNF in the K Basins.

Proposed Action and Alternatives

DOE's proposed action is to take expeditious action to reduce risks to public health and the environment by removing SNF from the K Basins and, subsequently, to take action to manage the SNF in a safe and environmentally sound manner for up to 40 years until ultimate disposition decisions are made and implemented.

DOE's proposed alternatives include

- no action
- enhanced K Basin storage
- new wet storage
- drying/passivation (conditioning) with dry storage
- calcination with dry storage
- onsite processing
- foreign processing

No action means to continue present storage in the KE and KW Basins for up to 40 years with no modifications except for maintenance, monitoring, and ongoing safety upgrades. Enhanced K Basin storage means to perform facility life extension upgrades for KW Basin, containerize KE Basin SNF and sludge, and consolidate with KW Basin SNF for up to 40 years of storage. New wet storage means to remove SNF from the K Basins and provide for up to 40 years of wet storage in a new facility away from the river. Drying/passivation (conditioning) with dry storage means to remove SNF from the K Basins, condition [i.e., dry (remove free and bound water)], oxidize exposed reactive areas of the fuel under controlled conditions, seal in canisters filled with an appropriate storage atmosphere, and provide for up to 40 years of dry storage in a new vault or cask facility. Calcination with dry storage means to remove SNF from the K Basins, calcine, and provide for up to 40 years of dry storage of SNF oxides in a new cask or vault facility. Onsite processing means to remove and chemically process K Basins SNF and provide for up to 40 years of dry storage of the recovered uranium (as UO_3) and plutonium (as PuO_2), and manage fission product waste in Hanford's double-shell tanks. Foreign processing means to remove K Basins SNF, ship overseas for processing, provide for up to 40 years of dry storage of returned uranium (as UO_3) and plutonium (as PuO_2), and store vitrified fission product waste, pending ultimate disposition.

For all alternatives except no action, management of sludge, basin water, and debris is included as part of the alternative. Sludge management could include management of the sludge as SNF, management by transfer to double-shell tanks at Hanford, or disposal as low-level waste, mixed waste, or transuranic waste. Water management could include processing through the 200 Area Effluent Treatment Facility (ETF) and disposal of the resulting solids as low-level waste. Debris not containing SNF would be managed as low-level waste.

Although storage of SNF at Hanford for 500 years might be possible, present designs are extendable to only about 75 years. Further design work would be necessary to extend storage to 500 years. The 40-year period analyzed in this EIS would not preclude such further design and later adoption of a longer interim-storage period, if warranted. However, DOE's policy is to provide for long-term storage of SNF in a geologic repository.

Differences in environmental impacts do not provide clear distinctions among alternatives (see "Environmental Consequences" section of the summary). Nevertheless, alternatives other than no action and enhanced K Basins storage would provide more assured protection of the Columbia River. Further, DOE believes that no action and enhanced K Basins storage are unacceptable alternatives because of the cost of maintaining SNF and one or both K Basins for 40 years, because of continued degradation of the SNF, and because some action to remove the SNF from one or both K Basins, such as one of the other alternatives considered in this EIS, would be required at the end of 40 years. Among the other alternatives, wet storage is a proven technology, although continued wet storage could result in continued SNF degradation. Calcining or processing might put the SNF in a form acceptable for disposal in a high-level waste repository, although this is not certain because the repository acceptance criteria have not been announced. Foreign processing would remove the SNF temporarily from the Hanford Site. Drying/passivation (conditioning) with dry storage leaves the SNF in a condition such that further operations could be carried out on the SNF to meet repository criteria.

DOE's preferred alternative is drying/passivation (conditioning) with dry vault storage, incorporating the following steps. Remove K Basin SNF from existing canisters, clean, and desludge. Repackage the SNF into fuel baskets designed for multicanister overpacks (MCOs) that would include provision for water removal, SNF conditioning, and criticality control. After loading SNF into the MCOs, welding the top, and draining an MCO through small penetrations on the top, initially dry the SNF under vacuum at approximately 50°C (120°F), flood the MCO with an inert gas, seal the penetrations, and place the MCO into a transportation cask. Transport the sealed MCOs in these casks via truck to the Canister Storage Building (CSB) site in the 200 East Area, and provide for temporary vented staging, as necessary. Vacuum condition the SNF in the MCOs, as soon as practicable, heating the SNF to about 300°C (570°F) to remove water that is chemically bound to the SNF and canister corrosion products, and to dissociate any reactive uranium hydride. Following conditioning, weld-seal the SNF in an inert gas in the MCOs for dry interim storage in a vault for up to 40 years. Collect the sludge removed from the basins and disposition as waste in Hanford's double-shell tanks after removal from the basin. Collect the debris from the basins and dispose of the debris as low-level waste in Hanford's existing low-level waste burial grounds. Remove and transport contaminated basin water to the 200 Area ETF for final disposal at the

200 Area State-Approved Land Disposal Site (SALDS), and replace the contaminated basin water with clean water, maintaining basin water levels. Eventually all basin water would be removed as part of facility deactivation activities.

The principal factors influencing the choice of drying/passivation with vault storage as the preferred alternative include speed of implementation, improved stability of the SNF, life-cycle cost, and beneficial reuse of an existing (but incomplete) structure (i.e., the CSB).

Affected Environment

The Hanford Site occupies approximately 1450 km^2 (560 mi^2) in south-central Washington State on the Columbia River in an area characterized as having a semiarid climate (16 cm or 6 in. of rain per year). Nearby land uses include dry and irrigated farming and commercial activities in the cities and towns. Summers are hot, and winters are mild. Severe weather is rare. The Columbia River is a large river that supplies ample potable and irrigation water. The probable maximum flood would not reach the K Basins or the 200 Areas where storage facilities could be located. The Washington State Department of Ecology classifies the water quality of the Columbia River at Hanford as Class A or excellent.

Population centers within 80 km (50 mi) of the Hanford Site are Yakima to the west and the Tri-Cities of Richland, Kennewick, and Pasco on the southeast corner of the Site. Approximately 380,000 persons live within 80 km (50 mi) of the 200 Areas. A satisfactory infrastructure exists in these communities for the implementation of any alternative discussed in this DEIS.

The Hanford Site is an attainment area for all criteria pollutants under the Clean Air Act (42 USC 7401 et seq.). However, there are occasional episodes of blowing dust on the Site, the source of which is typically recently plowed farmland adjacent to the Site.

No known cultural or historic resource is located in any area that would be impacted by any alternative. Similarly, no known federal or state threatened or endangered species is expected to be impacted by any alternative. However, the reference site for potential new storage and stabilization facilities contains sagebrush habitat that is suitable for some state and federal candidate species. This shrub-steppe habitat has been identified by the State of Washington as priority habitat. Should the reference site be chosen, suitable mitigation measures will be taken.

The potential for catastrophic earthquakes is low at the Hanford Site. A small amount of volcanic ash was deposited on the Hanford Site from the eruption of Mount St. Helens in 1980.

In 1989 the Hanford Site was placed on the National Priorities List by the U.S. Environmental Protection Agency (EPA). During the same year, the DOE, EPA, and Washington Department of Ecology signed a Federal Facilities Agreement and Consent Order (Tri-Party Agreement) to implement cleanup of the Hanford Site under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Resource Conservation and Recovery Act (RCRA), as required by the placement of Hanford on the National Priorities List. Some actions at the K Basins will be coordinated with other cleanup activities in the 100-K Area.

Since the Hanford Site began operation in 1943, it is estimated that the nearby population has received a cumulative population dose of approximately 100,000 person-rem from Hanford activities, most of which was received before 1972. For perspective, the annual natural background dose is approximately 110,000 person-rem per year for today's population of 380,000.

Environmental Consequences

As noted above in the "Proposed Action and Alternatives" section, differences in environmental impacts do not provide clear distinctions among alternatives.

The amount of land disturbed by new facilities (shrub-steppe habitat destroyed) would vary from no additional land for new facilities in the no action and enhanced K Basins storage alternatives to about 8 ha (20 acres) for onsite processing at the reference site (a previously undisturbed site adjacent to the 200 East Area). If the CSB site were chosen, no additional habitat would be disturbed, because this site is already within the developed 200 East Area. Even at the reference site, the high end of the range of habitat destruction is relatively small. However, since such an activity would further fragment shrub-steppe habitat, it is expected that this habitat destruction would be mitigated by nurturing similar habitat in other areas, for example those that have been burned out by range fires. Thus, habitat destruction is not considered to be an important discriminator among the alternatives.

Total employment ranges among the alternatives from about 4,100 worker-years for the preferred alternative (drying/passivation) to about 17,000 worker-years in the onsite processing alternative. Thus, in terms of man-power, the preferred alternative would represent a savings.

Human health impacts among the public and workers from releases of radionuclides during routine operations and incident-free transportation vary among the alternatives. However, doses are estimated to be very small fractions of the annual variation in natural background radiation dose at any given location. In the case of radiological accidents, there are scenarios in which latent cancer fatalities would be inferred if the accident were to happen. However, multiplying the consequences of each accident by the estimated annual frequency and the number of years at risk results in a point-risk estimate of latent cancer fatalities that in all cases does not exceed 1 latent cancer fatality. For perspective, the point-risk estimate of latent cancer fatalities from natural background radiation for this population (380,000) and time period (40 years) is about 2,000.

Except for the no action and enhanced K Basins storage alternatives, commitments of resources, other than water, gasoline, gases, and nitric acid are within a factor of 3 to 4 for all alternatives (it being assumed that resources equivalent to domestic processing would be required for foreign processing). The requirement for water in the onsite processing alternative would be about 10 times that for the preferred alternative; however, large water requirements would not be critical because of the abundance of water available from the Columbia River (maximum requirement of about 0.001% of annual flow) and would be within the capacity of existing supply lines. Although not required in other alternatives, sizeable quantities of gases, principally inert gases, would be required in the preferred alternative; however, there is no indication that these are in short supply. Nitric acid would be required in quantity for calcination and 10 times that for the processing alternatives, but would not be required at all in the other alternatives. Again, nitric acid is not in short supply and, also, it would be reclaimed as practicable.

While wastes would be generated in the process of implementing any of the alternatives, none of the wastes described would significantly impact Hanford's present capacity to store (as in the case of high-level and transuranic waste) or to dispose of low-level waste. Even in the case of high-level waste from onsite processing, the amount represents less than 10% of the volume of the now-remaining double-shell tank capacity.

Costs of implementing 40-year storage would range from about $1 to $4 billion. At the low end of $1 billion are enhanced K Basins storage, new wet storage, and the preferred alternative. The no action and calcine alternatives would cost about $2 billion and onsite processing about $3 billion. Costs of foreign processing would range from about $2 to $4 billion. If one assumes that processing of SNF would be required before repository acceptance, then the life-cycle costs (including 40-year storage) would be about $3 billion for enhanced K Basins storage, new wet storage, onsite processing, and the preferred alternative, and about $4 billion for no action and the foreign processing alternatives.

Regulatory Requirements

It is DOE's policy to conduct its operations in an environmentally safe and sound manner in compliance with the letter and spirit of applicable environmental statutes and regulations. Of specific interest are the permits that might be required for implementation of any of the alternatives. Air quality permits may be required for the release of oxides of nitrogen under the processing or calcination alternatives (EPA). An amendment to DOE's existing radioactive air emissions license issued by the Washington State Department of Health will be required for the emission of radionuclides to the atmosphere under any alternative, except possibly for no action. DOE will submit an application for approval of construction under the National Emission Standards for Hazardous Air Pollutants requirements for any facility under any alternative with projected radioactive emissions to the atmosphere (EPA). A National Pollutant Discharge Elimination System permit (EPA) will be required for any liquid point discharge to the Columbia River (EPA), and a discharge permit, or an amendment to an existing permit, will be required for any liquid released to the ground (Ecology). A RCRA permit will be required for the treatment, storage, or disposal of any hazardous waste (Ecology).

GLOSSARY

Terms in this glossary are defined based on the context in which they are used in this EIS.

Numerical Notation

Numbers that are very small or very large are often expressed in exponential notation. For example the number 0.000034 may be expressed as 3.4×10^{-5} and 65,000 may be expressed as 6.5×10^{4}. Multiples or submultiples of the basic units are also used. A partial list of multiples and submultiples is as follows:

Name	Symbol	Value Multiplied by	
milli	m	0.001	or 1×10^{-3}
micro	μ	0.000001	or 1×10^{-6}
nano	n	0.000000001	or 1×10^{-9}
pico	p	0.000000000001	or 1×10^{-12}
kilo	k	1,000	or 1×10^{3}
mega	M	1,000,000	or 1×10^{6}
giga	G	1,000,000,000	or 1×10^{9}
tera	T	1,000,000,000,000	or 1×10^{12}

In this EIS numerical values that are less than 0.001 or greater than 9,999 are expressed in exponential notation.

Units of Measurement

The principal units of measurement in this EIS are the SI units, a metric system accepted by the International Organization for Standardization as the legal standard at a meeting in Elsinore, Denmark, in 1966. SI is the abbreviation for Systême Internationale d'Unités. In that system most units are made up of combinations of six basic units, of which length in meters, mass in kilograms, and time in seconds are of importance in this EIS.

In this EIS values given in SI units are followed by values given in common units in parenthesis.

Acronyms and Abbreviations

ALARA	as low as reasonably achievable
bd ft	board foot, feet
BNFL	British Nuclear Fuels Limited
CBC	Columbia Basin College
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
Ci	curie(s)
CSB	Canister Storage Building
°C	degrees Celsius
dB(A)	A-weighted decibels (unit of measure for noise levels)
d	day(s)
DEIS	draft environmental impact statement
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DST	double-shell tank
DWS	drinking water standard
EA	environmental assessment
Ecology	Washington State Department of Ecology
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
E/Q	time-integrated concentration at the receptor location for an acute radiation release
ERPG	Emergency Response Planning Guide
ETF	effluent treatment facility
FFTF	Fast Flux Test Facility
FMEF	Fuels and Materials Examination Facility
FONSI	finding of no significant impact
FR	Federal Register
FRR	foreign research reactor
ft	foot, feet
ft^2	square foot, feet
ft^3	cubic foot, feet
°F	degrees Fahrenheit
g	gram(s)
gal	gallon(s)
ha	hectare(s)
HCRL	Hanford Cultural Resources Laboratory
HEPA	high-efficiency particulate air (filter)
HFSUWG	Hanford Future Site Uses Working Group

HIC	high-integrity container
hr	hour(s)
HVAC	heating, ventilation, and air conditioning
ICRP	International Commission on Radiological Protection
IDLH	Immediately Dangerous to Life and Health
in.	inch(es)
ISC2	Industrial Source Complex (computer model)
ISC2LT	Industrial Source Complex long term
ISC2ST	Industrial Source Complex short term
KE	K East
kg	kilogram(s)
kL	kiloliter(s)
km^2	square kilometer(s)
KW	K West
L	liter(s)
lb	pound(s)
LCFs	latent cancer fatalities
LWHIC	liquid waste high-integrity container
m	meter(s)
m^2	square meter(s)
m^3	cubic meter(s)
MCi	megacurie
MCOs	multicanister overpacks
MEI	maximally exposed individual
MEPAS	Multimedia Environmental Pollutant Assessment System
mg	milligram(s)
mi	mile(s)
mi^2	square mile(s)
mm	millimeter(s)
mpg	miles per gallon
mph	miles per hour
mrad	millirad
mrem	millirem(s)
mR	milliroentgen(s)
MT	metric ton
MTU	metric ton uranium
MWh	megawatt-hour(s)
National Register	National Register of Historic Places
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NO_2	nitrogen dioxide

NOI	notice of intent
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
OSHA	Occupational Safety and Health Administration
oz	ounce(s)
PCBs	polychlorinated biphenyls
PEIS	programmatic environmental impact statement
PFP	Plutonium Finishing Plant
PM_{10}	particulate matter less than 10 micrometers in diameter
PNL	Pacific Northwest Laboratory
PSD	prevention of significant deterioration
psig	pounds per square inch gauge
PUREX	Plutonium and Uranium Recovery through EXtraction
R	roentgen, a unit of radiation exposure
RIMS	Regional Input-Output Modeling System
RCRA	Resource Conservation and Recovery Act
ROD	record of decision
RTEC	Registry of Toxic Effects for Chemical
SALDS	State-Approved Land Disposal System
SI	Systême Internationale d'Unités (see "Units of Measure" section)
SNF	spent nuclear fuel
SNL	Sandia National Laboratories
SO_2	sulfur dioxide
SR	State Route
SWHIC	solid waste high-integrity container
TEDF	Treated Effluent Disposal Facility
TLV/TWA	threshold limit value/time-weighted average
Tri-Party Agreement	Hanford Federal Facility Agreement and Consent Order
TRU	transuranic
TRUSAF	Transuranic Waste Storage and Assay Facility
TWRS	Tank Waste Remediation System
μg	microgram(s)
μm	micrometer(s)
μmhos	micromhos
USC	United States Code
W	watt(s)
WAC	Washington Administrative Code
WHC	Westinghouse Hanford Company
wk	week(s)
WNP-4	Washington Nuclear Project Number 4

WSU-TC	Washington State University--Tri-Cities Branch Campus
yd^3	cubic yard(s)
yr	year(s)

Technical Terms

500-year flood A flood of such magnitude that it occurs, on average, every 500 years (equates to a 0.2% probability of occurring in any given year).

accident An unforeseeable and unplanned event.

activity A measure of quantity of a radioactive substance. The SI unit of measure is the becquerel (Bq), which is equal to one disintegration (nuclear transformation) per second. The common unit of activity is the curie (Ci), which is equal to 37 billion disintegrations per second [that number of disintegrations is approximately the disintegration rate of one gram (0.04 oz) of radium from which the original definition came]. One Ci equals 3.7×10^{10} Bq and is the unit of activity used in this EIS.

While activity gives a measure of rate of radioactive decay of a substance, if used alone, it may be misleading. The half-life of the substance, or the time it takes for one half of the activity to have disappeared is also important. For example one unit of activity of cesium-137 (half-life about 30 years) will have diminished to about 1% of the initial amount in 200 years, whereas one unit of activity of iodine-129 (half-life about 16 million years), for all practical purposes, will not have diminished at all.

background radiation Radiation from cosmic sources; naturally occurring radioactive materials, including radon (except as a decay product of source or special nuclear material); and global fallout as it exists in the environment from the testing of nuclear explosive devices. (Natural background excludes global fallout.)

board foot A common unit of measure for lumber equal to the volume of a board 1 ft wide by 1 ft long by 1 in. thick, or 144 cubic inches.

bounding The term bounding as used in bounding accidents, bounding resource commitments, etc., implies that whatever is referred to as bounding would have larger consequences than would other reasonable choices that might serve the intended purpose. For example, the consequences of constructing a three-vault facility would be bounding for those of a two-vault facility; hence, depending on the context of the analysis, only the consequences of a three-vault facility may need to be presented.

calcination The process of converting material to unconsolidated granules or powder, typically metallic oxides (also called calcining).

characterization The determination of waste composition and properties, whether by review of process knowledge, nondestructive examination or assay, or sampling and analysis, generally done for the purpose of determining appropriate storage, treatment, handling, transport, and disposal requirements.

cladding The outer jacket of reactor fuel elements usually made of aluminum, stainless steel, or zirconium alloy. Cladding is used to prevent fuel corrosion and retain fission products during reactor operation or to prevent releases into the environment during storage.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) A federal law (also known as "Superfund") that provides a comprehensive framework to deal with abandoned hazardous materials. CERCLA provides for liability, compensation, cleanup, and emergency response for hazardous substances released into the environment that could endanger public health, welfare, or the environment, as well as the cleanup of inactive hazardous waste disposal sites. CERCLA has jurisdiction over any release or threatened release of any "hazardous substance" to the environment. Under CERCLA, the definition of "hazardous substance" is much broader than the definition of "hazardous waste" under the Resource Conservation and Recovery Act, and the hazardous substance need not be a waste. If a site meets the CERCLA requirements for designation, it is ranked along with other "Superfund" sites and listed on the National Priorities List. This ranking and listing is the U.S. Environmental Protection Agency's way of determining which sites have the highest priority for cleanup.

contamination Something that pollutes, such as radioactive material in air, water, or on the ground or other surfaces.

crepuscular Active at twilight or just before sunrise.

curie (Ci) A unit used to describe the quantity (activity) of a radioactive substance. The curie is a quantity of any radionuclide that decays at a rate of 37 billion disintegrations per second (approximately the rate of decay of 1 gram of radium).

decay, radioactive A spontaneous nuclear transformation of one nuclide into a different nuclide or into a different energy state of the same nuclide by emission of particles or photons.

decommissioning The process of removing a facility from service. Decommissioning is typically preceded by decontamination of the facility.

decontamination The actions taken to reduce or remove substances that pose a substantial present or potential hazard to human health or the environment, such as radioactive contamination from facilities, soil, or equipment by washing, chemical action, mechanical cleaning, or other techniques.

DOE Orders Requirements internal to the U.S. Department of Energy (DOE) that establish DOE policy and procedures, including those for compliance with applicable laws.

dose, radiation In terms of public health and safety, a measure of the amount of ionizing radiation absorbed by the body or body tissue. The unit of absorbed dose in SI units is the gray (Gy) and is equal to the deposition of one joule of energy per kilogram of tissue. The unit of absorbed dose in common units is the rad, which is equal to the deposition of 100 ergs per gram of tissue. Various forms of radiation have different impacts on tissues and different tissues have different responses in terms of overall impact on the body.

The source of radiation may originate outside the body or inside the body as a result of inhalation, ingestion, absorption, or injection. Absorbed dose by itself is generally not sufficient as a measure of detriment or impact. As a consequence, a total effective dose equivalent (EDE) has been defined to take into account these differences and which yields a single risk-based value. Typically total effective dose equivalent, as used in this EIS, includes the 50-year committed dose from radionuclides internal to the body and the radiation dose received from external sources from a 1-year exposure (multiple exposures and cumulative dose are taken into account as appropriate). The unit of total effective dose equivalent is the sievert (Sv) in SI units and the rem in common units. One Sv equals 100 rem. (The fundamental units of effective dose equivalent are such that one sievert is equal to one joule of energy per kilogram of absorbing medium).

Typically, the total effective dose equivalent (usually referred to simply as dose in this EIS) is calculated for a "maximally exposed individual" and for populations of interest. The maximally exposed individual is that hypothetical individual who, by virtue of food consumption patterns, place of residence, etc., tends to receive the maximum dose for a given release of radionuclides to air, water, or ground. In this EIS the maximally exposed individual dose is reported in rem.

Population doses are based on doses to individuals under more typical dietary and other assumptions. The doses for various subgroups (the product of the number of individuals each receiving the same dose and that dose) are added together to obtain the collective dose to the population. In this EIS population dose is reported in person-rem.

dry storage Storage of spent nuclear fuel in environments where the fuel is not immersed in liquid for purposes of cooling and/or shielding.

environmental monitoring The process of sampling and analysis of environmental media in and around a facility being monitored for the purpose of (a) confirming compliance with performance objectives, and (b) early detection of any contamination entering the environment to facilitate timely remedial action.

fission products The nuclei (fission fragments) formed by the fission of heavy elements, plus the nuclides formed by the fission fragments' radioactive decay.

geologic repository A system for the disposal of radioactive waste or spent nuclear fuel in excavated geologic media.

groundwater Generally, all water contained in the ground. Water held below the water table available to freely enter wells.

hazardous waste Under the Resource Conservation and Recovery Act, a solid waste, or combination of solid wastes, which because of its quantity, concentration, or physical, chemical, or infectious characteristics may (a) cause, or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness; or (b) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of or otherwise managed. Source, special nuclear material, and by-product material, as defined by the Atomic Energy Act, are specifically excluded from the definition of solid waste.

high-level waste The highly radioactive waste material that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly from reprocessing and any solid waste derived from the liquid that contains a combination of transuranic and fission product nuclides in quantities that require permanent isolation. High-level waste may include other highly radioactive material that the U.S. Nuclear Regulatory Commission, consistent with existing law, determines by rule requires permanent isolation.

hydrology The study of water, including groundwater, surface water, and rainfall.

isotope One of two or more atoms with the same number of protons, but different numbers of neutrons, in their nuclei. Thus, carbon-12, carbon-13, and carbon-14 are isotopes of the element carbon, the numbers denoting the approximate atomic weights. Isotopes have very nearly the same chemical properties, but often different physical properties (for example, carbon-12 and -13 are stable, carbon-14 is radioactive).

low-level waste Radioactive waste not classified as high-level waste, transuranic waste, or spent nuclear fuel.

maximally exposed individual (MEI) A hypothetical individual whose location, time of residency, dietary habits, etc. are defined so as to maximize estimates of consequences of release of pollutants.

millirem (mrem) One thousandth of a rem (see rem).

mixed waste Waste that contains both hazardous waste under the Resource Conservation and Recovery Act and source, special nuclear, or by-product material subject to the Atomic Energy Act of 1954.

mitigation Those actions that avoid impacts altogether, minimize impacts, rectify impacts, reduce or eliminate impacts, or compensate for the impact.

nitrogen oxides (NO_x) Gases formed in great part from atmospheric nitrogen and oxygen when combustion takes place under conditions of high temperature and high pressure such as burning diesel fuel in heavy equipment; considered a major air pollutant. Two major nitrogen oxides, nitric oxide (NO) and nitrogen dioxide (NO_2) are important airborne contaminants. In the presence of sunlight, nitric oxide combines with atmospheric oxygen to produce nitrogen dioxide, which in high enough concentrations can cause lung damage.

nuclear fuel Materials that can be used in nuclear reactors to produce energy or special nuclear materials.

passivation The process of making metals inactive or less chemically reactive. For example, to passivate the surface of steel by chemical treatment.

picocurie One trillionth of a curie (see curie), or about 2 disintegrations per minute.

point-risk estimate The product of the probability of an event occurring, or the estimated frequency of the event, over the period of interest and the consequences of the event, if it were to occur. The point-risk estimate is useful as a comparative quantitative measure of potential adverse impacts arising from accidents. Thus, if accident A has a probability of 1 chance in 1,000 of 1 latent cancer fatality (LCF), it would have a point-risk estimate of 0.001 LCF. If another accident B has a probability of 1 chance in a million of 100 LCFs it would have a point-risk estimate of 0.0001 LCFs, or one-tenth the mathematical expectation of accident A. On that basis it would be more prudent to spent money to reduce the likelihood and/or consequences of accident A than accident B.

probable maximum flood The largest flood for which there is any reasonable expectancy in a specific area. The probable maximum flood is normally several times larger than the largest flood of record.

processing (of spent nuclear fuel) Applying a chemical or physical process designed to alter the characteristics (break down constituents) of the spent nuclear fuel matrix.

radioactive waste Waste that is managed for its radioactive content.

radioactivity The property or characteristic of material to spontaneously "disintegrate" with the emission of energy in the form of radiation.

record of decision (ROD) A public document that records the final decision(s) concerning a proposed action. The record of decision is based in part on information and technical analysis generated either during the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process or the National Environmental Policy Act (NEPA) process, both of which take into consideration public comments and community concerns. An ROD based on NEPA also takes into account cost and programmatic considerations.

rem The common unit of dose equivalent, effective dose equivalent, etc. The dosage of an ionizing radiation that will cause the same biological effect as 1 roentgen of x-ray or gamma-ray exposure.

repository A deep geologic facility for permanent disposal of high-level or transuranic wastes and spent nuclear fuel.

reprocessing (of spent nuclear fuel) Processing of reactor irradiated nuclear material (primarily spent nuclear fuel) to recover fissile and fertile material, in order to recycle such materials primarily for defense programs. Historically, reprocessing has involved aqueous chemical separations of elements (typically uranium or plutonium) from undesired elements in the fuel.

Resource Conservation and Recovery Act (RCRA) A federal law addressing the management of waste. Subtitle C of the law addresses hazardous waste under which a waste must either be "listed" on one of the U.S. Environmental Protection Agency's (EPA's) hazardous waste lists or meet one of the EPA's four hazardous characteristics of ignitability, corrosivity, reactivity, or toxicity, as measured using the toxicity characterization leaching procedure (TCLP). Cradle-to-grave management of wastes classified as RCRA hazardous wastes must meet stringent guidelines for environmental protection as required by the law. These guidelines include regulation of generation, transport, treatment, storage, and disposal of RCRA-defined hazardous waste. Subtitle D of the law addresses the management of nonhazardous, nonradioactive, solid waste such as municipal wastes.

risk The term risk has many interpretations; however, in this EIS risk means the product of the probability of an event occurring, or the estimated frequency of the event, over the period of interest and the consequences of the event, if it were to occur. See also point-risk estimate.

seismicity The phenomenon of earth movements; seismic activity. Seismicity is related to the location, size, and rate of occurrence of earthquakes.

SO_x A generic term used to describe the oxides of sulfur. The combination of sulfur oxides with water vapor produces acid rain (see sulfur oxides).

source term Quantity of a radioactive material or hazardous substance that causes exposure after release during normal operations or an accident.

special nuclear material (a) Plutonium, or uranium enriched in the isotope 233 or in the isotope 235, and any other material that the U.S. Nuclear Regulatory Commission, pursuant to the provisions of the Atomic Energy Act of 1954, Section 51, determines to be special nuclear material; or (b) any material artificially enriched by any of the foregoing, but does not include source material. Special nuclear material is exempt from regulation under the Resource Conservation and Recovery Act (RCRA).

spent nuclear fuel Fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated.

storage The collection and containment of waste or spent nuclear fuel, in such a manner as not to constitute disposal of the waste or spent nuclear fuel, for the purposes of awaiting treatment or disposal capacity (that is, not short-term accumulation).

sulfur oxides Pungent, colorless gases formed primarily by the combustion of fossil fuels; considered major air pollutants; sulfur oxides may damage the respiratory tract as well as vegetation (see SO_x).

transuranic waste Waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes, with half-lives greater than 20 years, per gram of waste, except for (a) high-level radioactive waste; (b) waste that the U.S. Department of Energy has determined, with the concurrence of the Administrator of the U.S. Environmental Protection Agency, does not need the degree of isolation required by 40 CFR 191; or (c) waste that the U.S. Nuclear Regulatory Commission has approved for disposal on a case-by-case basis in accordance with 10 CFR 61.

ultimate disposition The final step in which a material is either processed for some use or disposed of.

vadose zone The zone between the land surface and the water table. Saturated bodies, such as perched groundwater, may exist in the vadose zone. Also called the zone of aeration and the unsaturated zone.

vitrification The process of immobilizing waste material that results in a glass-like solid.

waste acceptance criteria The requirements specifying the characteristics of waste and waste packaging acceptable to a waste receiving facility; and the documents and processes the generator needs to certify that waste meets applicable requirements. To be distinguished from the Washington Administrative Code (WAC).

water pool A type of facility usually used for the storage of irradiated nuclear materials and spent fuel. The water shields the material being stored while allowing it to be accessible for handling. Sometimes referred to as a water pit.

wet storage Storage of spent nuclear fuel in a pool of water, or in canisters filled with water.

CONTENTS

FIGURES

TABLES

1.0 INTRODUCTION

Approximately 2,100 metric tons (2,315 tons) of spent nuclear fuel (SNF) are stored at the U.S. Department of Energy's (DOE's) Hanford Site in southeast Washington State in SNF storage basins at the K East (KE) and K West (KW) Reactors. This SNF is principally metallic uranium, but also includes about 5 metric tons (6 tons) of plutonium and about 1 metric ton (1.1 ton) of radioactive fission products. For the most part, this fuel is from the operation of the N Reactor. Some of the SNF stored in the KE Basin is damaged, and it has been estimated that about 1% of the original mass of the fuel has corroded away and become radioactive sludge (Bergsman et al. 1995).

The KE and KW Reactors and their associated SNF storage basins were constructed in the early 1950s and are located in the 100-K Area about 420 m (1,400 ft) from the Columbia River (Figures 1-1 and 1-2). Spent nuclear fuel has been stored in these basins since 1975 (KE) and 1981 (KW). The basins are unlined concrete, 4.9 million-L (1.3 million-gal) water pools with an asphaltic membrane beneath each pool. The interior of the KW Basin has been coated with epoxy. Approximately 1,200 metric tons (1,323 tons) of SNF are stored in the KE Basin under water in 3,673 open canisters. This SNF has been stored for varying periods of time ranging from 8 to 24 years. The fuel is corroding and an estimated 50 m^3 (1,800 ft^3) of sludge, containing radionuclides and miscellaneous materials, has accumulated on the floor of the KE Basin. The KE Basin has leaked water and radionuclides to the soil beneath the basin, most likely at the construction joint between the foundation of the basin and the foundation of the reactor. To mitigate the consequences of a seismic event, the construction joint in each basin has recently been isolated from the rest of the basin by metal isolation barriers.

Approximately 1,000 metric tons (1,102 tons) of SNF are stored in the KW Basin under water in 3,817 closed canisters. Because the SNF was placed in closed containers before storage, there is no appreciable sludge buildup on the floor of the KW Basin. The KW Basin is not believed to be leaking.

Candidate areas evaluated in this environmental impact statement (EIS) for the storage of SNF are shown in Figures 1-1 and 1-3.

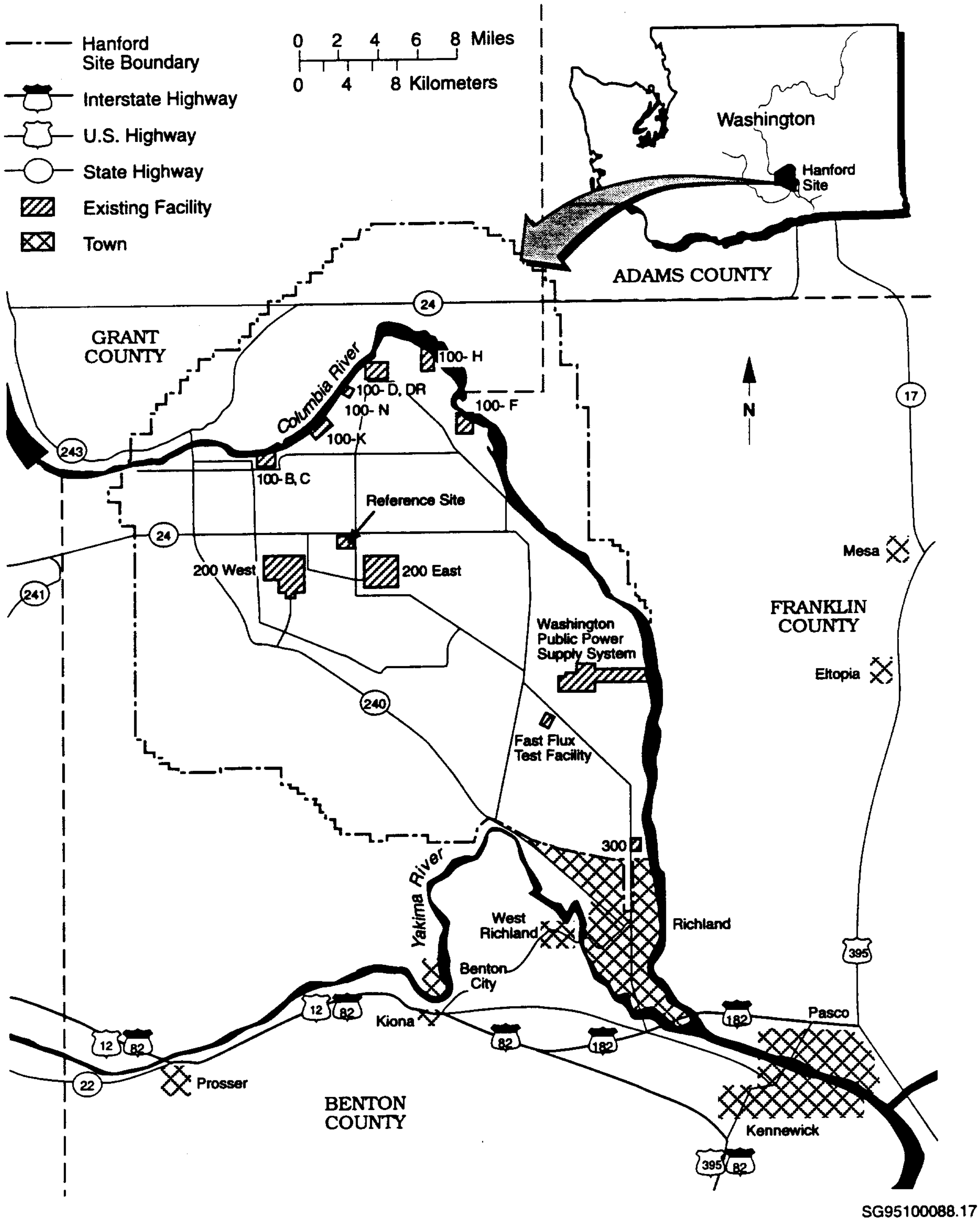


Figure 1-1. Hanford Site showing the 100-K Area, 200 East Area, and the Reference Site

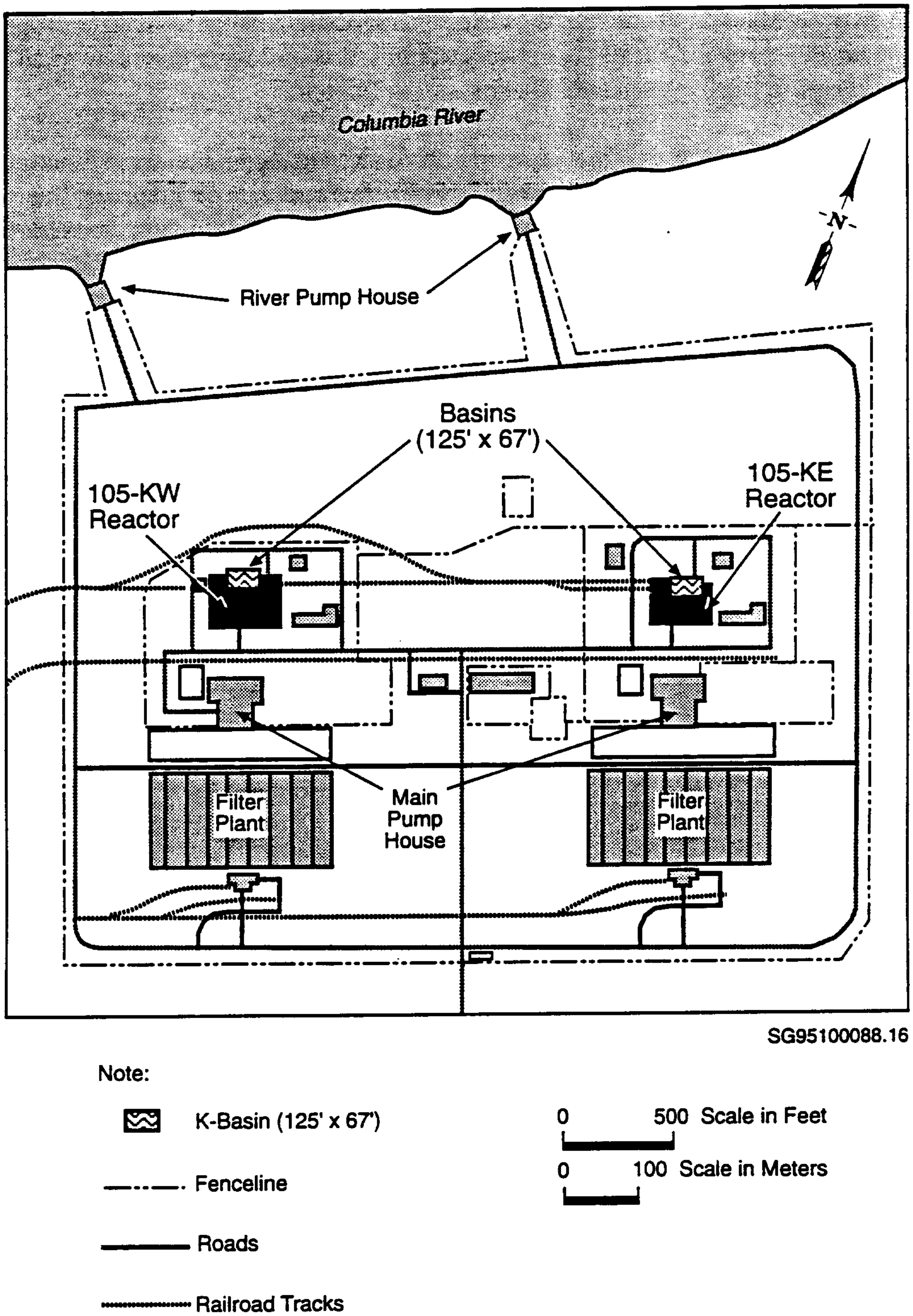


Figure 1-2. KW and KE Reactors in the 100-K Area of the Hanford Site

1.1 Advice and Consultation from Regulatory Agencies and Advisory Groups

In May 1994, the Defense Nuclear Facilities Safety Board in its recommendation 94-1 to DOE (DNFSB 1994) expressed significant concern with continued storage of SNF in the KE Basin as follows:

> "The K-East Basin at the Hanford Site contains hundreds of tons of deteriorating irradiated nuclear fuel from the N Reactor. The fuel has been heavily corroded during its long period of storage underwater, and the bottom of the basin is now covered by a thick deposit of sludge containing actinide compounds and fission products. The basin is near the Columbia River. It has leaked on several occasions, is likely to leak again, and has design and construction defects that make it seismically unsafe."

The Fourth Amendment to the Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement) among DOE, the U.S. Environmental Protection Agency (EPA) and the Washington State Department of Ecology (Ecology), dated January 1994, provides for the removal of all fuel and sludge from the K Basins by December 31, 2002. The Tri-Party Agreement is a legally enforceable agreement. In June 1995, the parties agreed to reconsider the December 2002 date following issuance of the record of decision (ROD) on this EIS.

The Hanford Advisory Board in a letter to DOE, EPA, and Ecology dated November 11, 1994 (HAB 1994) stated that:

> "[DOE, Ecology, and EPA] should continue to move toward expedited removal of spent fuel from the K-Basins as quickly as possible...";

> "Resolution of unresolved technical questions should be done expeditiously to allow timely removal of spent fuel from the basins by December 2002";

and

> "[T]he DOE, Ecology, and the EPA should not give further consideration to processing Hanford spent fuel at a foreign facility nor should they support further study of extended storage of spent fuels in the K Basins. Assume treatment of Hanford's wastes will occur on site; it is not productive to study transportation of Hanford's wastes off-site for treatment."

The Hanford Future Site Uses Working Group in its final report (HFSUWG 1992) stated:

> "To facilitate cleanup of the site, wastes from throughout the Hanford site should be concentrated in the Central Plateau, which contains over eighty percent of the known radionuclides on site."

1.2 DOE'S Programmatic Environmental Impact Statement on the Management of Spent Nuclear Fuel

In June 1995, DOE published a ROD based in part on a final programmatic environmental impact statement (PEIS), referred to as the DOE SNF Management Programmatic Environmental Impact Statement (DOE SNF PEIS), on the management of DOE-owned SNF located throughout the DOE complex (DOE 1995a). The DOE SNF PEIS examined various locations in the United States for storing SNF for approximately 40 years until decisions on ultimate disposition of the fuel are made and implemented. Ultimate disposition of the fuel includes storage of the fuel in a geologic repository or processing of the fuel to remove uranium, plutonium, and other metals as resources and disposing of the fission product waste in a geologic repository. In its ROD on SNF management, DOE elected to implement the "regionalization by fuel type" alternative. Under that alternative, SNF located in the Hanford K Basins will remain at Hanford until a decision is made on ultimate disposition of the SNF.

1.3 DOE'S Environmental Impact Statement on the Management of Spent Nuclear Fuel from the K Basins at the Hanford Site

In March 1995, DOE announced its intent to prepare a site-specific EIS on the management of SNF currently located in the K Basins at the Hanford Site (DOE 1995b). This EIS, called the Environmental Impact Statement on Management of Spent Nuclear Fuel from the K Basins at the Hanford Site, is tiered from the DOE SNF PEIS in accordance with Council on Environmental Quality regulations (40 CFR 1502.20 and 1508.28). Under the tiering process, information that appears in the programmatic EIS may be summarized in the tiered EIS and need not be repeated in detail. Therefore, some information that might ordinarily be presented in this EIS is incorporated by reference from the DOE SNF PEIS.

1.4 Other Environmental Documents Directly Related to the K Basins EIS

DOE prepared an environmental assessment (EA) in 1992 (DOE 1992b) to evaluate the environmental impacts of placing all of the SNF currently stored in open canisters in the KE Basin in sealable canisters and of placing SNF currently stored in Mark I canisters in the KW Basin in sealable canisters. A finding of no significant impact (FONSI) was issued, but these actions have not been carried out.

DOE prepared an EA in 1995 (DOE 1995f) to evaluate the environmental impacts of characterizing SNF currently stored in the K Basins. A FONSI was issued and the work is currently under way. The purpose of characterization is to evaluate the physical and chemical condition of the stored SNF to assist in the evaluation of alternative methods of treating and safely storing the SNF for up to 40 years.

DOE prepared an EA in 1995 on the transfer of SNF from the Plutonium and Uranium Recovery through EXtraction (PUREX) Plant and the N Reactor to the KE and KW Basins (DOE 1995g). A FONSI was issued for this action and DOE is presently carrying out these actions.

DOE is currently preparing an EIS on the Tank Waste Remediation System which will examine the continued management and eventual treatment, storage, and disposal of high-level radioactive wastes stored in tanks at Hanford.

1.5 Results of the Scoping Process

On March 28, 1995, DOE published a notice of intent (NOI) in the Federal Register to prepare an EIS on the Management of Spent Nuclear Fuel from the K Basins at the Hanford Site (DOE 1995b).

In the NOI, the DOE stated that its proposed action is to take expeditious action to reduce risks to public health and the environment by removing SNF from the K Basins and, subsequently, to take action to manage the SNF in a safe and environmentally sound manner for up to 40 years or until ultimate disposition decisions are made and implemented.

The NOI initiated a scoping process that ended on May 12, 1995. The purpose of scoping is to determine whether or not there are any actions, alternatives, or impacts that should be considered in the EIS that were not already listed in the NOI (40 CFR 1508.25). The results of the scoping process are presented in DOE's implementation plan, which was published in October 1995 (DOE 1995c). In summary except for cask storage, no new

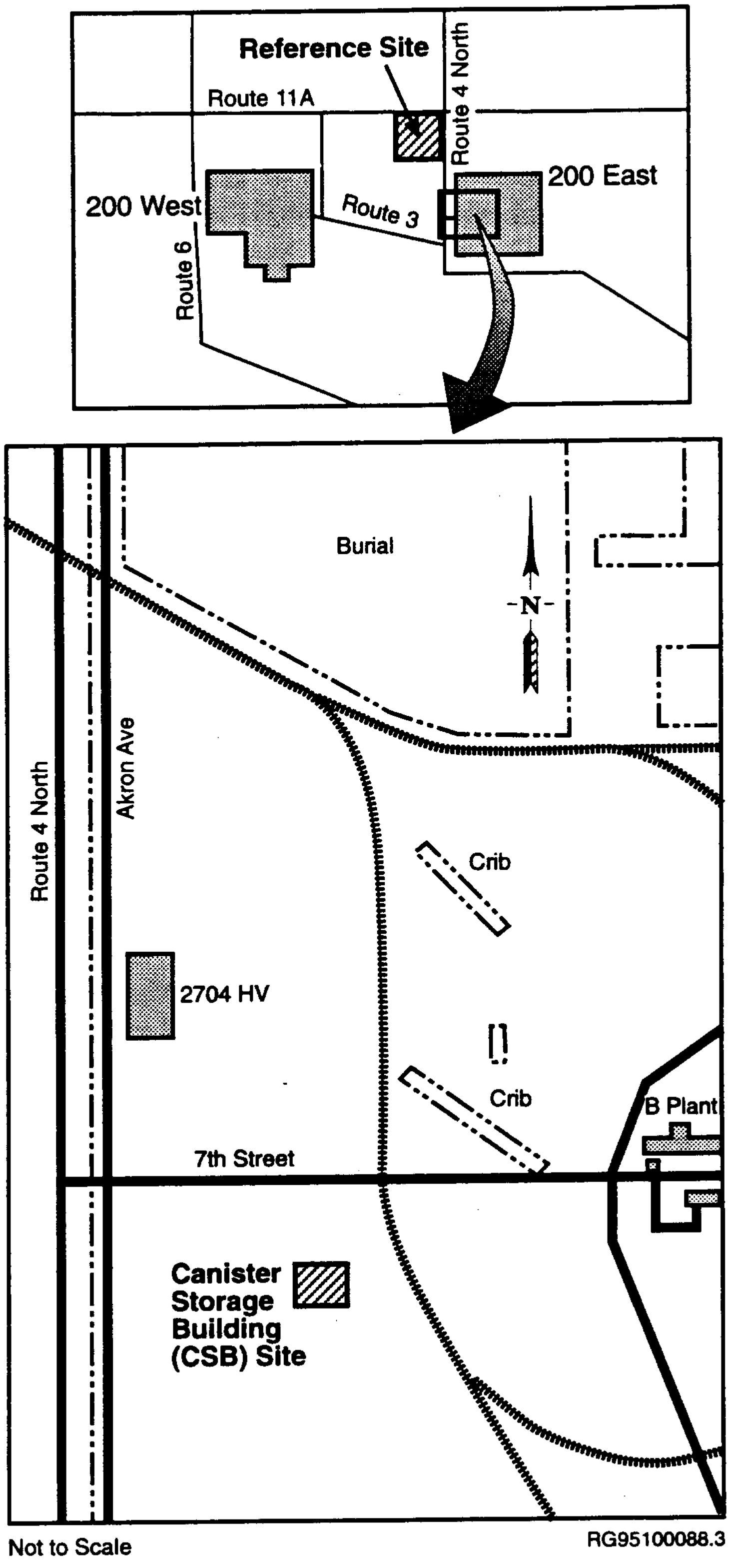


Figure 1-3. Locations of sites proposed for storage of SNF: the reference site and the Canister Storage Building site

actions, alternatives, or impacts were identified. Some alternatives suggested during the scoping process were dismissed from detailed discussion, as follows:

- Storage of SNF at the Washington Public Power Supply System abandoned plant WNP-4, the N Reactor, or the Fast Flux Test Facility (FFTF). The WNP-4 spray cooling pond, like the K Basins, has the disadvantage of being near the Columbia River. The N Reactor Basin is not large enough to accommodate K Basin fuel and is also near the river. The FFTF is less isolated from groundwater and population centers than the 200 Area.

- Storage of SNF at Hanford for up to 500 years rather than for 40 years. Although storage of SNF at Hanford for up to 500 years might be possible, present designs are extendable to only about 75 years. The 40-year period analyzed in this EIS and alternative disposition of SNF would not preclude further design and later adoption of a longer interim-storage period, if warranted. However, DOE's policy is to provide for long-term SNF storage in a geologic repository (DOE 1995d).

1.6 Other Issues

Metallic uranium is thermodynamically unstable with respect to its common oxides and with respect to uranium hydride. Similarly uranium hydride is thermodynamically unstable with respect to the oxides of uranium (Latimer 1952). These reactions require a supply of oxygen (air or water) to begin and to continue. The kinetics (rapidity) of the reactions depend on a number of other factors including the temperature of the uranium and the state of aggregation of the uranium (the larger the ratio of surface area to volume the more rapid the reaction). Under some conditions, metallic uranium can catch fire. This property was noted in testimony on the DOE SNF PEIS (BNFL 1994) and is discussed in the technical information document prepared by Westinghouse Hanford Company for the K Basins SNF EIS (Bergsman et al. 1995). This instability is of technical concern for the future management of K Basins SNF, as are two other well-known properties of SNF. These other properties are the intense radioactivity of SNF and the ability in certain geometric configurations to initiate (but not sustain) a nuclear reaction. For the purposes of this EIS, it is only necessary to determine the impacts of these properties during routine operations and under reasonably foreseen accident conditions. These impacts are evaluated in the EIS.

1.7 Record of Decision

Following final publication of the EIS, the DOE will publish an ROD on management of K Basins SNF at the Hanford Site. This ROD will be based in part on environmental impact information presented in this EIS. The ROD will also be based on information outside the scope of this EIS, for example, engineering feasibility information, the factors discussed in Section 1.6, and information on criteria for acceptance of DOE-owned SNF at a repository, which have not yet been fully determined.

2.0 PURPOSE AND NEED

The purpose of and need for DOE's action is to reduce risks to human health and the environment, specifically 1) to prevent the release of radioactive materials into the air or the soil surrounding the K Basins and the potential migration of radionuclides through the soil column to the nearby Columbia River, 2) to reduce occupational radiation exposure, and 3) to eliminate the risks to the public and to workers from the deterioration of SNF in the K Basins (DOE 1995b).

3.0 DESCRIPTION OF ALTERNATIVES AND COMPARISON OF IMPACTS AMONG THE ALTERNATIVES

Proposed Action:

DOE's proposed action is to reduce risks to public health and safety and the environment by removing SNF from the K Basins and, subsequently, to manage the SNF in a safe and environmentally sound manner for up to 40 years or until ultimate disposition decisions are made and implemented.

A range of alternatives for removal, staging, treatment, and subsequent management of K Basins SNF is described and compared in this chapter. A summary description of the alternatives is given in Section 3.1, details of the alternatives are provided in Section 3.2 with additional details in Appendix A, and a comparison of impacts among the alternatives is given in Section 3.3. Further detail is provided in Bergsman et al. (1995).

3.1 Summary Description of Alternatives

The alternatives together with their principal functional advantages and disadvantages are summarized as follows:

- **no action alternative**: continue present storage in the KE and KW Basins for up to 40 years with no modifications except for maintenance, monitoring, and ongoing safety upgrades. [Consideration of the no action alternative is required by Council on Environmental Quality regulations (40 CFR 1502.14).]

  The principal advantage of the no action alternative is that it would require no movement of SNF and no construction of new facilities.

  The principal disadvantages of this alternative are that the K Basins were never designed for an 80-year life (40 years to date and up to an additional 40 years) and would require increasing maintenance of aging facilities with associated increased radiological impacts on workers, would not place the SNF in a safer storage configuration, would not preclude leakage of radionuclides to the soil beneath the basins and near the Columbia River, would fail to alleviate concerns expressed by authoritative bodies and the public relative to environmental impacts induced by seismic events, and would not satisfy the *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) commitments.

- **enhanced K Basins storage alternative**: perform facility life extension upgrades for KW Basin, containerize KE Basin SNF and sludge, and consolidate with KW Basin SNF for up to 40-year storage.

  The principal advantages of the enhanced K Basins storage alternative are that it would remove degrading SNF from the KE Basin, permit deactivation of the KE Basin, and would require no construction of new facilities.

  The principal disadvantages of this alternative are that the K Basins were never designed for an 80-year life and would require increasing maintenance of the aging facilities despite completion of practical upgrades, would not arrest continued fuel degradation and might result in production of uranium hydride in the transferred KE Basin SNF, would fail to alleviate concerns expressed by authoritative bodies and the public relative to environmental impacts induced by seismic events, and would not satisfy Tri-Party Agreement commitments.

- **new wet storage alternative**: remove SNF from the K Basins and provide for up to 40 years of new wet storage in a new facility that meets current design criteria.

  The principal advantages of the new wet storage alternative would be accelerated removal of SNF from aging facilities near the Columbia River, would make use of a proven storage technology coupled with design to modern seismic criteria, and would maintain flexibility for preparing SNF for ultimate disposition.

  The principal disadvantages of this alternative are that it would require construction expense and continued maintenance, would reduce but not prevent the continuation of SNF degradation, and would not eliminate the potential for further hydriding of the SNF.

- **drying/passivation (conditioning) with dry storage**: remove SNF from the K Basins, condition [i.e., dry (remove free and bound water)], oxidize exposed reactive areas of the fuel under controlled conditions, seal in canisters filled with an appropriate storage atmosphere, and provide for up to 40-year dry storage in a new vault or cask facility.

Drying/passivation (conditioning) with dry vault storage, incorporating the options shown below, represents DOE's preferred alternative:

- remove K Basin SNF from existing canisters, clean, and desludge
- repackage the SNF into fuel baskets designed for multicanister overpack (MCO) dimensions, which would include provision for water removal, SNF conditioning requirements, and criticality control
- after loading SNF into the MCOs, welding on the top, and draining the MCOs through small penetrations on the top, initially dry the SNF under vacuum at approximately 50°C (120°F), flood MCOs with inert gas, seal penetrations, and place in transportation casks
- transport the SNF (in MCOs) in these casks via truck to the Canister Storage Building (CSB) site in the 200 East Area, and provide for temporary vented staging, as necessary
- vacuum condition the SNF in MCOs, as soon as practicable, heating the SNF to about 300°C (570°F) to remove water that is chemically bound to the SNF and canister corrosion products, and to dissociate any reactive uranium hydride present
- following conditioning, weld-seal the SNF in an inert gas in the MCOs for dry interim storage in a vault for up to 40 years
- collect the sludge removed from basins and disposition as waste in Hanford's double-shell tanks (DSTs) after removal from the basin
- collect the debris from the basins and dispose of as low-level waste in Hanford's existing low-level waste burial grounds
- remove and transport contaminated basin water to the 200 Area Effluent Treatment Facility (ETF) for final disposal at the 200 Area State-Approved Land Disposal Site (SALDS), and replace the contaminated basin water with clean water, maintaining basin water levels. (Eventually all basin water would be removed as part of facility deactivation activities.)
- prepare the K Basins for deactivation and turn over to decontamination and decommissioning program.

The principal advantage of the drying/passivation (conditioning) with dry storage alternative (either vault or cask) is that it would accelerate removal of SNF from aging facilities near the Columbia River, would result in passive dry storage of SNF requiring only minimal surveillance, would retard continued degradation of the SNF, and would reduce or eliminate hydrides in the SNF.

Principal disadvantages of this alternative are that new facilities would be required and some uncertainties exist regarding the chemical state and pyrophoric nature of the SNF and sludge in the KE and KW Basins, and the extent to which drying and passivation processes would be required to successfully reach the desired end state. Defense-in-depth measures (multiple barriers to prevent or mitigate the release of radionuclides) can be engineered to ensure the safety of the process; characterization of K Basins SNF is currently being conducted to reduce these uncertainties and make possible a more cost-effective conditioning process.

- **calcination with dry storage**: remove SNF from the K Basins, calcine, and provide for up to 40-year dry storage of SNF-oxides in a new cask or vault facility.

  The principal advantage of the calcination with dry storage alternative is that it would convert the SNF into stable oxides, which are readily storable in a dry form and may be suitable without further processing for ultimate disposal in a geologic repository.

  The principal disadvantage of this alternative is the need to construct and operate a new calcining facility.

- **onsite processing**: remove and chemically process K Basins SNF and provide for up to 40-year dry storage of the recovered uranium (as uranium trioxide) and plutonium (as plutonium dioxide), and manage fission product waste in Hanford's DSTs.

  The principal advantages of the onsite processing alternative are that it converts uranium (the major constituent of SNF) into uranium trioxide that is readily storable in dry form and for which future use (constituent of power reactor fuel) might be found; converts plutonium to a stable oxide for which a future use (constituent of power reactor fuel) might be found or for which storage in a geologic repository may be suitable without further processing; and converts fission products into a form suitable for storage in a geologic repository.

The principal disadvantages of this alternative are the need to construct and operate a relatively expensive separations facility, the plutonium dioxide product is no longer self-protecting and would require special storage and accountability that in turn may require construction of additional storage capacity, and no immediate need exists for either the separated uranium or plutonium.

- **foreign processing**: remove K Basins SNF, ship overseas for processing, provide for up to 40-year dry storage of returned uranium (as uranium trioxide) and plutonium (as plutonium dioxide), and store vitrified fission product waste, pending ultimate disposition.

  With the exception that foreign processing would obviate the need for construction of additional processing facilities at Hanford, the principal advantages of the foreign processing alternative are essentially the same as those for onsite processing.

  The principal disadvantages of the foreign processing alternative are the need to transport Hanford's SNF to a U.S. shipping/receiving port, transload the SNF to ocean vessels, ship the SNF to a foreign port, transport the SNF to an operating reprocessing plant, and ship the uranium and plutonium products and vitrified high-level waste back to Hanford. Additional disadvantages include uncertainties about the feasibility of shipping the degraded fuel overseas, costs of new shipping casks, and construction of a new head-end facility at the processing plant. The need for special storage for plutonium product would be the same as in the onsite processing alternative.

In all but the no action alternative, sludge, debris, and existing contaminated water would be removed from the basins and although there are options for their treatment, those options are essentially invariant among the alternatives. To facilitate expedited removal of the SNF from the K Basins, all alternatives, except for the no action and enhanced K Basins storage alternatives, would likely use some form of temporary storage (staging) at the CSB site or the reference site. In the case of the new wet storage alternative, staging would not be necessary.

The CSB site within the 200 East Area is DOE's preferred site for new facilities for interim storage of SNF. The quarter-section reference site located adjacent to the north-west corner of the 200 East Area (see Figure 1-3) is an alternative site taken to be representative of a number of possible alternative sites [previously disturbed (inside 200 East or 200 West Areas) or undisturbed] on the 200 Areas plateau which may have equivalent attributes for siting new facilities for interim storage of SNF.

For reasons described in Section 3.1.8, the following alternatives were considered but dismissed from detailed evaluation:

- **WNP-4 wet storage**: remove K Basins SNF and transfer to wet storage in modified WNP-4 Spray Cooling Pond.
- **N Reactor Basin storage**: remove K Basins SNF and transfer to wet storage in N Reactor Basin.
- **FFTF/Fuels and Materials Examination Facility (FMEF) storage**: remove K Basins SNF and transfer to dry storage at the FFTF/FMEF.
- **offsite disposition**: remove K Basins SNF and transfer to another DOE site for storage and/or processing.

3.2 Details of Alternatives

Details of the alternatives evaluated are presented in the following subsections. In each of the alternatives there are a number of options that could be taken to accomplish the same objective and that would have similar impacts within that alternative. The descriptions that follow are intended to provide a general description of what might be done and to permit encompassing the associated environmental impacts. These should not be construed as the exact process steps that would be performed if an option were selected (e.g., operating temperatures, inert gases, etc., may change during process development).

3.2.1 No Action Alternative

In this alternative, present storage in the K Basins would continue for up to 40 years with no modifications except for maintenance, monitoring, and ongoing safety upgrades (analysis of the no action alternative is required by 40 CFR 1502.14). Current activities to maintain and operate the K Basins would continue, for example:

- completing day-to-day activities required to maintain storage of K Basins SNF in conformance with the existing safety authorization basis

- providing requisite control and accountability of special nuclear materials in the K Basins in conformance with DOE Orders

- establishing and maintaining a program at the K Basins to improve safety of ongoing operations

- improving water cleanup by providing redundant systems to ensure that adequate ion exchange capability is always available

- minimizing loading of the ion exchange modules with transuranic (TRU) radionuclides thereby reducing the amount of TRU waste requiring disposal

- retrieving, packaging, and shipping samples of K Basins SNF and sludge to other Hanford Site facilities for characterization

Upgrades to four essential systems at the K Basins would be completed as follows:

- **water supply and distribution system**: the 100-K Area water supply and distribution upgrade would replace the existing oversized (because the reactors are shut down) and inefficient system and result in a reliable, energy-efficient source of clean water for area operations. The upgraded water supply system would be sized to accommodate operational consumption that is anticipated to be 110 m^3 (30,000 gal) or less per day.

- **fire protection system**: fire protection for the 100-K Area needs to be upgraded to bring the fire protection systems in the operational areas of 105-KE, 105-KW, and 190-KE into compliance with fire protection program requirements. This activity would consist of installing automatic fire suppression systems and fire protection features in the KE Reactor, KW Reactor, 165-KE, and 190-KE buildings.

- **100-K Area electrical supply system**: this proposed upgrade would consolidate the 4,160-volt distribution system into the 151-KE sub-station yard and the 165-KE distribution switchboards, with feeds to the KE and KW Buildings. The upgrade would also reconfigure the motor control centers in the KE and KW Buildings.

- **maintenance shop/support facility**: this activity would result in restroom upgrades and other minor repairs of the existing 1717-K maintenance building. Additional shop space would be provided by a new 500 m^2 (5,000 ft^2) building built adjacent to the 1717-K Building.

In addition to the above listed activities, roof upgrades will be completed for KE and KW buildings.

Also, work would be carried out to reduce the radiation levels in the storage bays and the surrounding pits, which in turn would reduce worker dose. Activities could include high-pressure pipe cleaning, coating basin walls, installing of shielding, and possibly replacing facility components.

Aside from the above activities, if the no action alternative were selected, SNF in KW and KE Basins would continue to be stored as at present. The SNF inventory would include material currently in the Plutonium and Uranium Recovery through EXtraction (PUREX) Plant and N Basin.

3.2.2 Enhanced K Basins Storage Alternative

Enhanced K Basins storage would involve consolidation of the SNF in the KW Basin and would include the upgrade activities identified in Section 3.1.1 and the following reference options (a set of options likely to be selected, if DOE were to choose this alternative). SNF would not be removed from the 100-K Area:

- containerize fuel to isolate KE Basin SNF from the basin water
- consolidate K Basins SNF at the KW Basin
- manage sludge; collect sludge from KE Basin and transfer to the tank farms
- remove debris from basins and dispose of it in existing low-level waste burial grounds
- remove and transport contaminated KE basin water to the 200 Area ETF for final disposal at the 200 Area SALDS, and replace the contaminated basin water with clean water, maintaining basin water levels. (Eventually all basin water would be removed as part of facility deactivation activities.)

- conduct life extension upgrades for continued storage at the KW Basin through the year 2035

- deactivate the KE Basin.

A schematic diagram of the enhanced K Basins storage activities is provided in Figure 3-1. A schedule of activities is provided in Figure 3-2. A description of the enhanced K Basins storage activities is as follows.

Containerization

The SNF currently packaged in open top canisters in the KE Basin would be repackaged to isolate it from the basin water. Two containerization options are currently envisioned. These are:

- placing the existing fuel canisters into overpacks that can be sealed to isolate the fuel from the basin water

- encapsulating the fuel by repackaging into sealed Mark II canisters as was previously done for the KW Basin and repackaging fuel currently in the KW Basin that is in Mark I aluminum canisters.

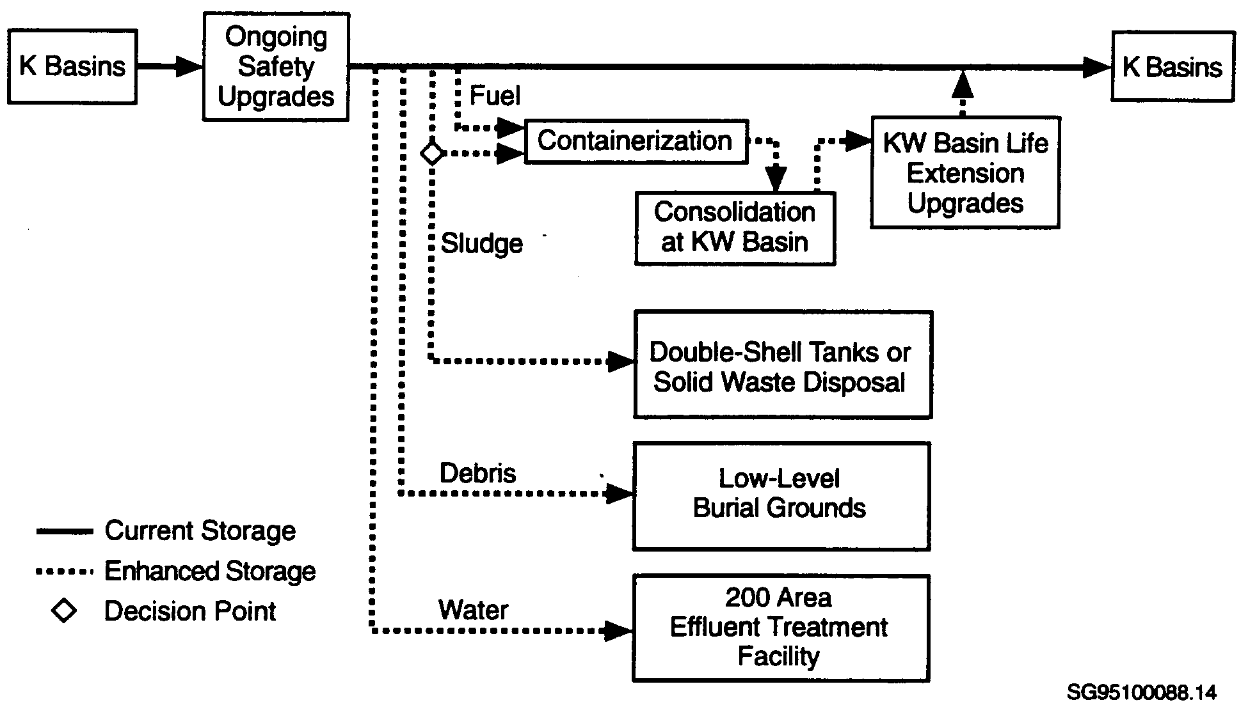


Figure 3-1. Enhanced K Basin storage alternative activities

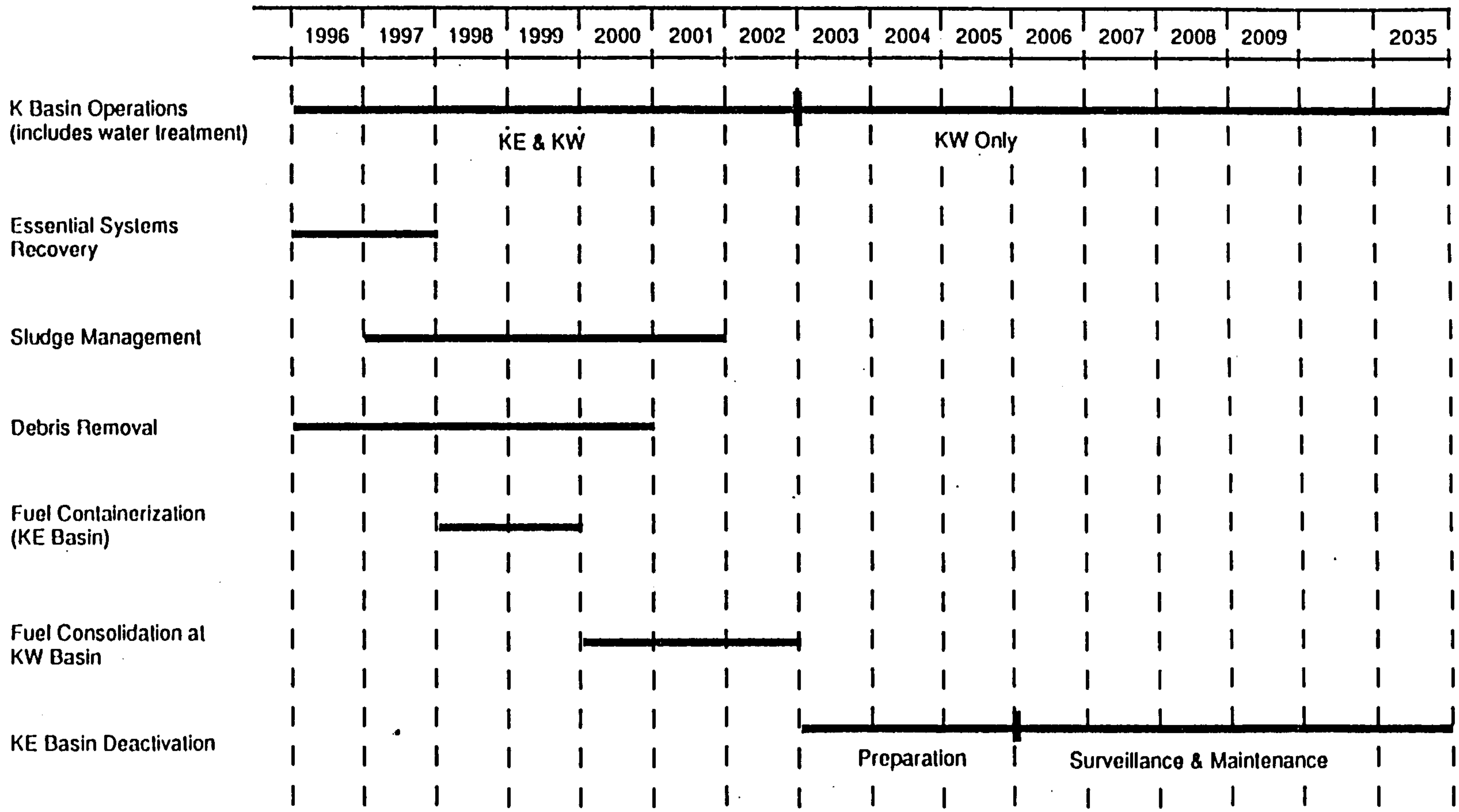


Figure 3-2. Summary schedule of enhanced K Basin storage alternative (Bergsman et al. 1995)

Containerization would likely involve overpacking existing canisters; however, the EIS impact analysis is based on a previous proposal involving encapsulation (DOE 1992b) because the earlier analysis provides a more conservative estimate of overall impacts, which would likely bound the impacts for overpacking (i.e., the impacts of encapsulation would be greater than the impacts of overpacking existing containers).

Repackaging or overpacking equipment would be installed at the basins. Pieces of SNF and SNF fines too small to be retrieved [<0.64 cm (1/4 in.)] would be placed in a container and dispositioned with the sludge.

Consolidation

Containerized SNF from KE Basin would be consolidated with SNF in KW Basin. Consolidation would include:

- installation of new multitiered storage racks in the KW Basin and making minor facility modifications to increase SNF storage capacity
- transfer of containerized fuel from the KE Basin to the KW Basin
- disposition of excess KW Basin water [approximately 280 m^3 (10,000 ft^3)], which would be displaced by the addition of the new storage racks; handled through temporary higher water levels and evaporation losses.

Sludge Management

The KE Basin contains sludge, which is located outside fuel canisters as well as inside. The sludge located outside of the fuel canisters contains fuel corrosion products and small fuel pieces that have fallen out of the perforated bottoms of canisters or were released during fuel sorting and repackaging activities. The sludge also contains iron and aluminum oxide from the storage racks and canisters, concrete grit from the basin walls, fission and activation products from the fuel, and other materials (including sand and dust from the outside environment). The estimated volume of this sludge is about 50 m^3 (1,800 ft^3). The sludge contained in the open canisters is assumed to contain fuel corrosion products that have mixed with dust and debris.

The KW Basin also contains sludge located outside of fuel canisters as well as inside. Visually, the sludge that is located outside of the sealed fuel canisters appears to consist primarily of dust that has been deposited on the floor since use of the facility was restarted following coating with epoxy. The estimated volume of sludge is 4 m^3 (140 ft^3). The sludge inside of the sealed fuel canisters is assumed to consist primarily of fuel corrosion products.

For the enhanced K Basins storage alternative, sludge within the canisters would not be segregated; it would be left in the canisters and managed as SNF. The sludge on the floor of the KW Basin is expected to be categorized as low-level waste upon removal from the basin. It would be grouted (mixed with cementitious material) at the K Basins and transported to the 200 Area for disposal at the Solid Waste Operations Complex, or it may be transported similarly to other sludge for management at the tank farms.

Two sludge management options exist for the KE Basin floor sludge under the enhanced K Basins storage alternative. The options would be to transfer the floor sludge to Hanford's DSTs or solid waste disposal facilities, depending on material characteristics, or continue management of sludge as SNF and transfer the sludge to the KW Basin. The KE Basin floor sludge transfer to tank farms is presented as the representative approach for managing the KE Basin floor sludge as waste.

Waste categories that the sludge may fit into are mixed and/or transuranic. The actual category associated with each type of sludge would be determined through a characterization process.

The actions required for sludge management assuming disposition to DSTs would be as follows.

1. **retrieval of the sludge**: sludge may be retrieved using manually operated equipment, remotely operated equipment, or a combination of the two. Because sludge is intermixed with basin components, sludge retrieval in some cases would be integrated with activities associated with fuel, debris, and water management.

2. **separation/segregation of the sludge**: sludge in the basins varies considerably from light flocculent particles that are easily suspendable to heavy granules and chunks of fuel or cladding. The sludge on the floor of the K Basins also contains debris. Because no single process may be suitable for all of these materials, some separation/segregation may be appropriate. Separation/segregation would be performed within the K Basins buildings.

3. **loading and transporting sludge**: sludge meeting DST acceptance criteria would be loaded into a 3- to 6-m^3 (100- to 200-ft^3) shielded, high-integrity container for transportation to the 200 East Area tank farms. Load-out operations would be performed at the K Basins facility. The load-out area would include installation of a spill pad and a weather shell to permit year-round operation. Connection of the load-out system to the transport container may be a manual operation; however, the load-out system would be expected to be remotely operated. For purposes of this analysis it is assumed that KE Basin floor sludge would meet DST acceptance criteria, with separation of unacceptable particle sizes, if necessary. The transport container would be transported using a standard, "low-boy" trailer. The transport vehicle would use existing roads, none of which are open to the general public. If the sludge were to be transported to tank farms, 50 to 100 shipments are assumed to be required. If the floor sludge were to be transported to the KW Basin for continued storage, approximately 2,000 Mark II containers are estimated to be required.

4. **offloading sludge at 200 Areas tank farms**: sludge transported to the tank farms would be unloaded by directly pumping the contents of the transport container into a DST riser. A spill pad and associated piping and controls would be installed. The transport container is assumed to be manually connected to the offloading system and that offloading operations would be performed remotely. Also, some chemical adjustment is assumed to be required to make sludge suitable for storage in a tank, e.g., adjustment of pH. Small adjustments with chemicals, such as hydroxide, nitrite, and nitrate, would be likely be performed during the offloading process. Any spills or drips would be contained within a concrete spill pad and pumped into the DST.

If a decision were made to manage the sludge (currently dispersed throughout the K Basins) as SNF, the sludge would be containerized and moved to the KW Basin.

Debris Removal

Debris in the K Basins includes discrete non-SNF items such as empty canisters or other equipment and the storage racks used to hold the SNF canisters. Debris is defined as anything that is over 0.6 cm (1/4 in.)[a] in diameter that is not physically attached to the basin or any permanent structure within the basin, is not used for current or planned operations or maintenance activity, and is not SNF. The debris includes such things as up to 2,000 unused fuel canisters, old equipment, hand tools, and miscellaneous scrap. Most of the debris other than the storage racks is in the KE Basin.

Debris would be generally be removed using existing equipment, including cranes and tongs, although some use of new special equipment might prove necessary. Debris may be collected on screens as sludge is removed from the pools. A high-pressure water-jet cleaning system would be used to decontaminate debris under water. During removal from the basin water, the debris would be rinsed, drip-dried, and then bagged while in a "greenhouse" containment structure to prevent release of loose contamination.

The radioactive waste volume of the debris may be reduced by mechanical compaction and/or cleaning. Development and testing of the debris removal equipment would occur at other existing facilities.

Water Disposition

About 4,500 m^3 (1.2 million gallons) of water would remain in the KE Basin following removal of the fuel, sludge, and debris. This water is contaminated with radionuclides including tritium. Most radionuclides can be removed from water using the existing filtering and ion exchange treatment methods. Tritium, although present only in small amounts (<20 Ci), cannot be effectively separated from the water. Contaminated basin water may be transported to the 200 Area ETF for final disposal into the 200 Area SALDS. This removed water would be replaced with clean water, maintaining the KE Basin water level. Eventually all basin water would be removed as part of facility deactivation activities.

(a) The size is based on considerations for criticality prevention and the maximum size that can be passed through typically used sluicing pumps with minimal expectation of damage to the pumps.

Life Extension Upgrades

Life extension upgrades would be completed to enable continued storage at the KW Basin through the year 2035. The extent of upgrades for that period is contingent on the continued performance of KW Basin systems and applicable regulatory criteria. The following upgrades are assumed to be completed:

- heating, ventilating, and air conditioning upgrades that may be necessary to provide confinement by installing a high-efficiency particulate air filtration system

- security system upgrades.

KE Basin Deactivation

KE Basin deactivation would follow removal of fuel, sludge, and debris from the basin. Deactivation includes KE Basin preparations for turnover to DOE's decommissioning program and surveillance and maintenance before implementing decommissioning. An analysis of environmental impacts associated with decommissioning eight Hanford reactors, which included the K Basins, was presented in *Surplus Production Reactor Decommissioning EIS* (DOE 1989) and is not repeated in this EIS.

3.2.3 New Wet Storage Alternative

In the new wet storage alternative, the SNF in the K Basins would be relocated to a wet storage facility away from the Columbia River and the K Basins prepared for turnover to DOE's decommissioning program. This alternative is depicted in Figure 3-3.

Two approaches were evaluated for new wet storage:

- a new wet pool would be constructed on the 200 Areas plateau (reference site or CSB site) that provides an equivalent level of safety to current storage criteria identified in 10 CFR 72 for commercial SNF

- a new vault would be constructed on the 200 Areas plateau (reference site or CSB site), where the fuel would be stored in water-filled MCOs.

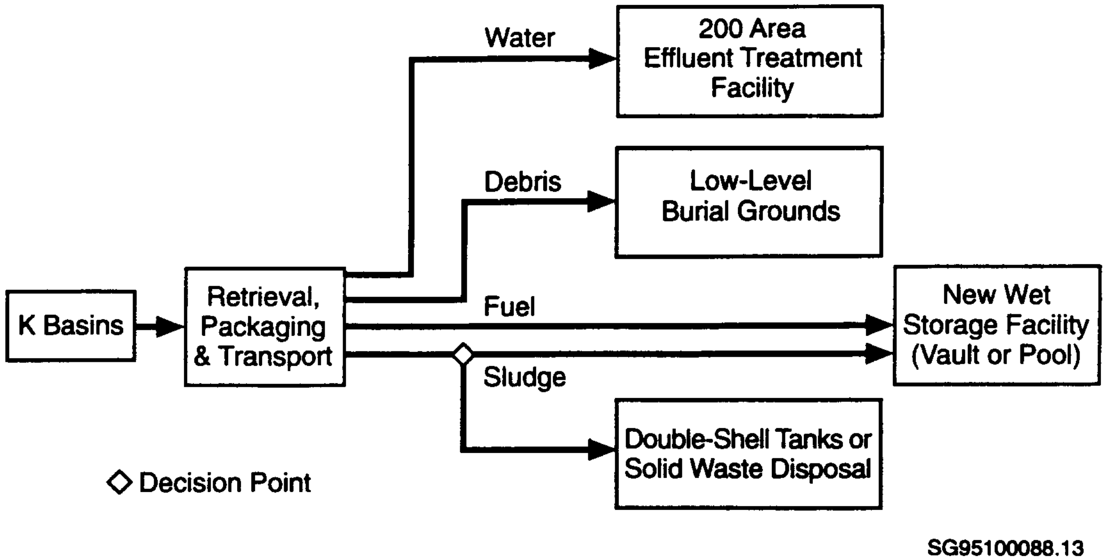


Figure 3-3. New wet storage alternative activities

The steps for implementing the reference options in the new wet storage alternative would be as follows:

- continue K Basin operations until the removal of fuel, sludge, and debris and disposition of water are completed

- retrieve the canistered fuel from the existing storage positions, placing the canistered fuel into water-filled MCOs, placing the MCOs in transport casks, and transporting the fuel wet via truck to a new wet storage facility at the CSB site

- store the SNF in water-filled MCOs in dry storage tubes in concrete-enclosed shielding vaults

- retrieve the sludge, containerize in MCOs, and store at new wet storage facility as SNF

- retrieve and dispose of debris at the 200 Areas low-level waste burial grounds

- remove and transport contaminated KE Basin water to the 200 Area ETF for final disposal at the 200 Area SALDS, and replace the contaminated basin water with clean water, maintaining basin water levels. (Eventually all basin water would be removed as part of facility deactivation activities.)

- prepare the K Basins for deactivation and turn over to the decontamination and decommissioning program.

A summary schedule for the new wet storage alternative, which assumes construction at the CSB site, is shown in Figure 3-4.

K Basins Operation

The K Basins would continue to operate during the SNF, sludge, and debris removal. K Basins operation would be as described in the no action alternative in Section 3.1.1, with no modifications except for ongoing safety upgrades and those modifications required to support fuel retrieval.

Fuel Retrieval

MCOs would be designed to hold canisters of fuel and sludge during transport and storage. They would be approximately 0.6 m (24 in.) outside diameter and 4.6 m (15 ft) high and made of stainless steel, nominally 1 cm (3/8 in.) thick. The MCOs would have a removable, but sealable, thick-walled top closure, with features allowing monitoring of internal conditions and venting of any excessive gas. The thick-walled top provides sufficient shielding to allow operator access to the monitoring and venting features of the top closure, and to seal and leak-check the MCO before shipment. The MCOs would be capable of holding nominally 10 fuel canisters each, arranged in five layers with two canisters in each layer.

The SNF canisters would be packaged in the MCOs at existing K Basins facilities. The transport cask containing the MCO would be removed from its conveyance, the cask lid and then the MCO top closure would be removed, and the cask would be submerged underwater in the cask load-out pit using the K Basins overhead cranes.

The existing fuel canisters would be placed into the MCOs "as is." An existing fuel canister, which may hold fuel elements or SNF sludge, would be lifted out of the storage rack, so it clears the rack but would still be under at least 2.4 m (8 ft) of water, using the canister handling trolley system. The lids of the canisters in the KW Basin would be removed. The SNF canister would be transported to the cask load-out pit. At the load-out pit, the canister would be lifted toward the surface of the water, placed over the open MCO, and lowered into it.

Additional canisters would be loaded into the MCO one at a time until the 10 canisters were loaded. The shielded top closure of the MCO would be

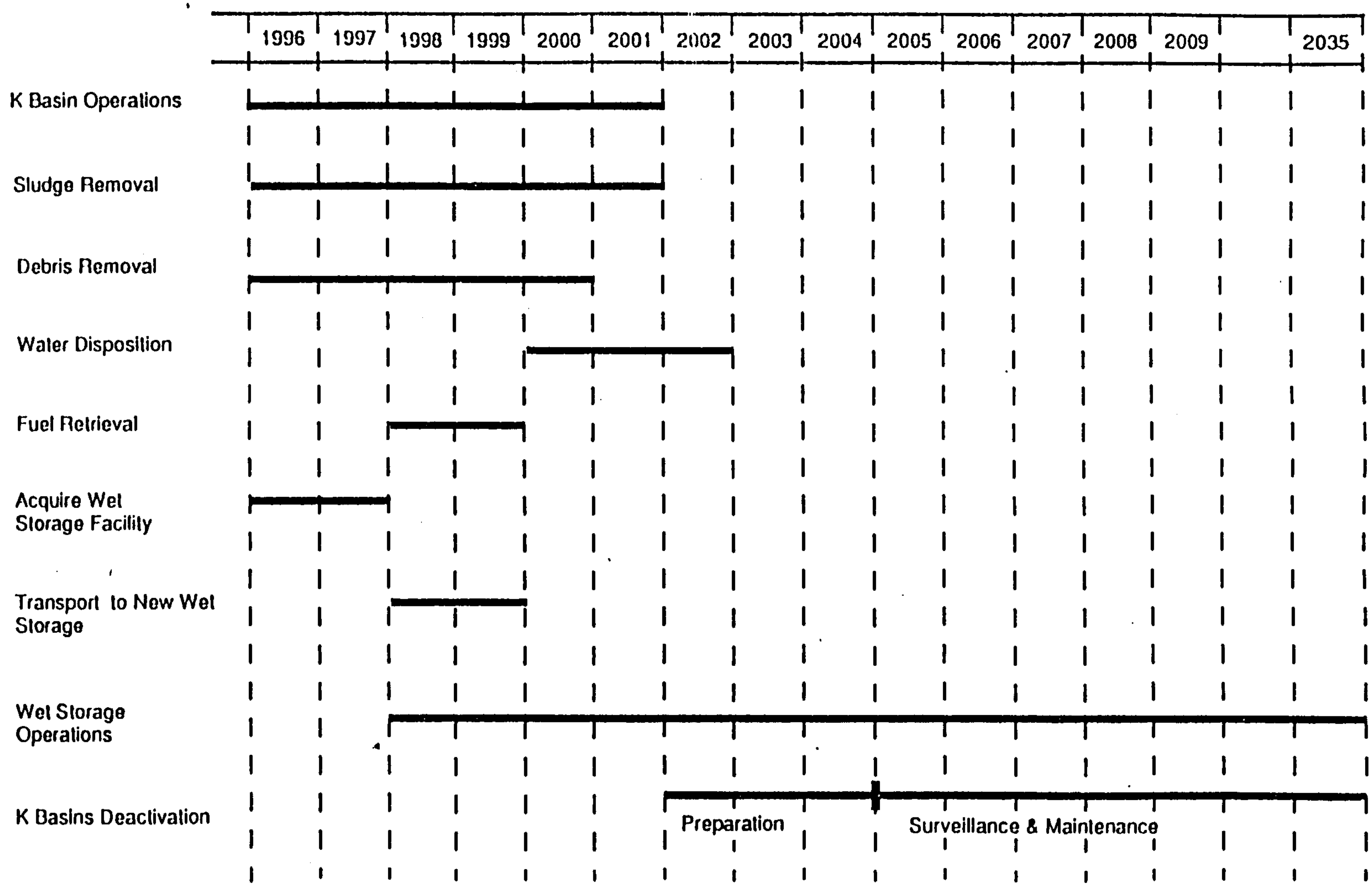


Figure 3-4. Summary schedule for new wet storage alternative (Bergsman et al. 1995)

set in place and the MCO, still inside the cask, would be lifted such that its top would be just above the surface of the water. The top closure would be sealed. A gas line would be connected to the MCO to force out some of the water in the MCO, creating a space to accumulate any gases that might be generated during transport. The MCO would be vented before transport to reduce internal pressure and then sealed. Cooling during transport might be required.

Before sealing, the MCO seal surface would be cleaned by removing debris that may have accumulated. The cask lid sealing surface, the top of the MCO lid, and the upper portion of the cask would be washed down with a decontamination spray system as it is hoisted out of the water. The cask lid would be put in place, the water in the annular volume of the cask would be removed, and the cask would be sealed. The cask would be lifted from the water, rinsed, and placed back on the railcar or truck trailer. The water would be allowed to drain into the basin. The transport casks containing the MCOs would then be shipped to the new storage facility via truck or train.

This loading approach results in placing the SNF within water-flooded MCOs. In the water-flooded condition, the fuel would continue to corrode and generate gaseous corrosion products. Shipments would have to be timely and closely supervised to prevent unacceptable gas pressure buildup inside the MCO. The MCO design would provide for emergency pressure relief, which could take the form of a rupture disk.

Sludge Management, Debris Removal, and Water Disposition

Sludge management, debris removal, and water disposition for the new wet storage alternative are the same as described in Section 3.1.2, except that the sludge would be containerized in MCOs and stored at the new wet storage facility for management of sludge as SNF. If the floor sludge is transported to the new wet storage facility using MCOs, it is estimated that approximately 70 MCOs would be required.

Wet Storage in a Vault Facility

The wet vault storage approach would use water-filled MCOs stacked two high in dry or water-filled storage tubes. The tubes would extend into below-grade, concrete-enclosed, shielding vaults, which could be cooled by recirculating refrigerated air, if necessary. The vault storage tube material would be stainless steel, if the tubes were to be filled with water, to minimize electrochemical corrosion between the tubes and the stainless steel MCOs. If the tubes were to be dry, the tube material would be carbon steel (Corten®).

If the CSB site were selected, the vault facility would likely use the entire foundation of the CSB (see Appendix A, Figure A-7). As such, three below-grade vaults would likely be constructed instead of two vaults, which would be sufficient for the estimated 750 MCOs of fuel and maximum anticipated 70 MCOs of KE Basin floor sludge (assuming all basin sludge is managed with the SNF). The CSB design provides space for up to 880 MCOs, each with 10 fuel canisters. Any excess vault capacity could potentially be used at a later date for storage of other compatible Hanford Site materials (e.g., cesium/strontium capsules, vitrified waste, and possibly staging of other Hanford SNF).

If the reference site were selected, a somewhat smaller facility with only two storage vaults would likely be built. It would be sized sufficiently to meet the needs for only K Basins SNF storage. Therefore, the information provided for the CSB site would be conservative and is used as the basis for estimating impacts at both potential sites in Chapter 5.0.

Wet Storage in a Pool

The concept for wet storage in a pool would use the existing site preparation and concrete basemat, as well as some of the completed engineering for the CSB site. This design also serves as the basis for the pool storage facility at both potential storage sites, even though only one of the three vault structures is needed to store the SNF, because it is readily available, conservatively estimates the technical information needed, and avoids both having to backfill the large existing excavation and having to redesign the structure to eliminate the extra vaults.

The new pool storage baseline design assumes the MCOs would be stored in racks in a single layer in an open pool of water with a recirculating water treatment system that would return the water to the pool at about 7°C (45°F). This portion of the new pool facility would utilize approximately one-third of the completed CSB foundation. The balance of the facility would be constructed at the same time as the pool vault for the reasons described above.

For the wet pool approach at the CSB site or reference site, a new facility would be constructed to house up to 880 MCOs (with 10 fuel canisters each) in a water-filled open storage pool. This pool would be large enough to store all the K Basins fuel (750 MCOs) and potentially all the segregated K Basins canister sludge (60 MCOs) and KE Basin floor sludge (70 MCOs). The new facility would have three vaults within the pool located below grade level, even though only one vault would be used as a 40-year interim storage pool. The MCOs stored in the pool would be placed in underwater stainless steel racks. The exposed uranium metal in the damaged fuel elements would continue to corrode and release uranium and small amounts of plutonium and fission products within the MCOs. The gases would be vented continuously, similar to the SNF storage in the KW Basin. Any excess vault capacity could potentially be used at a later date for storage of other compatible Hanford Site materials (e.g., cesium/strontium capsules, vitrified waste, and possibly staging of other Hanford SNF).

3.2.4 Drying/Passivation (Conditioning) with Dry Vault Storage Alternative--Preferred Alternative and Options

The drying/passivation (conditioning) with dry storage alternative would provide for drying of the SNF, placing it in MCOs in an inert atmosphere, and storing it in a vault or in casks for up to 40 years. Figure 3-5 provides a block diagram of operations associated with the preferred alternative.

Achieving dry storage of SNF in the preferred alternative (incorporating reference options) would involve the following primary activities:

- continue K Basin operations until the removal of fuel, sludge, and debris and disposition of water are completed

- remove K Basin SNF from existing canisters, clean, and desludge

- construct a new dry storage facility at the CSB site

- repackage the SNF into fuel baskets designed for MCO dimensions, which would include provision for water removal, SNF conditioning requirements, and criticality control

- after loading SNF into the MCOs, welding on the top, and draining the MCOs through small penetrations on the top, initially dry the SNF under vacuum at approximately 50°C (120°F), flood MCO with inert gas, seal penetrations, and place in transportation cask

- transport the SNF (in MCOs) in casks via truck to the CSB site in the 200 East Area, and provide for temporary vented staging, as necessary

- vacuum condition the SNF in MCOs, as soon as practicable, heating the SNF to about 300°C (570°F) to remove water that is chemically bound to the SNF and canister corrosion products, and to dissociate any reactive uranium hydride present

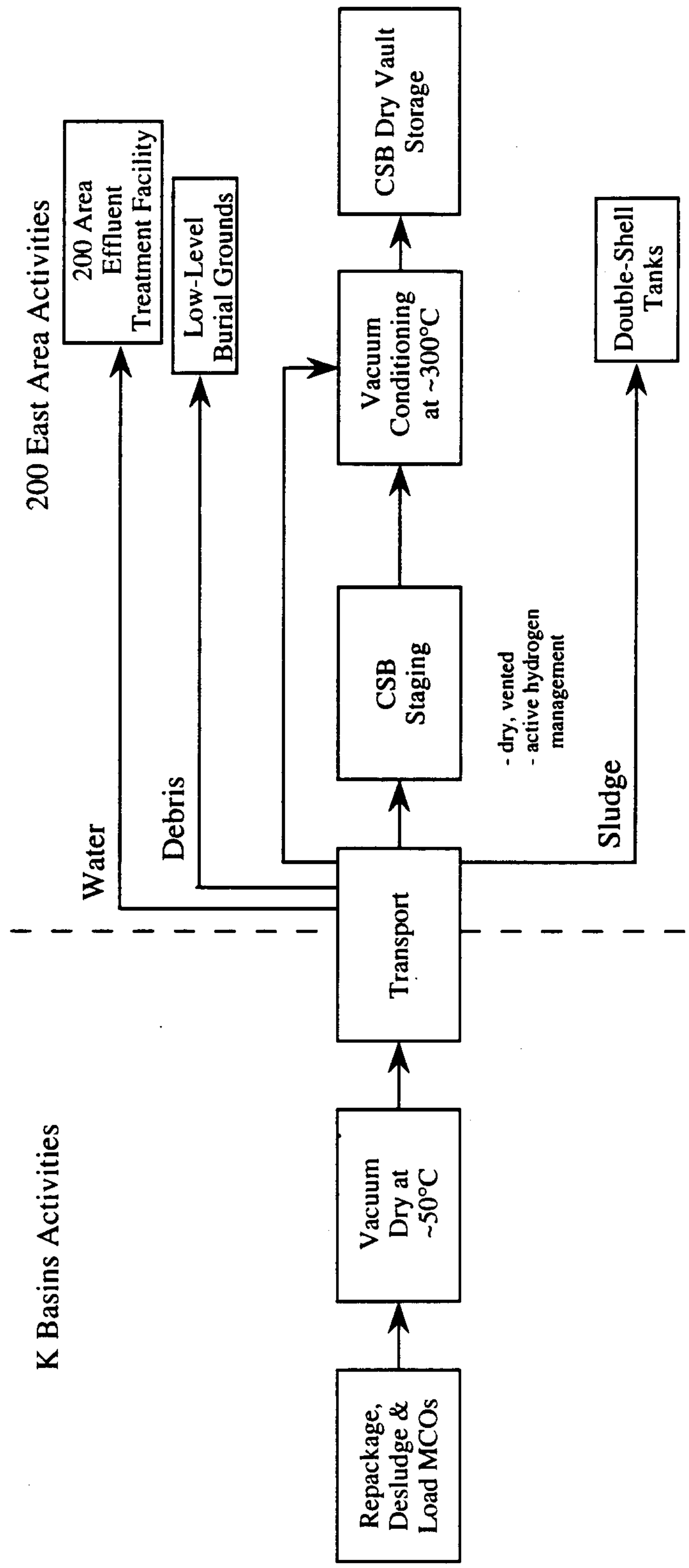


Figure 3-5. Drying/passivation (conditioning) with dry vault storage--preferred alternative options

- following conditioning, weld-seal the SNF in an inert gas in the MCOs for dry interim storage in a vault for up to 40 years

- collect the sludge removed from basins and disposition as waste in Hanford's DSTs after removal from the basin

- collect the debris from the basins and dispose of as low-level waste in Hanford's existing low-level waste burial grounds

- remove and transport contaminated basin water to the 200 Area ETF for final disposal at the 200 Area SALDS, and replace the contaminated basin water with clean water, maintaining basin water levels. (Eventually all basin water would be removed as part of facility deactivation activities.)

- prepare the K Basins for deactivation and turn over to decontamination and decommissioning program.

A summary schedule for activities for the drying/passivation (conditioning) with dry storage alternative is provided in Figure 3-6.

For the various steps involved in this alternative, those associated with the preferred alternative are addressed first followed by a description of other available options. An overview of options is provided in Table 3-1; the preferred alternative is identified with process option number 7.

Loading of Fuel in MCOs

Preferred option:

The fuel would be removed from existing canisters, cleaned, desludged, and repackaged into fuel baskets designed specifically for the MCOs described earlier. These baskets would include provision for water removal, SNF conditioning requirements, and criticality control (e.g., a borated steel rod or rods). Repackaging would help ensure removal of most of the sludge from the SNF and would allow optimum MCO loading, up to 1.9 times that of other configurations. In this case, the inventory of SNF, excluding the separated canister sludge, could be stored in as few as 390 MCOs.

Other options:

Other methods were also considered for loading SNF into MCOs and preparing the MCOs for transport. The simplest of these was described previously

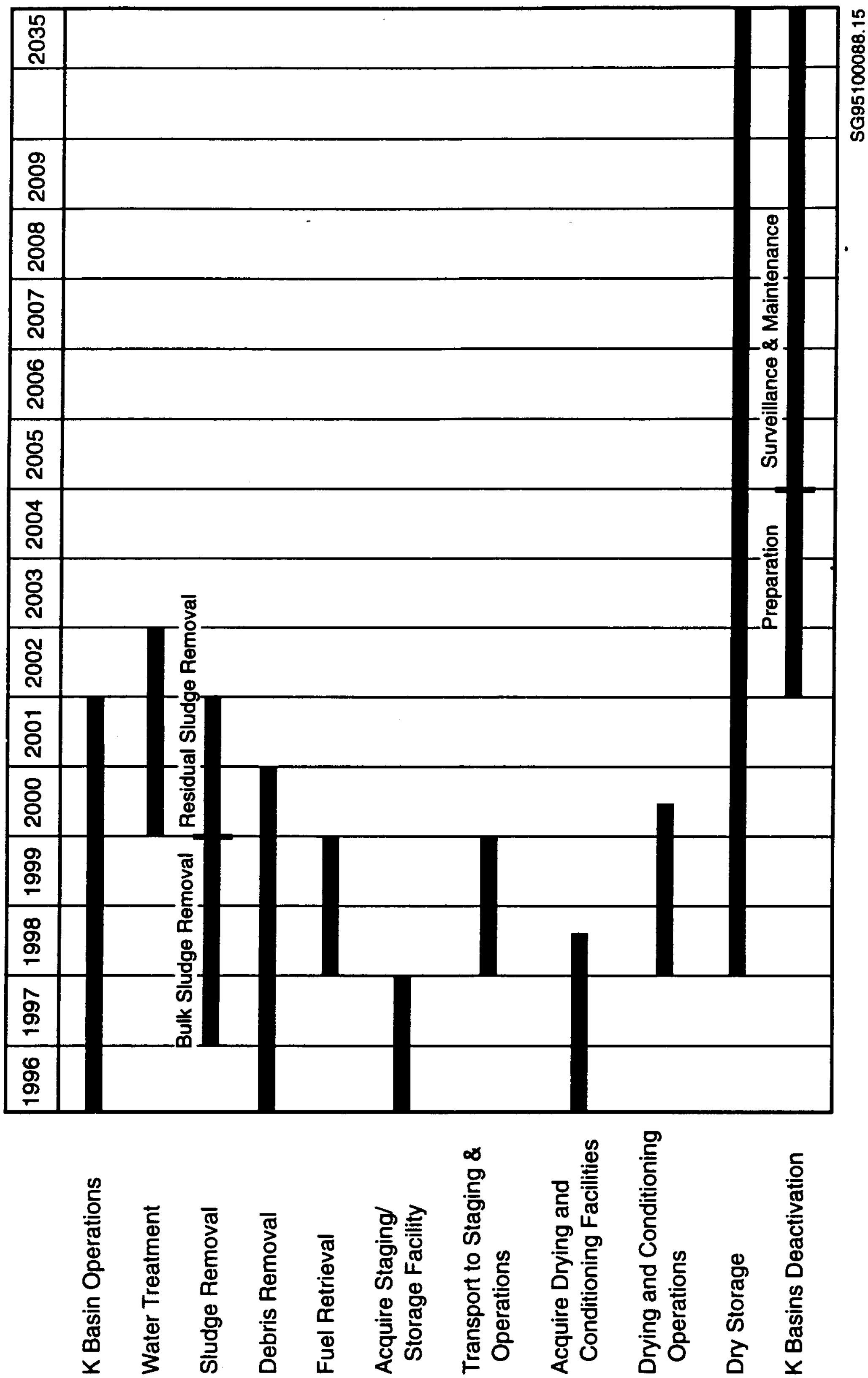


Figure 3-6. **Summary schedule of drying/passivation (conditioning) with dry storage alternative** (Bergsman et al. 1995)

Table 3-1. Options within the drying/passivation (conditioning) with dry storage alternative (after Bergsman et al. 1995)

Process option number	Key process decisions						Evaluation criteria		
	Canister preparation	Processing	Transport	Staging	Conditioning	Interim storage	Schedule risk	Technical viability	Cost ($M)
0	As-Is	None	Wet (flooded)	Wet (flooded)	Passivation	Dry	Low	Acceptable	$ 960
1	Perforate, desludge, and selective repack	Vacuum dry at K Basins	Dry (sealed)	Dry (vented)	Hot vacuum	Sealed	Moderate	Good	$ 670
2	Total repack	None	Wet (flooded)	None	Hot vacuum	Sealed	Very high	Marginal	$ 610
3	Total repack	None	Dry (sealed)	None	Hot vacuum	Sealed	Very high	Good	$ 620
4	Perforate and desludge, no repacking	Vacuum dry at K Basins	Dry (sealed)	Dry (vented)	Hot vacuum	Sealed	Moderate	Marginal	$ 660
5	Perforate and desludge, no repacking	Vacuum dry at CSB	Wet (flooded)	Dry (vented)	Hot vacuum	Sealed	Moderate	Marginal	$ 650
6	As-Is (lids removed)	None	Wet (vented)	Dry (vented)	Hot vacuum	Sealed	Low	Poor	$ 660
7	Total repack	Vacuum dry at the K Basin annexes	Dry (sealed)	Dry (vented)	Hot vacuum	Sealed	Moderate	Very good	$ 620
8	Total repack	Vacuum dry at the K Basin annexes	Dry (sealed)	None	Self-heating	Vented	Moderate	Good[a]	$ 590

(a) Additional evaluation is required to establish technical and safety viability.

for the new wet storage alternative (i.e., the fuel canisters would be placed into the MCOs "as is"). Other options would be to provide holes in the canister bottoms for water drainage and gas flow, or to provide holes in canister bottoms and sides for water drainage and gas flow, and remove the canister sludge by flushing basin water through the canisters.

All three of these other methods, as described, would result in the SNF being placed within water-flooded MCOs or damp within dry MCOs. In the water-flooded or damp condition, the fuel would continue to corrode and generate gaseous corrosion products, as noted above. Shipments would have to be timely and closely supervised to prevent excessive gas pressure buildup inside the MCO because of corrosion.

Drying of SNF

Preferred option:

Vacuum-drying of the SNF would be initiated at the K Basins in a facility having comparable control of pollutant releases to the atmosphere as provided at the CSB conditioning facility. Initial vacuum-drying would take place with the repackaged SNF in MCOs at a temperature of about 50°C (120°F). This step would be expected to remove essentially all free (i.e., chemically unbound) water, essentially arresting further corrosion and excessive hydrogen generation.

Other options:

All vacuum drying could be performed at conditioning facilities located at the CSB site or reference site.

Transport of SNF

Preferred option:

SNF would be transported from the K Basins in shielded casks via truck to the CSB site in the 200 Areas.

Other options:

SNF could be shipped by rail from the K Basins to either the CSB site or reference site.

Staging

Staging would be considered to the extent necessary to expeditiously remove SNF from the K Basins to the 200 Areas, either the CSB site or reference site. It may only be needed in early stages of implementing the alternative.

Preferred option:

Dry Vault Staging. The present concept is very similar to that described in Section 3.2.3 for the new wet storage alternative; however, the SNF would be staged dry. This staging would use the existing design of the CSB site with the addition of some support facilities. As in the new wet storage alternative, it is assumed for the purposes of this EIS that the features and design of the new facility would be very similar to those of the CSB.

Vault staging would use MCOs stored in two layers in inert gas-filled tubes extending into three below-grade, concrete-enclosed, shielding vaults, which could be cooled by recirculating 2°C (35°F) refrigerated air, if necessary, or by natural circulation cooling. This would utilize the entire foundation and design of the CSB. The facility has space for up to 880 MCOs, each with 10 fuel canisters, substantially more than required for the preferred alternative. When all the MCOs have been conditioned, the recirculating refrigerated air system would be shut down. Natural circulation (passive cooling) would be established and the staging portion of the facility would then become a dry storage facility.

Differences in the facility (compared to the new wet storage alternative) if vacuum-dried SNF were stored in the MCOs would be:

- MCO servicing would not include water level adjustments
- SNF temperatures would not need to be as low because of the significantly lower potential for continued corrosion
- radioactive gas release from the staged MCOs would be much lower, simplifying contamination control in operating areas and lowering routine releases to the atmosphere.

Other options:

A completely new dry vault staging facility could be built at the reference SNF storage site using the existing configuration of the CSB.

Wet Staging. The wet staging concept is very similar to that described in Section 3.2.3 for the new wet storage alternative. It would also use the unchanged version of the existing design of the CSB site, with the addition of some support facilities, and includes consideration of building a completely new facility at the reference site using the existing design of the CSB.

Pool staging assumes the MCOs would be stored in racks in a single layer in an open pool of water, with a recirculating water treatment system that would return the water to the pool at about 7°C (45°F). This portion of the new wet storage facility would utilize approximately one-third of the completed CSB foundation. The facility has space for up to 880 MCOs each with 10 fuel canisters. Only 750 MCOs would be stored if the desired sludge disposal options prove successful, where segregated canister and KE Basin floor sludge would not be stored in the new wet storage facility.

The balance of the facility, which would utilize the remaining two-thirds of the CSB foundation and the dry storage vaults, would be constructed at the same time as the pool staging vault. Primary activities that would remain to be completed would be installing the storage tubes in the dry storage vaults, installing some support equipment, and installing the concrete operating deck above the dry vaults. These activities would be completed so that the dry storage vaults would be operational at the same time as the conditioning facility. After conditioning, the MCOs would be returned to the newly completed dry storage vaults. The staging portion of the facility would then become a dry storage facility.

The pool staging facility itself would be the same as that described in Section 3.2.3 for the new wet storage alternative, when the SNF would be loaded into water-flooded MCOs. The facility design for repackaged SNF would be bounded by the description of SNF in fuel canisters. The differences in the facility resulting from vacuum dried SNF in the MCOs are:

- MCO servicing would not include water level adjustments

- SNF temperatures would not need to be as low because of the significantly lower potential for continued corrosion

- radioactive gas releases from the staged MCOs would be much lower, simplifying control in operating areas and lowering routine releases to the atmosphere

- MCO transfer to the close-coupled conditioning facility could be done by cart. Water-filled MCOs would likely be stored in water-filled tubes, and vacuum dried MCOs would likely be stored in dry tubes.

Drying/Passivation (Conditioning) for Dry Storage

Preferred option:

Once at the CSB staging facility, the MCOs would be transferred from the staging area into a new drying/passivation (conditioning) facility. The conditioning facility would be built adjacent to the staging/storage facility. A transfer corridor would connect the two facilities and allow transfer of the fuel-filled MCOs back and forth between the staging/storage facility and the conditioning facility. The MCOs would be retrieved from the staging/storage facility tube into a bottom-loading transfer cask and the cask moved into the conditioning facility. The MCO would be lowered from the transfer cask into a processing pit in the floor of the conditioning facility. The transfer cask would be removed, and the MCO would be connected to conditioning process piping and process control systems.

Vacuum-drying and conditioning would continue at the CSB facility where the following steps would be carried out on the SNF in MCOs:

- heat to about 300°C (570°F) while purging with a suitable inert gas (for about 24 hours)

- evacuate and hold at temperature (for about 48 hours)

- cool down to about 150°C (300°F) by forced-air cooling of the exterior of the MCO

- oxidize (passivate) by introducing a suitable inert gas-oxygen mixture (for about 24 hours)

- flood the MCO with a suitable inert gas and cool down to ambient temperature (for 8 to 16 hours) and seal.

The vacuum conditioning process would remove adsorbed water and the majority of chemically bound water and dissociate any reactive uranium hydride present. Following this process the SNF in MCOs would be ready for storage for up to 40 years in the CSB dry storage facility.

Other options:

The drying/passivation (conditioning) process could be carried out in new facilities at the reference site using designs similar to those intended at the CSB site. All of the drying and conditioning processes could take place at the CSB site or at the K Basins.

Dry Storage[(a)]

Preferred option:

Dry Vault Storage. To implement dry storage in a vault, the dry staging facility would become the dry storage facility and the SNF would be stored dry in sealed MCOs in dry tubes cooled by natural air circulation.

Other options:

Dry Storage in Casks. Dry storage could be accomplished by storing the SNF in casks. To implement dry storage in casks, the conditioned K Basin SNF would be stored in casks designed for storage of commercial SNF, with horizontal storage chosen as the basis for details, consistent with DOE (1995a). Each storage cask would be roughly 1.7 m (5.5 ft) in diameter, 4.9 m (16 ft) long, and would weigh over 100 metric tons (110 tons). The concrete storage modules that would hold the cask in the system would have dimensions of

---

(a) The DOE programmatically established period for interim storage is for up to 40 years. However, design engineers have indicated that dry storage for up to 75 years is currently achievable. Design for 200 years, while likely achievable, cannot be performed under currently available funding. The ability to store SNF with confidence for up to 500 years, as suggested during the scoping process, would likely be a somewhat greater challenge and has not been examined in detail. As a consequence, design for extended storage in new facilities is limited to 75 years in this EIS.

approximately 3 m (10 ft) wide, 5.5 m (18 ft) deep, and 4.6 m (15 ft) high. On the order of 140 casks would be required and would be stored outside on a concrete pad adjacent to the CSB site or at the reference site.

Sludge Management, Debris Removal, Water Disposition, and K Basins Deactivation

Preferred option:

The sludge would be removed from the basins and dispositioned as waste in Hanford's DSTs after removal from the basin. Debris would be collected from the basins and disposed of as low-level waste in Hanford's existing low-level waste burial grounds. Contaminated basin water would be removed and transported to the 200 Area ETF for final disposal at the 200 Area SALDS, and contaminated basin water would be replaced with clean water, maintaining basin water levels. (Eventually all basin water would be removed as part of facility deactivation activities.)

Deactivation would follow removal of fuel, sludge, and debris from the basin, and would include preparations for turnover to DOE's decommissioning program, and would provide for the surveillance and maintenance before implementing decommissioning. An analysis of environmental impacts associated with decommissioning eight Hanford reactors, which included the K Basins, was presented in *Surplus Production Reactor Decommissioning EIS* (DOE 1989) and is not repeated in this EIS.

Other options:

Sludge management, debris removal, and disposition of basin water could be essentially the same as described for the new wet storage alternative.

3.2.5 Calcination with Dry Storage Alternative

In this alternative, the steps (including reference options) before calcination would be essentially the same as those in the new wet storage alternative. However, in the calcination with dry storage alternative, a new facility would be constructed adjacent to the staging/storage facility. A transfer corridor would connect the two facilities and allow transfer of the fuel-filled MCOs in transfer casks back and forth between the two facilities. The MCOs would be unloaded remotely from the transfer casks and opened. The fuel canisters would be removed from the MCO, and then the fuel and sludge would be unloaded from the canisters.

The fuel assemblies would be sheared and prepared for calcination. One approach would be to place the material into a continuous dissolver and dissolve it in a nitric acid solution. The nitrate solution produced in the continuous dissolver would be routed to concentrators for concentration and acid removal. This concentrated dissolved fuel would then be converted from a nitrate form to a stable oxide in a calciner. The oxide would be blended with ceramic formers as necessary, would be heated and hot uni-axial pressed into a stable high-density ceramic form. After cooling, the high-density ceramic form would be placed back into the MCOs, and the MCOs would be welded shut. An acid absorber recovers nitric acid from the nitrogen oxides in the off-gas, and the off-gas would be filtered and treated as necessary to remove volatile fission products before release. A block diagram of the shear leach calcine process is provided in Figure 3-7. A schedule of activities is presented in Figure 3-8. Alternatively a fluidized-bed calcine process might be used.

The sealed MCOs would be loaded remotely into transfer casks, transferred back to the staging/storage facility, and placed into interim dry storage as described for the drying/passivation (conditioning) alternative.

The site proposed for the calcination facility would be the same as discussed in Section 3.2.3. The calcination facility would be a multilevel steel-reinforced, cast-in-place concrete structure typically required to process high-level radioactive materials. The seismically qualified and highly shielded main canyon for this facility would have a width of 6 m (20 ft), a length of 70 m (230 ft), and a height of 26 m (85 ft). The process

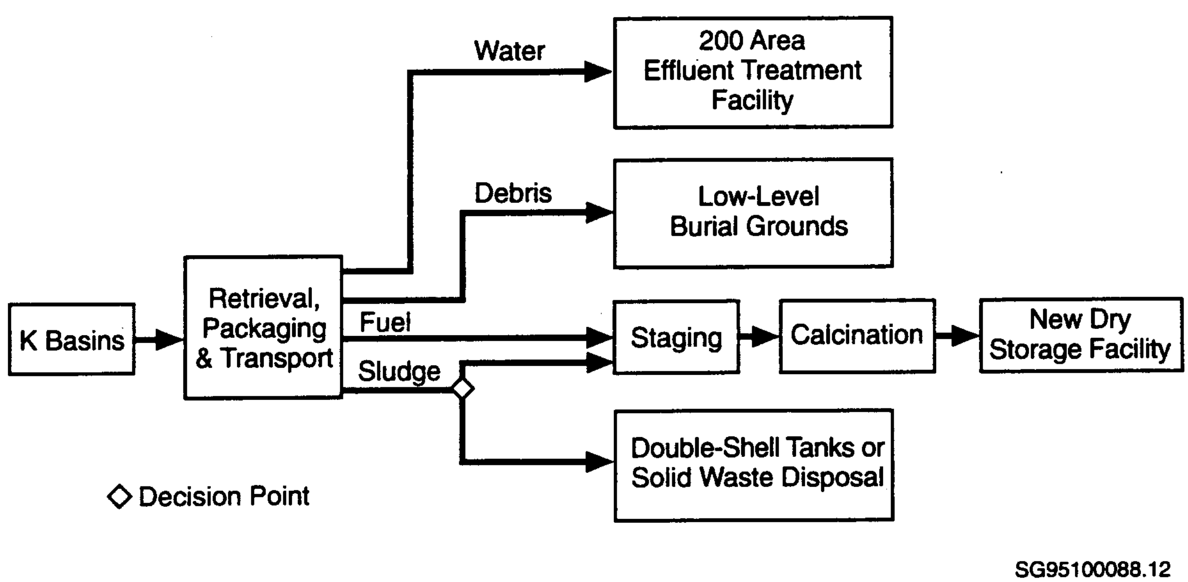


Figure 3-7. Calcination with dry storage alternative activities

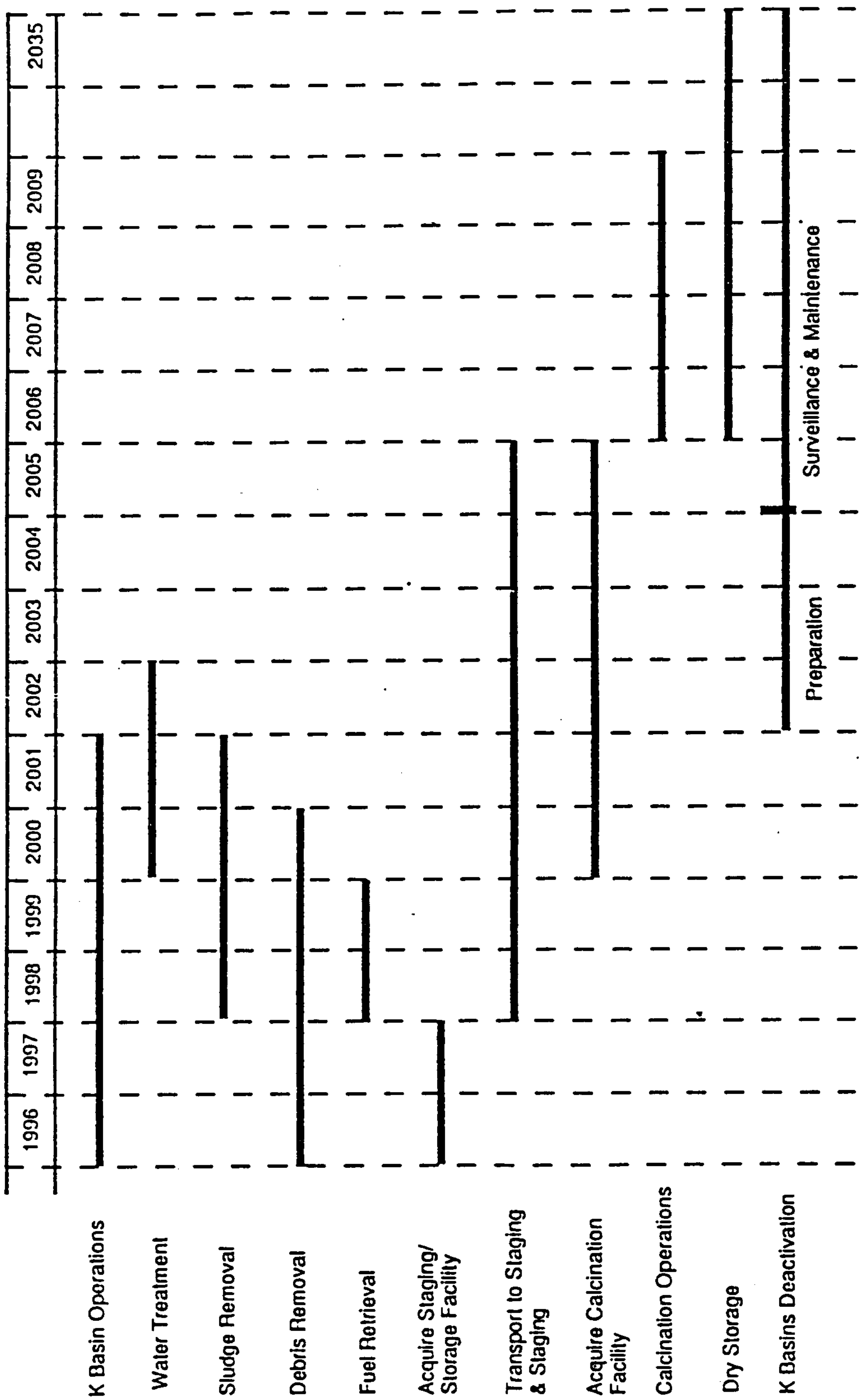


Figure 3-8. Summary schedule of calcination with dry storage alternative (Bergsman et al. 1995)

building would be approximately 110 m (360 ft) long, 50 m (160 ft) wide, and 26 m (85 ft) tall, with approximately 10 m (30 ft) of the facility height located below grade.

The calcination facility would be sized to finish calcining of the 2,100 metric tons (2,300 tons) of fuel within 4 years. The facility is assumed to be operated 24 hours a day, 7 days per week during scheduled operating periods. Further, the facility is assumed to be scheduled for operation 280 days per year, with 85 days per year allowed for scheduled down time. During scheduled operating days, the facility is assumed to have a total operating efficiency of 75% as a result of unscheduled repairs, etc.

To implement dry storage of the calcined product, the staging/storage facility (described in Section 3.2.4) would be modified to allow dry storage of the MCOs arriving from the adjacent calcining process. Different modifications would be required for the two different staging concepts but each would result in calcine product being stored dry in MCOs in dry tubes cooled by natural air circulation. The calcined product would remain in dry storage pending ultimate disposition.

Periodic monitoring of the stored calcined product would likely be required and might be done by checking gas buildup in the storage tube or MCO. Defective MCOs could be overpacked, if necessary.

Optional dry storage of calcined waste in casks would be similar to that described previously for the drying/passivation with dry storage alternative.

3.2.6 Onsite Processing Alternative

The onsite processing alternative would involve removal of the SNF from the K Basins and transport of the SNF to a facility where the uranium and plutonium constituents would be separated from the fission products and from each other, with subsequent storage at the Hanford Site until decisions on ultimate disposition based on their respective material properties were made and implemented. This approach is depicted schematically in Figure 3-9. A summary schedule for activities in the alternative is shown in Figure 3-10.

The onsite processing alternative might be employed in the future in conjunction with any of the interim-storage alternatives, if it were to facilitate ultimate disposition of SNF.

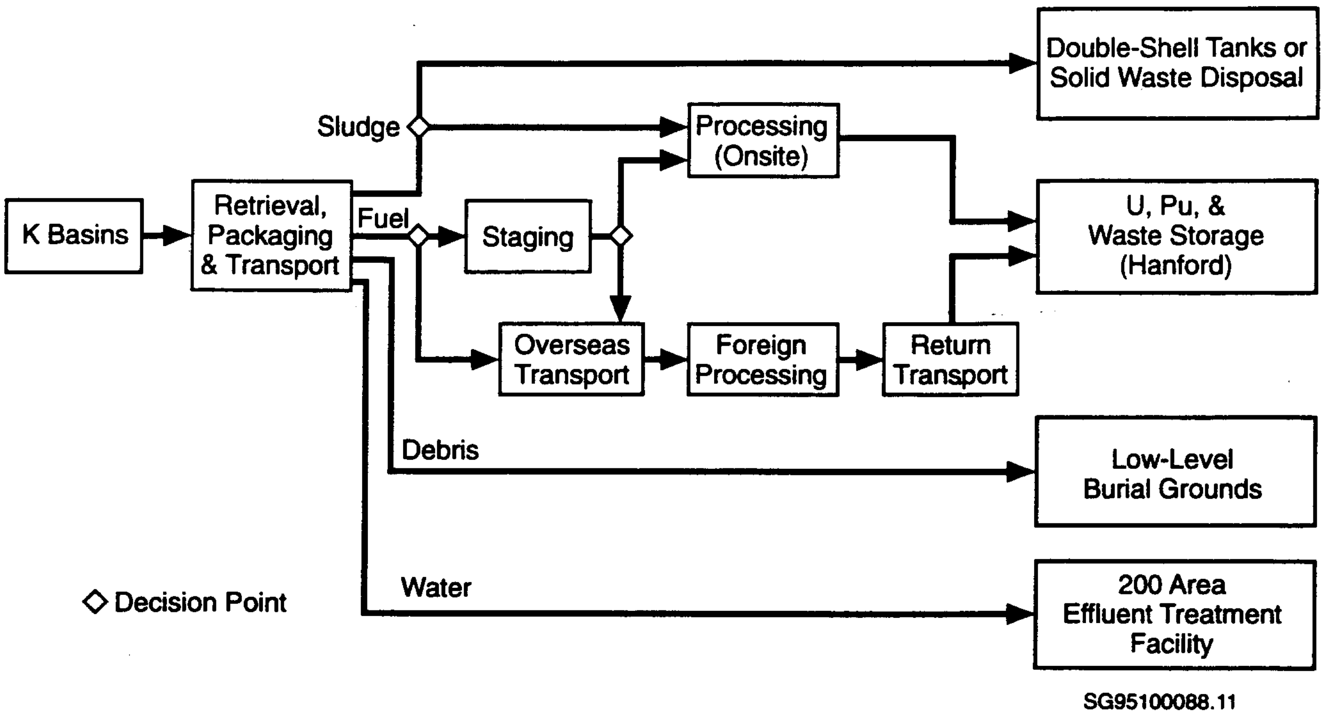


Figure 3-9. Onsite and foreign processing alternatives

In the onsite processing alternative, many of the major activities would be very similar to those in the new wet storage (Section 3.2.3) or dry storage alternatives. The activities incorporating the reference options in the onsite processing alternative would be as follows:

- continue K Basins operations through facility deactivation
- retrieve, package, and handle the fuel at the K Basins
  - retrieval of the irradiated fuel would be accomplished in a similar fashion as previously discussed for wet storage
  - packaging of the fuel into MCOs would be accomplished in a similar fashion as previously discussed for wet storage
- transport the packaged fuel from the K Basins to a new staging/storage facility at the CSB site. The storage area in the staging/storage facility would be a dry vault with the SNF stored in water-filled MCOs in dry tubes.

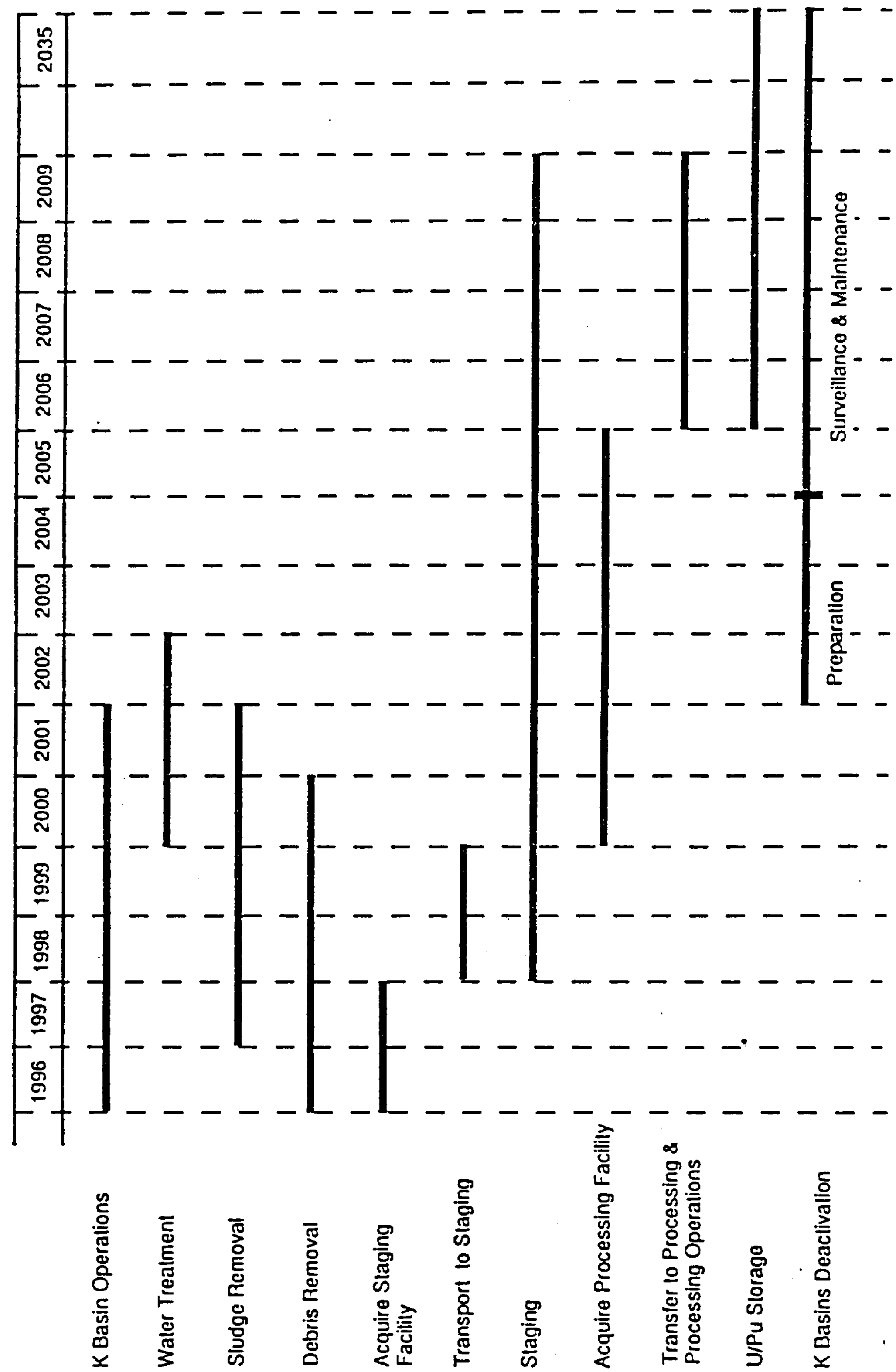


Figure 3-10. Summary schedule for onsite processing alternative (Bergsman et al. 1995)

- process the fuel in a new facility at the Hanford Site, which would be located near the staging/storage facility
- store the recovered uranium trioxide in drums on a concrete slab in prefabricated metal weather-tight buildings, store the plutonium dioxide in the Plutonium Finishing Plant (PFP) facility (2736-ZB with modifications), if possible, or in a newly constructed secure facility similar to the existing 2736-ZB vault facility, and store the high-level waste from processing in Hanford's DSTs
- collect the sludge removed from basins and disposition it as waste in Hanford's DSTs after removal from the basin
- collect, remove, and dispose of K Basins debris at the 200 Areas low-level waste burial grounds
- remove and transport contaminated basin water to the 200 Area ETF for final disposal at the 200 Area SALDS, and replace the contaminated basin water with clean water, maintaining basin water levels. (Eventually all basin water would be removed as part of facility deactivation activities.)
- ready the K Basins to be turned over for decommissioning.

For the onsite processing alternative, a new facility would be constructed to process K Basins SNF. The process facility would receive metallic fuel from storage. The fuel assemblies would be sheared into a continuous dissolver and dissolved in a nitric acid solution.[a] The nitrate solution produced in the continuous dissolver would then be processed through an extensive solvent extraction system for removal and purification of uranium and plutonium. The uranium nitrate product from the solvent extraction system would be converted to uranium trioxide in a calciner and packaged for potential future beneficial use. The plutonium nitrate product from solvent extraction would be converted to plutonium dioxide and packaged for storage in onsite vaults, also for potential future beneficial use.[b] The high-level

(a) Although an acid dissolution process is described here, an electrometallurgical process in development by Argonne National Laboratory might also be feasible. The latter process is undergoing testing with unirradiated N Reactor fuel.
(b) The equivalent heat energy of the uranium-235 and plutonium-239 that remains in the K Basins SNF, if fully fissioned, would amount to that from about 5,000,000,000 metric tons (6,000,000,000 tons) of coal.

waste from the solvent extraction process would be concentrated, sugar denitrated before neutralization, and transferred to Hanford's double-shell tanks. The removal of uranium and plutonium from the dissolved fuel would greatly reduce the ultimate amount of repository space required to dispose of the fuel. An acid absorber would be used to recover nitric acid from the nitrogen oxides in the off-gas, and the off-gas would be filtered and treated as necessary to remove volatile fission products.

The processing facility would be located at either of the sites described in Section 3.2.3. The process facility would be a multilevel steel-reinforced, cast-in-place concrete structure typically needed for processing highly radioactive materials. The seismically qualified and highly shielded main canyon for this facility would have a width of about 6 m (20 ft), a length of about 76 m (250 ft), and a height of about 26 m (85 ft). The process building would be approximately 130 m (420 ft) long, 78 m (260 ft) wide, and 26 m (85 ft) tall, with approximately 10 m (33 ft) of the facility located below grade.

Storage of Recovered Materials

Recovered materials (i.e., plutonium and uranium oxides) would be managed with existing stockpiles at the Hanford Site until disposition of those materials is defined. The high-level waste would transferred to DSTs.

The uranium trioxide could be considered an asset to be sold, if a market were to exist at the time it was produced, or it could be dispositioned as contact-handled low-level waste. Using the maximum weight limit for a 55-gal drum of 380 kg (840 lb), the approximately 2,500 metric tons (2,800 tons) of uranium trioxide produced would require about 6,600 drums. These drums could be palletized and housed in two prefabricated metal buildings situated on concrete slabs, most likely located near the processing facility. Each would be approximately 18 m (60 ft) by 70 m (230 ft) by 4 m (13 ft) high. Buildings could be higher if required by the fire protection system, but a dry standpipe fire suppression system would likely be adequate if combustible material use could be minimized. Floors would be reinforced concrete slabs approximately 15 cm (6 in.) thick. No insulation, heating, or cooling needs would be expected, but roof ventilators would be required. Road construction should be minimal. Drums could be brought into the facility by either truck or rail.

Approximately 4.6 metric tons (5 tons) of plutonium dioxide would be produced and require suitable storage in the PFP (modified 2736-ZB) or a newly constructed facility. With an average processing rate of 23 kg/wk (50 lb/wk), shipments would be expected approximately three times every 2 weeks over a 4-year campaign, and approximately 300 plutonium shipments to the PFP would be required. U.S. Department of Transportation (DOT) Specification 6M containers would be used for transport. Expansion of existing vault capacity or additional facilities might be required depending on national plutonium management decisions, that might relocate the plutonium inventory to or from the PFP and might result in concentration of existing plutonium inventories.

High-level waste would be transferred to the Hanford DSTs via underground piping. The processing schedule would be developed to enable use of existing DSTs rather than constructing new tanks.

K Basins Deactivation

K Basins deactivation would be consistent with actions and impacts described for the new wet storage alternative in Section 3.2.3. In the onsite processing alternative, providing for deactivation and decommissioning of the temporary storage/staging and processing facility at the conclusion of the campaign would also be necessary.

3.2.7 Foreign Processing Alternative

Foreign processing of K Basins SNF would include up to 40-year storage of returned uranium trioxide and plutonium dioxide, and vitrified high-level waste. Foreign processing is depicted schematically with onsite processing in Figure 3-9. Except for the transportation step, the reference options are essentially the same as those for the onsite processing alternative.

As in the case of onsite processing, the foreign processing alternative might be employed in the future in conjunction with any of the interim-storage alternatives, if it were to facilitate ultimate disposition of SNF.

For foreign processing, the custody of the packaged SNF would be transferred to a foreign enterprise that would assume responsibility for trans-oceanic transport and for processing to forms suitable for storage. Fuel transfer and management assumptions are based on information provided by British Nuclear Fuels Limited, Inc. (BNFL), which has previously expressed interest in processing the K Basins SNF at Sellafield in the United Kingdom. The BNFL information would be representative of expected Hanford Site impacts should the fuel be transferred for processing to the United Kingdom or another foreign location. Use of the cited BNFL information in this EIS should not be construed as DOE endorsement of any BNFL processing proposals.

Reference options in this approach include:

- continued operation of the K Basins until the SNF, sludge, and debris removal and water disposition are completed
- dispositioning sludge, debris, and basin water at the Hanford Site as in the onsite processing alternative
- modifying the K Basins cask load-out facilities or constructing a transloading facility to accommodate overseas transport casks
- packaging N Reactor SNF from both basins
- shipping the SNF overland to a dock on the Columbia River for shipment by barge to overseas shipping facilities at Vancouver, Washington
- transferring custody of the SNF to the foreign enterprise and shipping the SNF overseas
- processing the SNF overseas
- returning the separated materials to the Hanford Site for interim dry storage (recovered uranium might be stored elsewhere in the U.S.)
- prepare the K Basins for deactivation and turn over to decontamination and decommissioning program.

A summary schedule of activities in the foreign processing alternative is shown in Figure 3-11. The schedule in Figure 3-11 assumes maximum cask payloads within a short time frame and that, based on SNF characteristics and existing available licensed casks, as many as 4,000 shipments might be required because of smaller allowed payloads and longer shipping times.

Temporary storage of the SNF in a new staging facility before shipment overseas might be implemented if fuel receipt schedules by the foreign enterprise would cause prolonged storage of SNF at the K Basins.

Packaging, Transport, and Processing

The canisters of SNF are assumed to be loaded into existing K Basins casks for transfer to a transloading facility. At the transloading facility,

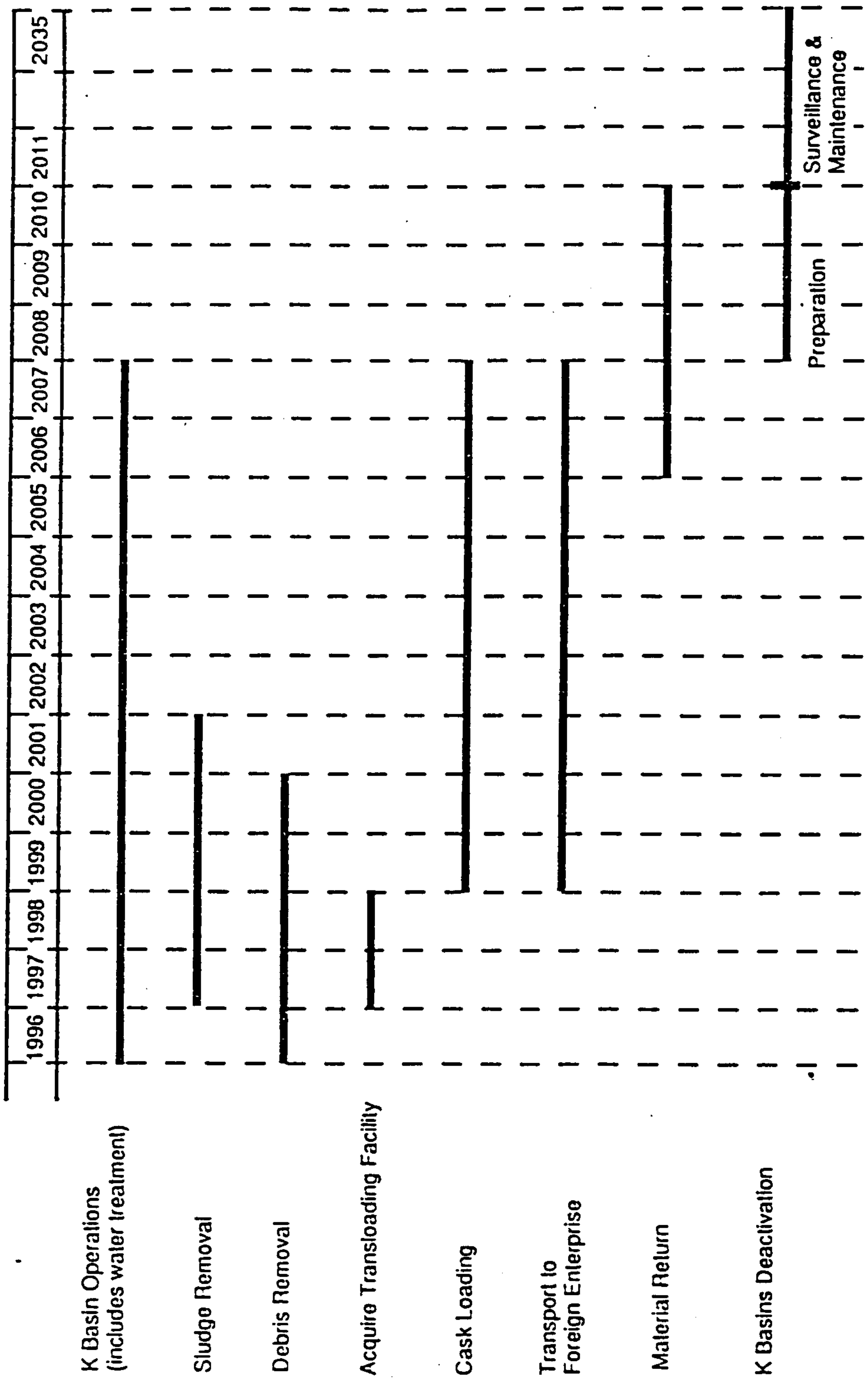


Figure 3-11. Summary schedule for the foreign processing alternative (Bergsman et al. 1995)

the canisters would be transferred to an internationally licensed cask, such as the Chaplecross Magnox cask. (The K Basins cranes have insufficient capacity to load the Chaplecross casks.)

The casks could be transported by truck, rail, or barge from the Hanford Site to a northwest port for loading on a BNFL ship. (The SNF could also be shipped on rail cars to port facilities at Bremerton, Washington, or by rail or truck to Norfolk, Virginia.) The assumption is that the SNF would be transported by road or rail to a location on the Columbia River suitable for loading the casks on a barge for shipment to port facilities at Vancouver, Washington; however, the actual shipping/receiving port is speculative. The proposed barge capacity of 24 casks corresponds to a BNFL shipload. A more complete range of possible shipping/receiving ports is discussed in DOE (1995h).

Ships employed by BNFL would comply with international agreements governing shipment of irradiated materials and would be approved by the U.S. Coast Guard.

If dictated by schedule constraints, the SNF would be transported to a new staging facility for temporary storage as described in Section 3.2.3. From the temporary storage location, the fuel would then be transloaded into the Magnox Cask for transport overseas as described previously.

At the overseas site, the assumption is that the fuel would be dissolved in a new chop/leach process facility. The resulting solution would contain the dissolved uranium, plutonium, and fission products. Fuel hulls and any shear overcans do not dissolve in the chop/leach process. The hulls and shear overcans would be mixed with other solid waste and cemented in waste containers.

The separations processes produce uranium, plutonium, and high-level waste streams. The recovered uranium would be converted to uranium trioxide and placed in 55-gal drums. The plutonium would be converted to plutonium dioxide. The high-level waste would be vitrified in borosilicate glass and would occupy about 500 half-ton containers.

Returned Uranium Trioxide

Processing of all the N Reactor spent fuel would result in the return of approximately 2,500 metric tons (2,800 tons) of purified uranium as uranium trioxide. The returned uranium would likely become the property of the U.S. Enrichment Corporation, a quasi-public agency of the U.S. Government that owns the uranium processing facilities at Paducah, Kentucky, and Portsmouth, Ohio. The uranium would be shipped in 55-gal drums as low-specific activity material. The uranium can be considered an asset to be sold, if a market exists at the time it is returned, or dispositioned as contact-handled low-level waste. Using the maximum weight limit for a 55-gal drum of 380 kg (840 lb), the 2,500 metric tons (2,800 tons) of uranium trioxide would require approximately 6,600 drums. If the uranium were to be returned to Hanford, it would be returned on an ocean vessel from the foreign enterprise and transported to Hanford via barge to a Hanford dock and rail or truck to the storage facility.

Storage of uranium on the Hanford Site would be the same as described in Section 3.2.6 for onsite processing.

Returned Plutonium Dioxide

About 4.6 metric tons (5 tons) of plutonium as plutonium dioxide would be returned to the U.S. on a military ship and unloaded at the Bremerton Naval Shipyard or other U.S. Navy installation. Safe secure transport vehicles, routinely used by DOE for transport of special nuclear materials, would be used to transport the plutonium to the Hanford Site.

The safe secure transport vehicles would be unloaded at the vault facilities and plutonium dioxide storage would be essentially the same as described for the onsite processing alternative.

Returned Vitrified Waste

The vitrified waste would be transported to the U.S. on an ocean vessel through a northwest port. Because of the size of the shipping casks required to return the containers [100 metric tons (110 tons)], the assumption is that the casks would be returned by rail to the Hanford Site and unloaded directly at the storage facility planned for vitrified tank waste. Each cask would hold 21 vitrified waste containers, requiring approximately 25 cask shipments.

The 500 half-ton containers of vitrified waste that would be returned from the foreign processor may be stored at Hanford.

If contracted to process the K Basins SNF, BNFL has proposed that they retain and store the special nuclear material for 5 years and the vitrified high-level waste until such time as a permanent geologic repository becomes available. Secondary low-level waste would be retained and disposed of by the foreign enterprise. Other variations on this alternative include having the special nuclear materials and the vitrified high-level waste retained and stored at the processing site until 2035 or having them returned to a destination in the U.S. other than the Hanford Site.

K Basins Deactivation

K Basins deactivation would be consistent with actions and impacts described for the new wet storage alternative in Section 3.2.3. In the foreign processing alternative, the deactivation of the transloading and staging facilities, if employed, would need to be provided at the conclusion of the shipping campaign.

3.2.8 Alternatives Considered but Dismissed from Detailed Evaluation

The following alternative was also evaluated by DOE (DOE 1995a). However, because it was not adopted in a record of decision (ROD) based on the referenced EIS (DOE 1995a) and published on June 1, 1995, the alternative was dismissed from detailed evaluation in this EIS. The ROD specified that Hanford production reactor fuel would remain under management at the Hanford Site for up to 40 years pending decisions on ultimate disposition. The alternative was as follows:

- **offsite disposition**: remove K Basins SNF and transfer to another DOE site for storage and/or processing.

A description of impacts associated with this alternative may be found in DOE (1995a).

Three other alternatives were suggested during the scoping process that were considered but dismissed from detailed analysis. These were as follows:

- **WNP-4 wet storage**: remove K Basins SNF and transfer to wet storage in modified WNP-4 Spray Cooling Pond. The WNP-4 Spray Cooling Pond, like the K Basins, has the disadvantage of being near the Columbia River. It has no obvious environmental advantages over the reference site or CSB site and would require acquisition from the Washington Public Power Supply System, which would likely require considerable time to negotiate thereby precluding expeditious removal of the SNF from the K Basins.

- **N Reactor Basin storage**: remove K Basins SNF and transfer to wet storage in N Reactor Basin. The principal reason for dismissing the

N Reactor Basin from detailed analysis is that the basin is not large enough to accommodate the K Basins fuel. It also has the disadvantages of being over 30 years old and near the Columbia River.

- **FFTF/FMEF storage**: remove K Basins SNF and transfer to dry storage at the FFTF/FMEF facilities in the 400 Area. The FMEF itself is not large enough to accommodate dry storage of K Basins SNF. With modification, the FMEF could be used as a support facility to an adjacent newly constructed dry storage facility. Although the 400 Area has already been disturbed, there appear to be no environmental advantages to storing SNF there as compared to the reference site or CSB site. In addition, the 400 Area is off the 200 Areas plateau which, because of its remoteness and greater distance to ground water, is being emphasized for consolidation of waste management activities.

3.3 Comparison of Impacts Among the Alternatives

Table 3-2 provides a comparative summary of environmental impacts among the alternatives.

As shown in Table 3-2, land committed to facilities only would vary from no additional land use for new facilities in the no action and enhanced K Basins storage alternatives to about 3 ha (6 acres) for dry cask storage, which at most is small compared to the already industrialized area.

Because of the need for laydown areas, roadways, etc., construction would require disturbance of a larger amount of land than occupied by new facilities. The amount of land disturbed or shrub-steppe habitat destroyed would range from zero for the no action and enhanced K Basins storage alternatives to 8 ha (20 acres) for the onsite processing alternative. If the CSB site were chosen, no additional habitat would be disturbed, because the site is already within the developed 200 East Area. Even at the reference site, the high end of the range of habitat destruction is relatively small. However, because such an activity would further fragment shrub-steppe habitat, it is expected that this habitat destruction would be mitigated by nurturing shrub-steppe species in other areas, for example those that had been burned out by range fires.

Total employment would range among the alternatives from about 4,000 worker-years for the preferred alternative (drying/passivation) to 17,000 worker years in the onsite processing alternative. Thus, in terms of man-power, the preferred alternative would represent a considerable savings.

Table 3-2. Comparative summary of environmental impacts by alternative

Consequence Category	Unit of Measure	Alternatives: No Action	Enhanced K Basin Storage	New Wet Storage	Passivation Dry Storage	Calcination Dry Storage	Onsite Processing	Foreign Processing[a]
Land Use (New Facilities):								
Total disturbed	ha	0	0	2.8	3.5 (5.9)[b]	5.2	8.1	3.6
	acres	0	0	6.9	8.6 (15)[b]	13.	20.	8.9
Facilities only	ha	0	0	0.9	1.4 (2.6)[b]	1.5	2.3	3.6
	acres	0	0	2.2	3.5 (6.5)[b]	3.7	5.7	8.9
Ecological Resources: New habitat destruction	ha	0	0	0-2.8	0-3.5 (2.4-5.9)[b]	0-5.2	0-8.1	0
	acres	0	0	0-6.9	0-8.6 (6.0-15)[b]	0-13.	0-20.	0
Socioeconomics:								
Primary employment								
Maximum annual	workers	280	280	520	690 (610)[b]	850	1300	310
Storage annual		280	190	80	10	10	10	10
Total labor (1996-2035)	100 worker-years	110	83	54	41 (43) [b]	120	170	41
Human Health Impacts								
Routine Operations over 40 years:								
Maximum offsite individual								
Maximum annual dose	rem	$1.7x10^{-7}$	$6.6x10^{-7}$	$8.9x10^{-6}$	$1.7x10^{-5}$	$8.2x10^{-4}$	$8.2x10^{-4}$	$6.6x10^{-7}$
Storage annual dose		$1.7x10^{-7}$	$4.2x10^{-9}$	$8.9x10^{-6}$	0	0	0	0
Offsite population								
Maximum annual dose	person-rem	0.0051	0.019	0.31	0.59	30	30	0.019
Storage annual dose		0.0051	$1.1x10^{-4}$	0.31	0	0	0	0
40-year cumulative dose		0.2	0.19	12	2.0	120	120	0.29
Latent cancer fatalities		none ($1x10^{-4}$)	none ($1x10^{-4}$)	none (0.006)	none (0.001)	none (0.06)	none (0.06)	none ($1x10^{-4}$)
Involved workers								
Collective dose								
40-year cumulative	person-rem	910	950	1000	960-1200	1100	1500	1000
Latent cancer fatalities		none (0.4)	none (0.4)	none (0.4)	0-1	none (0.4)	1	none (0.4)

Table 3-2 (contd)

Consequence Category	Unit of Measure	Alternatives: No Action	Enhanced K Basin Storage	New Wet Storage	Passivation Dry Storage	Calcination Dry Storage	Onsite Processing	Foreign Processing[a]
Human Health Impacts (contd)								
Noninvolved onsite workers								
Collective dose								
Maximum annual	person-rem	$9.6x10^{-4}$	0.0035	0.0035	0.0035	0.5	0.5	0.0035
Storage annual		$9.6x10^{-4}$	$4.6x10^{-4}$	0.0011	0	0	0	0
40-year cumulative		0.038	0.049	0.073	0.037	20	20	0.053
Latent cancer fatalities		$1.5x10^{-5}$	$2.0x10^{-5}$	$2.9x10^{-5}$	$1.5x10^{-5}$	$8.2x10^{-4}$	$8.2x10^{-4}$	$2.1x10^{-5}$
Highest Consequence, Reasonably Foreseeable Radiological Facility Accident:		Cask Drop	Cask Drop	MCO Drop	MCO Fire	U Fire in Dissolver	U Fire in Dissolver	Cask Drop
Estimated accident frequency	per year	-- [c]	0.005 - 0.07	0.002 - 0.03	$1x10^{-6}$ - $1x10^{-4}$	$1x10^{-6}$ - $1x10^{-4}$	$1x10^{-6}$ - $1x10^{-4}$	--[c]
Time at risk of event	years	40	2	2	2	4	4	9
Cumulative probability (period of operation)[c]	--	0.009-0.14[c]	0.009-0.14	0.004-0.07	$2x10^{-6}$ $2x10^{-4}$	$4x10^{-6}$ $4x10^{-4}$	$4x10^{-6}$ $4x10^{-4}$	0.019-0.28[c]
Noninvolved workers								
Collective dose	person-rem	54	54	880	1300 (2500)[d]	580	580	54
Latent cancer fatalities	--	0	0	0	1 (1)[d]	0	0	0
Offsite population[e]								
Collective dose	person-rem	410-720	410-720	$1.1x10^{4}$ - $1.9x10^{4}$	2600 - $8.8x10^{4}$ ($4900-1.7x10^{5}$)[d]	2100 - $7.3x10^{4}$	2100 - $7.3x10^{4}$	410 - 720
Latent cancer fatalities		0	0	6 - 10	1-44 (3-84)[d]	1-37	1-37	0
Point-Risk estimate of latent cancer fatality[f]	LCF	0.002 - 0.05	0.002 - 0.05	0.02 - 0.6	$3x10^{-6}$ - $9x10^{-3}$ ($5x10^{-6}$ - $2x10^{-2}$)[d]	$4x10^{-6}$ - $2x10^{-2}$	$4x10^{-6}$ - $2x10^{-2}$	0.004 - 0.1

Table 3-2 (contd)

Consequence Category	Unit of Measure	Alternatives: No Action	Enhanced K Basin Storage	New Wet Storage	Passivation Dry Storage	Calcination Dry Storage	Onsite Processing	Foreign Processing[a]
Industrial Accidents:								
Injuries/illnesses		360	270	200	150-160	410-420	480-490	150
fatalities		none	none	none	none	(0.6)	(0.7)	none
		(0.4)	(0.3)	(0.2)	(0.2)	1	1	(0.1)
Incident-Free Transportation:								
Collective dose	person-rem							
Involved workers (crew)								
Minimum		--	0.0026	0.044	0.026	0.026	0.026	3.3
Maximum		--	0.3	0.39	0.4	0.4	0.4	1100
Other onsite workers								
Minimum		--	$6.8x10^{-5}$	$4.2x10^{-4}$	$2.9x10^{-4}$	$2.9x10^{-4}$	$2.9x10^{-4}$	--
Maximum		--	0.0012	0.0016	0.0016	0.0016	0.0016	--
Offsite population								
Minimum		--	0	0	0	0	0	0.41
Maximum		--	0	0	0	0	0	250
Transportation Accidents:								
Onsite collective dose								Offsite
Minimum	person-rem	--	$1.3x10^{-4}$	0.0064	0.0065	0.0065	0.0065	0.027
Maximum		--	0.075	0.099	0.099	0.099	0.099	0.085
Latent cancer fatalities			none	none	none	none	none	none
			$(<3.0x10^{-5})$	$(<4.0x10^{-5})$	$(<4.0x10^{-5})$	$(<4.0x10^{-5})$	$(<4.0x10^{-5})$	$(<4.2x10^{-5})$
Transportation-Nonradiological:								
Accidental fatalities		--	none	none	none	none	none	none
		--	$(<9.4x10^{-4})$	(<0.003)	(<0.0031)	(<0.0031)	(<0.0031)	(<0.13)
Latent cancer fatalities			none	none	none	none	none	none
(emissions)			$(<3.6x10^{-5})$	$(<1.4x10^{-4})$	$(<1.5x10^{-4})$	$(<1.5x10^{-4})$	$(<1.5x10^{-4})$	(<0.016)
Air Quality:								
Construction								
PM_{10}	% 24-hour Limits	--	--	29.	34.	28.	30.	150.
SO_2	% Annual Limits	--	--	5.1	7.2	6.4	2.1	--
Operations								
NO_2	% Annual Limits	--	--	--	--	0.0084	0.0084	--

Table 3-2 (contd)

Consequence Category	Unit of Measure	No Action	Enhanced K Basin Storage	New Wet Storage	Passivation Dry Storage	Calcination Dry Storage	Onsite Processing	Foreign Processing[a]
		Alternatives						
Resource Use:								
SNF consolidation, removal, construction								
Electricity	MWh	--	--	1200-2800	3500-4600	6100-7200	6900-8500	--
Diesel fuel	m^3	--	--	500-1100	890-1300	1500-1900	1600-2200	--
	1000 gal	--	--	130-290	240-350	400-500	420-580	--
Gasoline	m^3	--	--	--	190	830	1100	--
	1000 gal	--	--	--	50	220	290	--
Lumber	m^3	--	--	--	61	850	1100	--
	1000 board-ft	--	--	--	26	360	470	--
Gases	m^3	--	100	100	7200	4000	100	100
	100 ft^3	--	35	35	250	140	35	35
Stainless steel	Tonnes	--	--	1500-3000	1600-3100	1900-3400	2300-3700	130-200
	Tons	--	--	1700-3300	1800-3400	2100-3700	2500-4100	140-220
Construction steel	100 Tonnes	--	1.0	32-62	39-67	76-100	84-110	2.6
	100 Tons	--	1.1	35-68	43-74	84-110	92-120	2.9
Concrete	100 m^3	--	--	59-140	120-170	300-360	350-430	18
	100 yd^3	--	--	77-180	160-220	390-470	460-560	24
Water	100 m^3	--	3-6	350	80	5300	7400	3.0-6.0
	1000 gal	--	80-160	9300	2100	1.4×10^5	2.0×10^5	80-160
Operations								
Electricity, maximum storage	100 Mwh/yr	140	140	150	150	230	530	140
		140	93	140	1	1	1	--
Gases	1000 kg/yr	--	--	--	41	--	--	--
	1000 lb/yr	--	--	--	90	--	--	--
Chlorine	kg/yr	1300	1300	1300	1300	1300	1300	1300
	lb/yr	2900	2900	2900	2900	2900	2900	2900
Alum	100 kg/yr	88	88	88	88	88	88	88
	100 lb/yr	190	190	190	190	190	190	190

Table 3-2 (contd)

Consequence Category	Unit of Measure	Alternatives: No Action	Enhanced K Basin Storage	New Wet Storage	Passivation Dry Storage	Calcination Dry Storage	Onsite Processing	Foreign Processing[a]
Nitric acid	1000 L/yr	--	--	--		10	110	--
	1000 gal/yr	--	--	--		27	290	--
Water	100 m^3/yr	5.8	38	23-39	40	200	300	38
	1000 gal/yr	1500	1000	610-1000	1100	5300	8000	1000
Waste Generation:								
K Basin SNF containerization and deactivation								
Low-level radioactive	m^3	--	540	610	1100	1100	610	610
	yd^3	--	710	800	1400	1400	800	800
Transuranic[g]	m^3	--	65	125	160	160	125	125
	yd^3	--	85	160	210	210	160	160
Contaminated water	100 m^3	--	45	91	91	91	91	91
	100 yd^3	--	59	120	120	120	120	120
Construction wastes	m^3	--	20	590-1400	590-1730	2600	3400	--
	yd^3	--	26	770-1800	770-2200	3400	4500	--
Operational wastes								
Low-level radioactive	m^3	3800	1200	1500	250	1400	2200	1400
	yd^3	5000	1600	2000	330	1900	2900	1900
Transuranic	m^3	80	30	38	30	120	210	30
	yd^3	100	390	50	39	160	280	39
High-level radioactive	m^3	--	--	--	--	--	230	--
	yd^3	--	--	--	--	--	300	--
Mixed waste	m^3	40	6.9	8.7	0.46	9.8	11	15
	yd^3	52	9.0	11	0.6	13	14	20
Hazardous waste	m^3	92	30	38	2.0	20	24	35
	yd^3	120	39	50	2.6	26	31	45

Table 3-2 (contd)

Consequence Category	Unit of Measure	Alternatives: No Action	Enhanced K Basin Storage	New Wet Storage	Passivation Dry Storage	Calcination Dry Storage	Onsite Processing	Foreign Processing[a]
Cost:								
40-year storage	Billion Dollars	1.7	1.2	0.96	0.99	2.0	2.7	2.1-3.8
Life cycle		2.1-3.7	1.6-3.2	1.3-2.9	1.1-2.7	2.1	2.7	2.2-3.9

a) Foreign processing does not include consequences of operating the process facility or of transportation at the overseas location. Consequences of these activities are assumed to be similar to those estimated for transportation to a U.S. port, and for operation of the process facility at Hanford, respectively.
b) Values in parentheses represent the consequences of cask storage; otherwise dry vault storage is assumed.
c) Cumulative probability is the product of the estimated annual frequency and the number of years at risk. Annual frequencies have not been estimated for the cask drop accident in the no action and foreign processing alternatives. Therefore, the cumulative probability for the no action alternative was conservatively assumed to be the same as for the enhanced K Basin storage alternative (this would correspond to handling all of the fuel and sludge in the KE basin during the period of operation). The cumulative probability for the foreign processing alternative was estimated to be approximately twice that for the enhanced K Basin storage (this would correspond to handling all of the fuel and sludge in both the KE and KW basins during the period of operation).
d) Values in parentheses represent the projected consequences if SNF is packaged 19 canisters per MCO; otherwise 10 SNF canisters per MCO are assumed.
e) The ranges for offsite collective dose and latent cancer fatalities represent hypothetical outcomes of the accidents for exposure via all pathways (assuming the accident occurs just before harvest, maximizing the ingestion pathway), or for exposure via the inhalation and external pathways only (if exposure occurs when no crops are growing or if protective action is taken to prevent consumption of contaminated food). They are highly conservative estimates assuming minimum atmospheric dispersion (i.e., exposures that would be exceeded only 5% of the time) and no protective action for offsite residents.
f) The point-risk estimate of latent cancer fatality is equal to the product of the number of latent fatal cancers, if the accident occurs, and the cumulative probability of the accident over the period of operation. The risks for the highest consequence accidents are presented in this table. For the no action, enhanced K Basin storage, foreign processing and new wet storage alternatives, the highest consequence accidents are also associated with the highest risk to the public for those activities. The highest risk accident for the conditioning, calcination, or onsite processing alternatives would be equivalent to the MCO drop accident listed under the new wet storage alternative. For perspective, the point risk estimate for exposure to natural background radiation is the number of latent fatal cancers induced over 40 years in the offsite population (about 2000 for 380,000 people) multiplied by the probability that the exposure to natural background radiation would occur (1.0).
g) These quantities include sludge classified as transuranic waste if it is disposed at the 200 Area tank farm.
-- Indicates that a particular consequence category does not apply to, or is not expected for, this alternative.

Human health impacts among the public and workers from routine operations and incident-free transportation would vary among the alternatives; however, values were very small fractions of the annual variation in natural background radiation at any given location.

In the case of accidents there were scenarios where latent cancer fatalities would be inferred if the accident were to happen. However, taking the probability of the accidents occurring into account, the risk to public health and safety was found to be very small. In quantitative terms, multiplying the consequences of the accidents with the estimated annual frequency and the number of years at risk, the point-risk estimate of latent cancer fatalities in all cases did not exceed 1 latent cancer fatality (for perspective, the point-risk estimate of latent cancer fatalities for natural background radiation for this population (380,000) and period would be about 2,000 latent cancer fatalities).

Impacts would occur on air quality during construction activities for all but the no action and enhanced K Basins storage alternatives. The principal impact would be from particulates from use of earthmoving equipment. In all cases standard dust suppression techniques would be used to mitigate particulate emissions. For all alternatives releases of radionuclides during routine operations would result in doses well below EPA's 0.1-mrem/year reporting level.

Except for the no action and enhanced K Basins storage alternative, commitments of resources (other than water, gases, and nitric acid) were within a factor of 3 to 4 for all alternatives (it being assumed that resources equivalent to onsite processing would be required for foreign processing). The requirement for water in the onsite processing alternative would be about 10 times that in the preferred alternative; however, large water requirements would not be critical because of the abundance of water available from the Columbia River (maximum requirement of about 0.001% of annual flow) and would be within capacity of existing supply lines. Although not required in other alternatives, sizeable quantities of gases, principally inert gases, would be required in the preferred alternative; however, there is no indication that these are in short supply. Nitric acid would be required in quantity for the calcination and 10 times that in the processing alternatives, but not in the other alternatives. Again, nitric acid is not in short supply, however it would be reclaimed as practicable.

While wastes would be generated in the process of implementing any of the alternatives, none of the wastes described would significantly impact Hanford's present capacity to store (as in the case of high-level and TRU waste) or to dispose of low-level waste. Even in the case of high-level waste from onsite processing the amount represents less than 10% of the now remaining DST capacity.

Costs of implementing 40-year storage would range from about $1 to $4 billion. At the low end of about $1 billion were the enhanced K Basins storage and new wet storage alternatives, and the preferred alternative. The no action and calcine alternatives would cost about $2 billion and onsite processing about $3 billion. Cost of foreign processing would range from about $2 to $4 billion. If one presumed that processing of SNF would be required before repository acceptance, the life-cycle costs would be about $3 billion for the enhanced K Basins storage, new wet storage, preferred, and onsite processing alternatives and about $4 billion for the no action and foreign processing alternatives.

4.0 AFFECTED ENVIRONMENT

Information in this chapter is tiered from Chapter 4 of Appendix A to Volume 1 of the DOE SNF Programmatic Environmental Impact Statement (DOE SNF PEIS) (DOE 1995a) and is, therefore, presented in extended summary form here. More complete information on the affected environment may be found in the DOE SNF PEIS and in Cushing (1995).

4.1 Overview

The Hanford Site is characterized by a shrub-steppe habitat with large sagebrush dominating the vegetative plant community. Jack rabbits, mice, badgers, deer, elk, hawks, owls, and many other animals inhabit the Hanford Site. The nearby Columbia River supports one of the last remaining spawning areas for Chinook salmon and hosts a variety of other aquatic life. The climate is dry with hot summers and usually mild winters. Severe weather is rare. With construction of dams along the Columbia River, flooding is nearly nonexistent.

The Hanford Site was a major contributor to national defense during World War II and the Cold War era. The Site was selected because it was sparsely settled, and the Columbia River provided an abundant supply of cold, clean water to cool the reactors. As a result of wastes generated by these national defense activities, four areas on the Hanford Site have been placed on the National Priorities list by the U.S. Environmental Protection Agency (EPA) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). There are currently more than 1,500 waste management units and four major groundwater contamination plumes on the Site that have been grouped into 76 operable units. Each of these operable units is following a schedule for clean-up established by the Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement), among DOE, the Washington State Department of Ecology (Ecology), and the EPA.

4.2 Land Use

The Hanford Site is used primarily by DOE. Public access is limited to travel on two access roads as far as the Wye Barricade, on State Highway 240, and on the Columbia River (Figure 4-1). The Site encompasses 1,450 km^2 (560 mi^2), of which most is open vacant land with widely scattered facilities, old reactors, and processing plants.

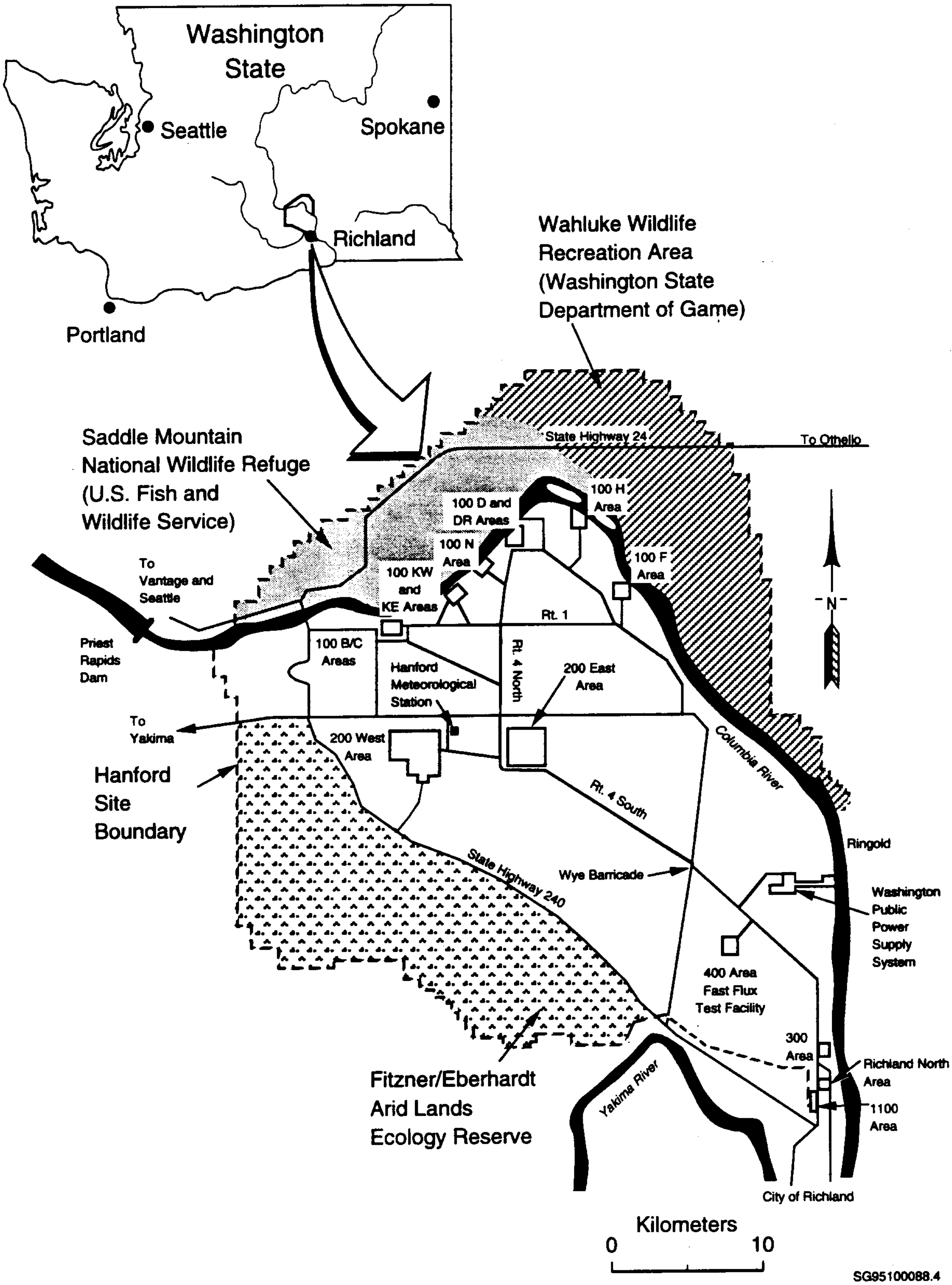


Figure 4-1. Hanford Site showing the 100 KW and KE Area

In the past, DOE has stated that it intends to maintain active institutional control of the Hanford Site in perpetuity (DOE 1989). In the future, DOE could release or declare excess portions of the Hanford Site not required for DOE activities. Alternatively, Congress could act to change the management or ownership of the Hanford Site. For a descriptive list of the DOE operational areas, see the DOE SNF PEIS (DOE 1995a). Cushing (1995) describes the areas within the Hanford Site that have been set aside as wildlife refuges, wildlife management areas, or research areas.

The Columbia River adjacent to the Hanford Site is used by boaters, water skiers, fishers, and hunters of upland game birds and migratory waterfowl. Some land along the shore and on certain islands is accessible and available for public use.

Land use adjacent to the Hanford Site to the southeast and generally along the Columbia River includes residential, commercial, and industrial development areas. The cities of Richland, Kennewick, and Pasco are located along the Columbia River and are the closest major urban land uses adjacent to the Hanford Site. These cities (known as the Tri-Cities) together support a population of approximately 105,000.

Irrigated orchards and produce crops, dryland farming, and grazing are also important land uses adjacent to the Hanford Site. Cushing (1995) presents information on the various crops and harvests.

4.3 Socioeconomics

Activity on the Hanford Site plays a dominant role in the socioeconomics of the Tri-Cities and other parts of Benton and Franklin counties. The agricultural community also has a significant effect on the local economy. Any major changes in Hanford activity would potentially most affect the Tri-Cities and other areas of Benton and Franklin counties.

4.3.1 Employment and Income

Table 4-1 provides available data on the economic base of the Tri-Cities area. Three major sectors have been the principal driving forces of the economy in the Tri-Cities since the early 1970s: 1) the DOE and its contractors who operate the Hanford Site; 2) the Washington Public Power Supply System in its construction and operation of nuclear power plants; and 3) an export-oriented agricultural community, including a substantial food-processing

Table 4-1. Selected information on the economic base of the Tri-Cities (Richland, Pasco, and Kennewick) and Benton and Franklin counties, Washington (1994 values unless otherwise noted)

Sector	Direct Employment	Income (Millions of Dollars)
Hanford Site (DOE and Major Contractors)[a]	18,400	$740 (1993)
Washington Public Power Supply System[a]	1,700	$ 84
Agriculture:		
- Wage employees covered by unemployment insurance[b]	9,500 (1993)	$ 97 (1993)
- Seasonal wage employees[c]	6,300	Not Available
-Proprietors[d]	2,300 (1992)	$ 83 (1992)
Other Major Employers[a]	3,550	Not Available
Tourism[e]	2,300 (1993)	$ 25 (1993)
Retirees[f]	-0-	$ 235 (1992)

(a) Personal contacts with personnel offices of the employers, March 1994.
(b) Washington State Employment Security (February 1994 - February 1995).
(c) U.S. Department of Labor (1994).
(d) Bureau of Economic Analysis (May 1994).
(e) Dean Runyan Associates (1994).
(f) Cushing (1995).

component. In addition to the direct employment and payrolls, these major sectors also support a sizable number of jobs in the local economy through their procurement of equipment, supplies, and business services.

In addition to these three major sectors, three other components can be readily identified as contributors to the economic base of the Tri-Cities. The first of these, loosely termed "other major employers," includes five such employers: 1) Siemens Nuclear Power Corporation, 2) Sandvik Special Metals, 3) Boise-Cascade, 4) Burlington Northern Railroad, and 5) Iowa Beef Processors. The second component is tourism. The Tri-Cities area has increased its convention business substantially in recent years, in addition to business generated by travel for recreation. The third component in the economic base relates to the local purchasing power generated not from current employees but from retired former employees. Government transfer payments in the form of pension benefits constitute a significant proportion of total spendable income in the local economy.

In 1994 Hanford employment accounted directly for 25% of total non-agricultural employment in Benton and Franklin counties and nearly 0.8% of all nonagricultural statewide jobs. The total wage payroll for the Hanford Site was estimated at over $740 million in 1993, which accounted for an estimated 45% of the payroll dollars earned in the area. Total employment at Hanford has declined from over 18,000 in 1994 to less than 14,000 in late 1995 and is expected to remain at about that level through 2004. Overall workforce in the Tri-Cities is expected to remain in the range of 81,000 to 86,000, while population in Benton and Franklin counties is expected to increase to about 173,000 by the year 2000 and 185,000 by 2005 (DOE 1995a). However, other projects may occur at Hanford in the near term, such as the tank waste remediation program; operations of the Hazardous Materials Management Emergency Response facility, Environmental Molecular Science Laboratory, and Laser Interferometer Gravitational-Wave Observatory; preparation for decommissioning of the older reactors and deactivating PUREX and other facilities; and other cleanup operations. The schedule and funding status of several of these operations is uncertain, making it difficult to improve on the projections in DOE (1995a).

Previous studies have revealed that each Hanford job supports about 1.2 additional jobs in the local service sector of Benton and Franklin counties (about 2.2 total jobs) or about 1.5 additional jobs in the state's service sector (about 2.5 total jobs) (Scott et al. 1987). Similarly, each dollar of Hanford income supports about 2.1 dollars of total local incomes and about 2.4 dollars of total statewide incomes. Based on these multipliers in Benton and Franklin counties, Hanford directly or indirectly accounts for more than 40% of all jobs. Overall employment losses in the Tri-Cities during 1995 have been less than would be predicted from the 2.2 employment multiplier for a number of reasons: 1) about half of the Hanford position losses were early retirees who remained in the community and continue to buy goods and services; 2) some of those laid off have started new businesses or were hired by non-Hanford contractor businesses; 3) there was some countervailing growth in businesses unrelated to Hanford; and 4) some of the job losses that can be expected as a result of reduced Hanford activity had not yet taken place by the end of fiscal year 1995.

Based on employee residence records as of December 1993, 93% of Hanford employees resided in Benton and Franklin counties. Approximately 81% of

Hanford employees resided in the Tri-Cities. More than 42% of Hanford employees resided in Richland, 30% in Kennewick, and 9% in Pasco. Hanford employees residing in West Richland, Benton City, Prosser, and other areas in Benton and Franklin counties account for 12% of the total employees.

The secondary sector consists of all other workers in Benton and Franklin counties. Total nonagricultural employment averaged 72,300 in 1994. Nonagricultural jobs increased by 2,800 during 1994 (a 4.1% growth rate) [Washington State Employment Security (February 1994-February 1995)].

In 1992 the total personal income for Benton County was $2,422 million, Franklin County was $633 million, and the State of Washington was $109.5 billion. Per capita income in 1992 for Benton County was $20,122, Franklin County was $15,620, and Washington State was $21,289 (Bureau of Economic Analysis May 1994). Median household income in 1992 for Benton County was estimated to be $40,288, Franklin County was estimated at $28,317, and the State of Washington was estimated at $36,648 (OFM 1994a).

4.3.2 Demography

Population estimates for 1994 for Benton and Franklin counties were 127,000 and 42,900, respectively (OFM 1994a). When compared to the 1990 census data in which Benton County's population was 112,560 and Franklin County's population was 37,473, the current population totals reflect the continued growth occurring in these two counties.

Within each county, the 1994 estimates distributed the Tri-Cities population as follows: Richland 35,430, Kennewick 46,960, and Pasco 22,170. The estimated populations of Benton City, Prosser, and West Richland totaled 11,985 in 1994. The unincorporated population of Benton County was 32,625. In Franklin County, incorporated areas other than Pasco had a total population of 3,155. The unincorporated population of Franklin County was 17,575 (OFM 1994b).

The 1994 estimates of racial categories by the Office of Financial Management indicate that in Benton and Franklin counties Asians represent a lower proportion and people of Hispanic origin represent a higher proportion of the population than in Washington State. County-wide, Benton and Franklin counties exhibit varying racial distributions, as shown in Table 4-2.

Benton and Franklin counties accounted for 3.2% of Washington State's population (OFM 1994a). In 1994, the population demographics for Benton and

Table 4-2. 1994 Population estimates by racial and ethnic categories and origins (OFM 1994a, Table 21)

Geographic District	Total	White	Black	Indian, Eskimo, & Aleut	Asian & Pacific Islander	Other n.e.c.[a]	Hispanic Origin[b]
Washington State	5,334,400	4,629,077 86.8%[c]	176,487 3.3%	92,401 1.7%	283,783 5.3%	152,652 2.9%	284,190 5.3%
Benton and Franklin Counties	169,900	140,237 82.5%	2,712 1.6%	1,310 0.8%	4,480 2.6%	21,161 12.5%	29,022 17.1%
Benton County	127,000	113,569 89.4%	1,400 1.1%	992 0.8%	3,113 2.5%	7,926 9.7%	12,360 9.7%
Franklin County	42,900	26,668 62.2%	1,312 3.1%	318 0.7%	1,367 3.2%	13,235 30.9%	16,662 38.8%

(a) The "other n.e.c." racial category is a count of persons who marked "Other Race" on the 1990 census questionnaire and wrote in specific entries, such as Cuban, Puerto Rican, Mexican, etc.
(b) Hispanic Origin is not a racial category; it may be viewed as the ancestry, nationality group, lineage, or country of birth of the person or person's parents or ancestors before arrival in the United States. Persons of Hispanic Origin may be of any race and are counted in the racial categories shown.
(c) Percentage figures refer to county, not state, populations.

Franklin counties were quite similar to those found within Washington State (OFM 1994b). Additional detail on minority and low-income populations is provided in Section 5.21.

4.3.3 Housing and Public Services

In 1994, 95% of all housing (of 41,562 total units) in the Tri-Cities was occupied (OFM 1994a). Single-unit housing, which represents nearly 59% of the total units, had a 98% occupancy rate throughout the Tri-Cities. Multiple-unit housing, defined as housing with two or more units, had an occupancy rate of 95%, a 4% increase since 1990. Pasco had the lowest occupancy rate, 93% in all categories of housing, followed by Kennewick with 96% and Richland with 97%. Representing nearly 11% of the housing unit types, manufactured homes had the lowest occupancy rate, 90%. Recent reductions in Hanford employment are beginning to alleviate what has been a very tight housing market over the last 5 years.

Education

Primary and secondary education are served by the Richland, Kennewick, Pasco, and Kiona-Benton school districts, with a combined 1994 spring enrollment of 31,970 students, an increase of 7.4% from the enrollment in 1993. In 1994, Richland was operating near capacity, Pasco was at capacity for primary education, Kennewick was at capacity at the primary level and over capacity at the high-school level, and Kiona-Benton was operating over capacity at all levels. Kennewick is constructing a new high school, one new middle school, and two new elementary schools. Post-secondary education in the Tri-Cities area is provided by Columbia Basin College (CBC) (fall 1994 enrollment was 6,800) and the Tri-Cities branch campus of Washington State University (WSU-TC) (fall 1994 enrollment was 1,300). Currently, 23 associate degree programs are available at CBC, and WSU-TC offers 10 undergraduate and 15 graduate programs.

Health Care

The Tri-Cities have three major hospitals and five minor emergency centers. Combined, the three hospitals have 346 beds and had about 15,000 admissions in 1994 (about 42% non-Medicare/Medicaid). All three hospitals offer general medical services and include a 24-hour emergency room, basic surgical services, intensive care, and neonatal care. Our Lady of Lourdes Hospital in Pasco offers skilled nursing and rehabilitation, and alcohol and chemical dependency services. Our Lady of Lourdes also operates the Carondelet Psychiatric Care Center, a 32-bed psychiatric hospital located in Richland, and provides a significant amount of outpatient and home health services.

Human Services

The Tri-Cities offer a broad range of social services. State human service offices in the Tri-Cities include the Job Services Office of the Employment Security Department, food stamp offices, the Division of Developmental Disabilities, financial and medical assistance, the Child Protective Service, emergency medical service, a senior companion program, and vocational rehabilitation. The local United Way incorporates 24 participating agencies and 48 programs, with a cumulative 1994 budget of $21.1 million.

Police and Fire Protection

Police protection in Benton and Franklin counties is provided by county sheriffs' departments, local municipal police departments, and the Washington State Patrol Division headquartered in Kennewick. In February 1995, the local departments had a combined total of 266 commissioned officers, 114 reserve officers, and 129 patrol cars. According to the Washington Uniform Crime Reporting Program of the Washington Association of Sheriffs and Police Chiefs, both Benton and Franklin counties' violent crime rate per 1,000 residents (2.8 and 2.4, respectively) were less than that of Washington State (5.1). Pasco's rate was higher than the state rate, while the other cities' rates were lower. Property crime rates were slightly above the state rate of 54.3 per 1,000 residents in Kennewick and Pasco, and at about half of the state rate in Richland and the rest of the two counties.

City fire protection in the Tri-Cities area is provided by three city fire departments and three additional rural fire districts. Together, they have 152 paid personnel and 160 volunteers. The separate Hanford Fire Department, composed of 155 fire-fighters, is trained to dispose of hazardous waste and to fight chemical fires. Each station has access to a Hazardous Material Response Vehicle, which is equipped with chemical fire extinguishing equipment, an attack truck that carries foam and Purple-K dry chemical, a mobile air truck that provides air for gas masks, and a transport tanker that supplies water to six brush-fire trucks. The Hanford Fire Department owns five ambulances and maintains contact with local hospitals.

Parks and Recreation

The Columbia, Snake, and Yakima rivers offer the residents of the Tri-Cities a variety of recreational opportunities. The boating, camping, and picnic facilities of the Lower Snake River Project attracted 2.5 million visitors in 1993, while Lake Wallula on the Columbia attracted an estimated 3 million visitors in the same year (Cushing 1995). The Columbia River Basin is also a popular area for migratory waterfowl and upland game bird hunting. The Tri-Cities also offer numerous tennis courts and ball fields; eight golf courses; several privately owned health clubs with indoor tennis and racquetball courts, pools, and exercise programs; and bowling lanes and roller skating rinks in each of the Tri-Cities. There are minor league professional sport franchises in hockey and baseball.

4.4 Cultural Resources

The Hanford Site contains numerous, well-preserved archaeological sites from both prehistoric and historical periods, and is still thought of as a homeland by many Native Americans. Historic period resources include sites, buildings, and structures from the pre-Hanford, Manhattan Project, and Cold War eras. Sitewide management of Hanford's cultural resources follows the Hanford Cultural Resources Management Plan (Chatters 1989) and is conducted for DOE Richland Operations Office by the Hanford Cultural Resources Laboratory (HCRL) of Pacific Northwest Laboratory (PNL). The following sections briefly discuss the cultural resource setting of the Hanford Site for the purposes of this document. More complete discussions can be found in Chatters (1989), Cushing (1995), and DOE (1995a). Results of cultural resource surveys for the proposed sites can be found in the DOE SNF PEIS (DOE 1995a). No prehistoric or historic archaeological properties were found at the reference site.

4.4.1 Prehistoric Archaeological Resources

Archaeological sites include remains of numerous pithouse villages, various types of open campsites, and cemeteries along the river banks (Rice 1968a, 1980); spirit quest monuments (rock cairns), hunting camps, game drive complexes, and quarries in mountains and rocky bluffs (Rice 1968b); hunting/kill sites in lowland stabilized dunes; and small temporary camps near perennial sources of water located away from the river (Rice 1968b). As of September 1995, 363 prehistoric archaeological sites are recorded in the files of the HCRL. Of these, 48 sites are currently included on the National Register of Historic Places (National Register).

4.4.2 Native American Cultural Resources

In prehistoric and early historic times, the Hanford Reach of the Columbia River was heavily populated by Native Americans of various tribal affiliations. The Wanapum and the Chamnapum band dwelt along the Columbia River from south of Richland upstream to Vantage (Relander 1956; Spier 1936). Some of their descendants still live nearby at Priest Rapids, and others have been incorporated into the Yakama and Umatilla reservations. Palus people, who lived on the lower Snake River, joined the Wanapum and Chamnapum to fish the Hanford Reach of the Columbia River, and some inhabited the river's east bank (Relander 1956; Trafzer and Scheuerman 1986). Walla Walla and Umatilla people also made periodic visits to fish in the area. These people retain traditional secular and religious ties to the region, and many, young and old alike, have knowledge of the ceremonies and lifeways of their aboriginal culture.

4.4.3 Historic Cultural Resources

Historic archaeological sites totaling 260 and 11 other historic localities have been recorded by the HCRL on the Hanford Site. Localities include the Allard Pumping Plant at Coyote Rapids, the Hanford Irrigation Ditch, the Hanford townsite, Wahluke Ferry, the White Bluffs townsite, the Richmond Ferry, Arrowsmith townsite, a cabin at East White Bluffs ferry landing, the

White Bluffs road, the old Hanford High School, and the Cobblestone Warehouse at Riverland (Rice 1980). Archaeological sites including the East White Bluffs townsite and associated ferry landings and an assortment of trash scatters, homesteads, corrals, and dumps have been recorded by the HCRL since 1987. In addition to the recorded sites, numerous unrecorded sites of gold mine tailings along the river bank and the remains of homesteads, farm fields, ranches, and abandoned Army installations are scattered over the entire Hanford Site. Of these historic sites, one is included in the National Register as an historic site, and 56 are listed as historic archaeological sites.

More recent locations are the defense reactors and associated material processing facilities that now dominate the Site. The first reactors (B, D, and F) were constructed in 1943 as part of the Manhattan Project. Plutonium for the first atomic explosion and the bomb that destroyed Nagasaki to end World War II were produced in the B Reactor. Additional reactors and processing facilities were constructed after World War II during the Cold War. All reactor containment buildings still stand, although many ancillary structures have been removed. The B Reactor has been listed on the National Register.

4.5 Aesthetic and Scenic Resources

The land near the Hanford Site is generally flat with little relief. Rattlesnake Mountain, rising to 1,060 m (3,500 ft) above mean sea level, forms the western boundary of the Site. Gable Mountain and Gable Butte are the highest land forms within the Site. The view toward Rattlesnake Mountain is visually pleasing, especially in the springtime when wildflowers are in bloom. Large rolling hills are located to the west and far north. The Columbia River, flowing across the northern part of the Site and forming the eastern boundary, is generally considered scenic, with its contrasting blue against a background of brown basaltic rocks and desert sagebrush. The White Bluffs, steep whitish-brown bluffs adjacent to the Columbia River and above the northern boundary of the river in this region, are a striking feature of the landscape. The reach of the Columbia River flowing through the Hanford Site is currently being considered for Wild and Scenic status.

4.6 Geology

This section summarizes the physiography, geology, and seismic and volcanic hazards at the Hanford Site and specifically at the 100-K and 200 Areas. A more detailed summary of these subjects can be found in Cushing (1995) and DOE (1988).

4.6.1 General Geology

A brief summary of the geology of the 100-K and 200 Areas is provided here. More detailed information on the geology of the 100-K and 200 Areas can be found in Connelly et al. (1992), Lindberg (1993), and DOE (1988). A generalized stratigraphic column is provided in Figure 4-2.

Physiography

The Columbia Plateau is a relatively flat region bounded on the north by the Okanogan Highlands, on the west by the Cascade Range, on the south by the Blue Mountains, and on the east by the Rocky Mountains (DOE 1988). The Hanford Site is located within the Pasco Basin, a topographic and structural low within the Columbia Plateau. The highest topographic point on the Hanford Site is 1,060 m (3,500 ft) on Rattlesnake Mountain, although the majority is much lower and relatively flat, ranging from 105 to 245 m (345 to 803 ft).

Geology

Columbia River Basalts are overlain by either Ringold or Hanford formation sediments in the 200 Areas and by Ringold sediments in the 100-K Area. Geologic units present in the 100-K Area in ascending order are Unit A, Lower Mud unit; Unit B, unnamed mud unit; Unit C, another unnamed mud unit; and Unit E of the Ringold Formation, and coarse-grained sediments of the Hanford formation. In the southern part of the 200 East Area, Unit A, Lower Mud unit; Unit E; and coarse- and fine-grained sediments of the Hanford formation overlie the basalt. In the northern part of 200 East Area, primarily coarse-grained sediments of the Hanford formation lie directly on the basalt. Hajek (1966) describes 15 different soil types on the Hanford Site. The soil types are primarily sandy to silty sandy loam. Because there has not been an update of this report on the Hanford Site, some of the nomenclature used in Hajek (1966) no longer correlates directly with areas outside the Hanford Site.

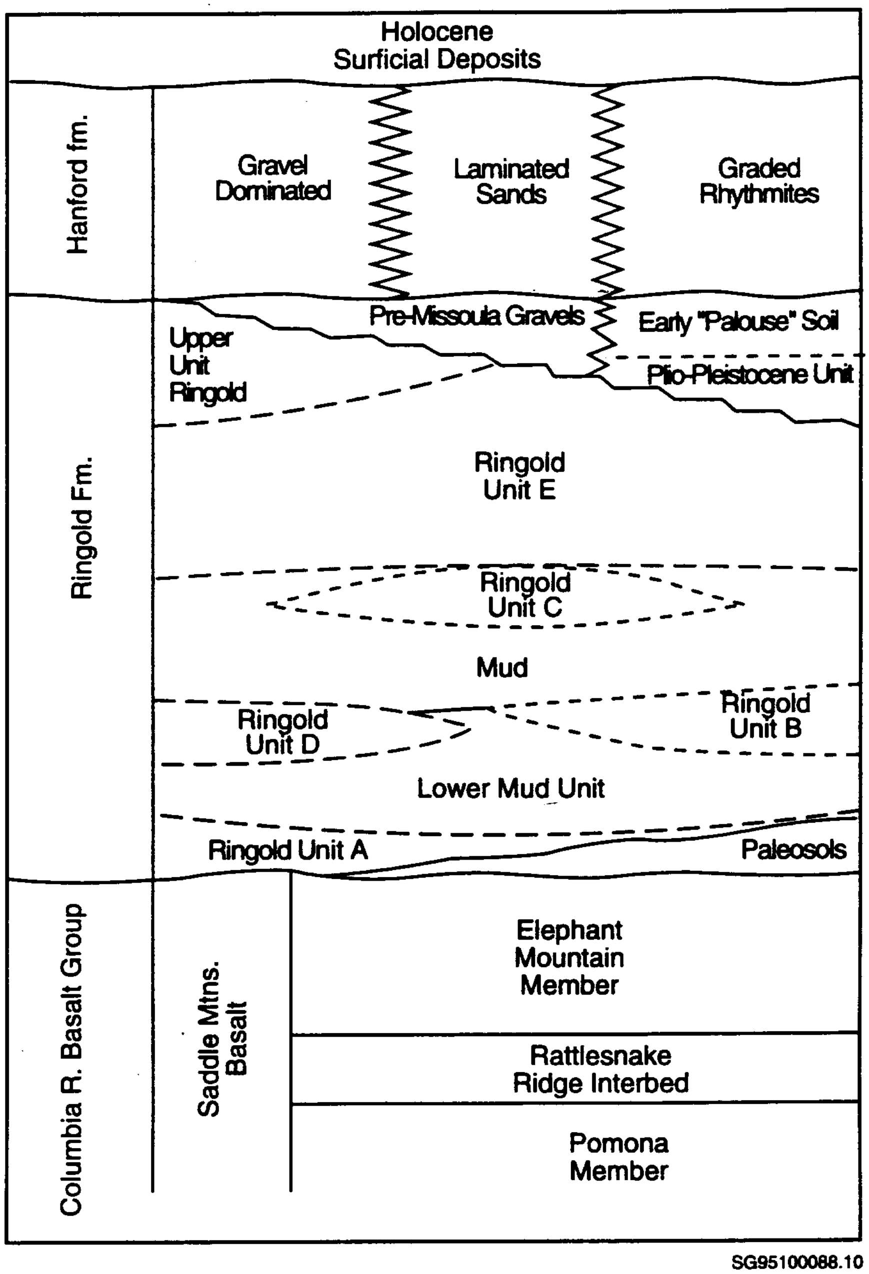


Figure 4-2. General stratigraphy of the 200 East Area and vicinity

The anticlinal ridges bounding the Pasco Basin are separated by relatively gently folded synclines. These folds are oriented roughly east-west. Thrust or high-angle faults parallel to the axis of the fold are often found along the base of the steeper limb (DOE 1988). The 100-K Area is located above one of the synclines, while the 200 East Area is above the northern limb of another syncline.

The Cold Creek Fault occurs on the west end of the Cold Creek syncline and appears to be a high-angle fault that has faulted the basalts and the older Ringold units (Johnson et al. 1993). Another fault, informally called the May Junction fault, is located nearly 4.8 km (3 mi) east of the 200 East Area. Like the Cold Creek fault, this fault is thought to be a high-angle fault that has offset the basalts and the older Ringold units. Neither of these faults appear to have affected the younger Ringold or the Hanford formation sediments.

4.6.2 Mineral Resources

Sand, gravel, and cobble deposits are ubiquitous components of the soils over the Columbia Basin in general and the Hanford Site in particular. Other than proximity to areas where sand or gravel are needed, no particular quarry site is much different from other quarries.

4.6.3 Seismic and Volcanic Hazards

The following discussion briefly summarizes seismic and volcanic hazards on the Hanford Site. A more complete summary is provided in Cushing (1995).

Seismic Hazards

Seismic hazards are of concern because of the potential damage to facilities and disruption of services such as electricity and water. Figure 4-3 shows the historical seismicity of southeastern Washington between 1969 and 1989 for earthquakes of Modified Mercalli Intensity IV or magnitude of 3 or greater. Large earthquakes with magnitudes greater than 7 on the Richter scale have occurred in the Pacific Northwest, but only one seems to have occurred in eastern Washington. This earthquake occurred in 1872 and is thought to have been located between Lake Chelan, Washington, and British Columbia (DOE 1988). The Columbia Plateau is generally considered an area of low seismicity and is classified as Uniform Building Code Zone 2.

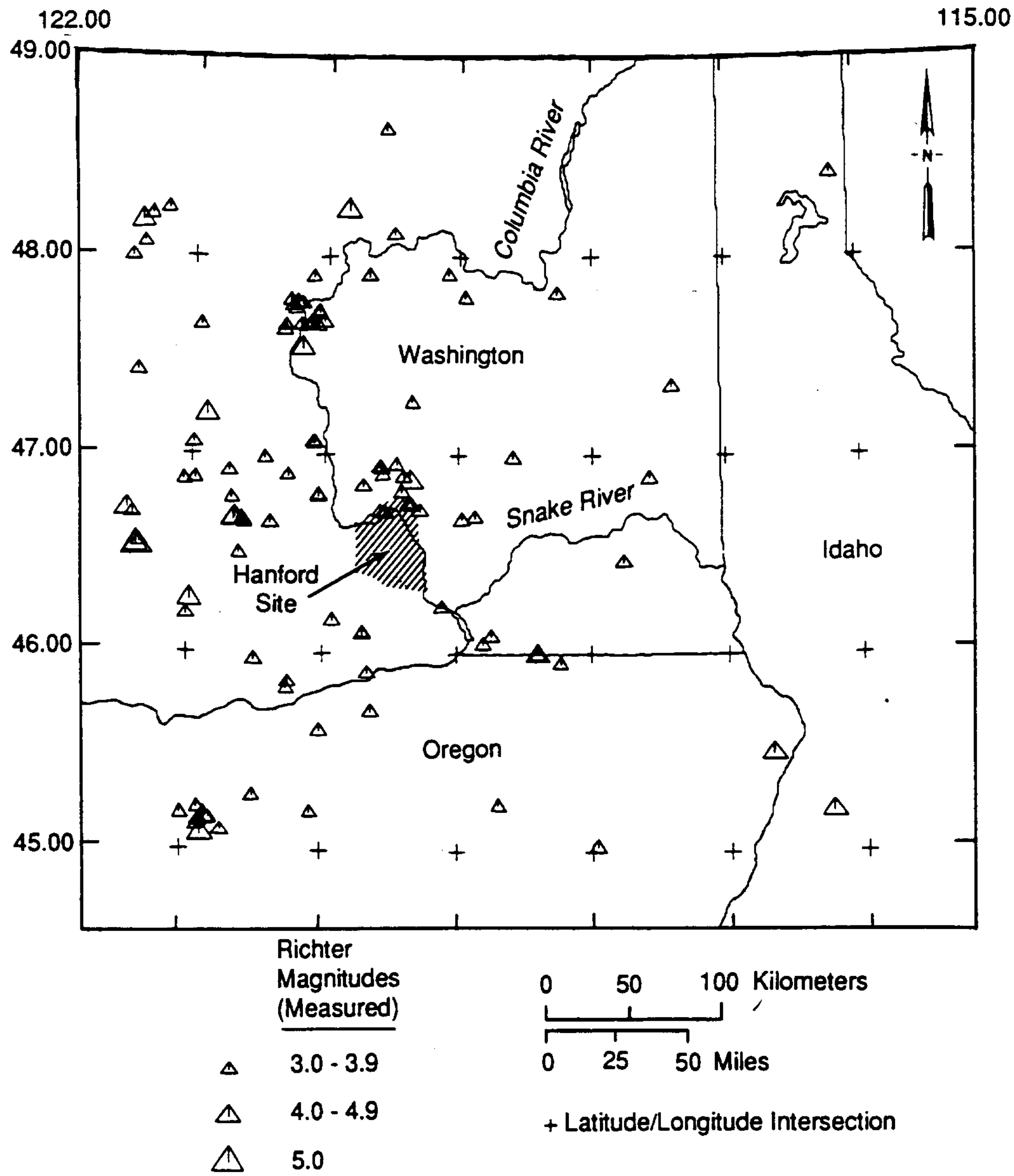


Figure 4-3. Recent seismicity of the Columbia Plateau and surrounding areas. All earthquakes between March 23, 1969 and 1989 with a magnitude of 3 or larger are shown (Rohay 1989).

Swarms of low-magnitude earthquakes have been recorded on the Hanford Site, as well as low-magnitude individual earthquakes. These swarms form both temporal and spatial clusters, are not associated with a large or outstanding event, generally have magnitudes of 2 or less, and do not appear to be associated with known faults. The maximum swarm earthquake for the purpose of seismic design is a magnitude 4 event. The Site design basis earthquake for a safety class 1 system, structure, and component is 0.20 g (acceleration)

(Hanford Plant Standard, Standard Design Criterion 4.1). The most recent probabilistic seismic hazard analysis calculated an annual probability of recurrence of 5 x 10^{-4} for exceeding the design basis earthquake.

Volcanic Hazards

Volcanism is of concern primarily because ash fall might affect operations of communications equipment and electronic devices, as well as vehicle traffic. Quaternary volcanism in the region has been associated with the Cascade Range, and airfall deposits from at least three Cascade volcanoes have blanketed the central Columbia Plateau since the late Pleistocene. Mount St. Helens has erupted several times since the Pleistocene, most recently in May 1980 when an eruption resulted in about 1 mm (0.039 in.) of ashfall over a 9-hour period at the Hanford Site. Glacier Peak erupted twice about 11,200 years ago, and Mount Mazama in Oregon erupted 6,600 years ago, both spreading ash across the Site.

4.7 Air Resources

This section addresses general air resources at the Hanford Site and surrounding region. Included in this section are discussions of climate, meteorology, and ambient air quality. Detailed information about the climate at the Hanford Site are presented in Stone et al. (1983), Glantz et al. (1990), and Hoitink and Burk (1994).

4.7.1 Climate and Meteorology

The climate of the Hanford Site can be classified as mid-latitude semiarid or mid-latitude desert, depending on the climatological classification scheme used. Summers are warm and dry with abundant sunshine. Large diurnal temperature variations result from intense solar heating during the day and radiative cooling at night. Daytime high temperatures in June, July, and August periodically exceed 38°C (100°F). Winters are cool with occasional precipitation. Outbreaks of cold air associated with modified arctic air masses can reach the area and cause temperatures to drop below -18°C (0°F) (Stone et al. 1983).

Topographic features have a significant impact on the climate of the Hanford Site. All air masses that reach the region undergo some modification resulting from their passage over the complex topography of the Pacific Northwest. The climate of the region is strongly influenced by the Pacific Ocean and the Cascade Range to the west. The relatively low annual average rainfall of 16 cm (6.3 in.) at the Hanford Meteorological Station is caused largely by the rain shadow created by the Cascade Range. These mountains limit much of the maritime influence of the Pacific Ocean, resulting in a more continental-type climate than would exist if the mountains were not present. Maritime influences are experienced in the region during the passage of frontal systems and as a result of movement through gaps in the Cascade Range (such as the Columbia River Gorge).

The Rocky Mountains to the east and the north also influence the climate of the region. These mountains play a key role in protecting the region from the more severe winter storms and the extremely low temperatures associated with the modified arctic air masses that move southward through Canada. Local and regional topographical features, such as Yakima Ridge and the Rattlesnake Hills, also impact meteorological conditions across the Hanford Site (Glantz and Perrault 1991). In particular, these features have a significant impact on wind directions, wind speeds, and precipitation levels.

Climatological data are collected for the Hanford Site at the Hanford Meteorological Station. The station is located between the 200 West and 200 East Areas and is close to the reference site. Data have been collected at this location since 1945 and are summarized in Stone et al. (1983). Beginning in the early 1980s, data have also been collected at a series of automated monitoring sites located throughout the Hanford Site and the surrounding region (Glantz et al. 1990). This Hanford Meteorological Monitoring Network is described in detail in Glantz and Islam (1988).

Wind

Winds at the Hanford Site are strongly influenced by their proximity to local terrain features. The prevailing wind direction in the 200 Areas is from the west-northwest. In the southeastern portion of the Site (300 and 400 Areas), the prevailing wind direction is generally from the southwest (Glantz et al. 1990). Wind speeds near the 200 Areas average about 3.4 m/s (7.7 mph) at about 15 m (50 ft) above ground level. Average wind speeds are highest in June [4 m/s (9 mph)] and lowest in November and December [3 m/s (6 mph)] (Stone et al. 1983). Figure 4-4 displays wind direction distributions (wind roses) for meteorological monitoring stations located on the Hanford Site and in neighboring areas.

In the 100 Area (station 13 on Figure 4-4), wind speeds of less than 1.3 m/s (3 mph) occur on average about 40% of the time, with 0.8% being

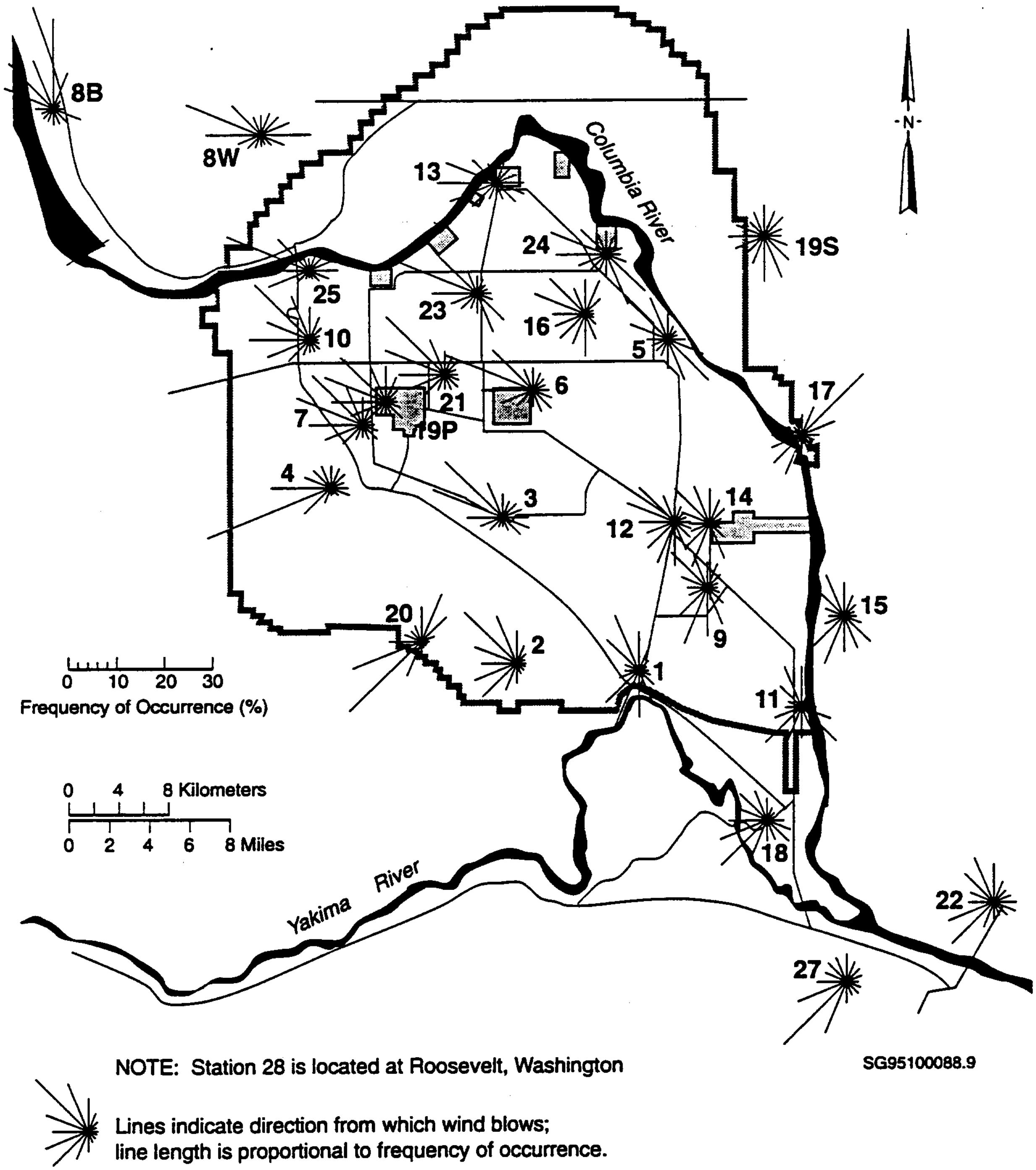


Figure 4-4. Wind roses for the Hanford Site. The "petals" in a wind rose, shown for each Hanford wind monitoring station, indicate the frequency with which the wind blows toward the station from each of sixteen directions. The wind roses are based on data collected from 1982 through 1994 at sensors located 10 m (30 ft) above ground level. Stations 8 and 19 were moved during this period; data are presented for both old and new locations.

reported as calm. In the 200 Area (station 21 on Figure 4-4), wind speeds of less than 1.3 m/s (3 mph) occur on average about 29% of the time, with 1.6% being reported as calm (Hoitink and Burk 1994).

Atmospheric Stability

There are a number of methods for estimating the "stability" of the atmosphere. Using a method based on the vertical temperature gradient (NRC 1980) and measurements made at the Hanford Meteorology Station, thermally unstable conditions are estimated to occur an average of about 25% of the time, neutral conditions about 31% of the time, and thermally stable conditions about 44% of the time. Detailed information on Hanford's atmospheric stability and associated wind conditions are presented in Glantz et al. (1990).

Temperature and Humidity

Ranges of daily maximum and minimum temperatures vary from normal maxima of 2°C (36°F) in early January to 35°C (95°F) in late July. On the average, 55 days during the summer months have maximum temperatures greater than or equal to 32°C (90°F), and 13 days have maxima greater than or equal to 38°C (100°F). From mid-November through mid-March, minimum temperatures average less than or equal to 0°C (32°F), with the minima in early January averaging -6°C (21°F).

The annual average relative humidity at the Hanford Meteorological Station is 54%. It is highest during the winter months, averaging about 75%, and lowest during the summer, averaging about 35%.

Precipitation

Annual precipitation is on the order of 16 cm (6.3 in.), with over 40% falling during November, December, and January (Stone et al. 1983). The relatively low precipitation total is largely because of the rain shadow created by the Cascade Mountain Range, which lies between the Hanford Site and the Pacific Ocean. Measurable precipitation (defined as 0.01 in. or greater) is recorded on an average of 68 days per year and the area experiences an average of 10 thunderstorm days per year. Daily snowfall accumulations of 2.5 cm (1 in.) or greater occur an average of 6 days per year (Stone et al. 1983); the average annual snowfall is 34 cm (13 in.).

Severe Weather

Because tornadoes are infrequent and generally small in the Pacific Northwest (and hurricanes do not reach this area), risks from severe winds are generally associated with thunderstorms or the passage of strong cold fronts. The greatest peak wind gust recorded at 15 m (50 ft) above ground level at the Hanford Meteorology Station was 36 m/s (80 mph). Extrapolations based on 35 years of observations indicate a return period of about 200 years for a peak gust in excess of 40 m/s (90 mph) at 15 m (50 ft) above ground level. Stone et al. (1983) discuss blowing dust, hail, fog, glaze, ashfalls, extreme temperatures, and blowing and drifting snow in more detail.

4.7.2 Nonradiological Air Quality

National ambient air quality standards have been set by the EPA as mandated in the Clean Air Act. Standards exist for sulfur oxides (measured as sulfur dioxide), nitrogen dioxide, carbon monoxide, particles with an aerodynamic diameter less than or equal to 10 μm (PM_{10}), lead, and ozone. State and local governments have the authority to impose standards for ambient air quality that are stricter than the national standards and establish standards for pollutants that are not covered by national standards. Table 4-3 summarizes Washington State or federal standards and background concentrations for six criteria pollutants at Hanford.

In addition to ambient air quality standards, the EPA has established standards for the Prevention of Significant Deterioration (PSD) of air quality (40 CFR 52.21, "Prevention of Significant Deterioration of Air Quality"). The PSD standards provide maximum allowable increases in concentrations of pollutants for areas already in compliance with the national ambient air quality standards. Different PSD standards exist for Class I areas (where degradation of ambient air quality is to be severely restricted) and Class II areas (where moderate degradation of air quality is allowed). The closest such area to the Hanford Site is the Goat Rocks Wilderness Area (a Class I area), located about 145 km (90 mi) west of the Site.

Particulate concentrations can reach relatively high levels in eastern Washington because of exceptional natural events (dust storms, volcanic eruptions, and large brushfires) that occur in the region. When estimating maximum background concentrations of particulates in rural areas east of the Cascade Mountain crest, Washington State standards exclude the contribution

Table 4-3. Washington State ambient air quality standards for six criteria pollutants at Hanford (Standards and concentrations are in microgram per cubic meter)[a]

Pollutant	Averaging Time	Washington State or Federal Standard[b]	Maximum Background Concentration
Sulfur dioxide	annual	52	0.5
	24 hr	260	6
	1 hr	1,018	49
	1 hr	655[c]	49
Particulate matter			
TSP[d]	annual	60	56
	24 hr	150	356
PM_{10}	annual	50[e]	
	24 hr	150	
Carbon monoxide	8 hr	10,000	6,500
	1 hr	40,000	11,800
Ozone	1 hr	235	not estimated
Nitrogen dioxide	annual	100	36
Lead	calendar quarter	1.5	not estimated

(a) Air Quality Impact Analysis in Support of the New Production Reactor Environmental Impact Statement.
(b) Standards are found in WAC 173-470 (particulate matter), WAC 173-471 (sulfur oxides), WAC 173-475 (carbon monoxide, ozone, and nitrogen dioxide), and 40 CFR 50.12 (lead).
(c) The standard is not to be exceeded more than twice in any seven consecutive days.
(d) The total suspended particulates (TSP) standards have been replaced by the particulate matter with aerodynamic diameters ≤ 10 micron (PM_{10}) standards, but the former are serving as interim standards.
(e) Arithmetic mean of the quarterly arithmetic means for the four calendar quarters of the year.

from such natural events. Similarly, the EPA also exempts the rural fugitive dust component of background concentrations when considering permit applications and enforcement of air quality standards (Cushing 1995).

The annual emission rates for stationary sources within the Hanford Site boundaries are reported to Ecology by DOE.

4.7.3 Radiological Air Quality

Radionuclide emissions to the atmosphere from the Hanford Site have been steadily decreasing over the last few years as Site operations have changed emphasis from the historical mission of materials production and processing to waste management, environmental restoration, and research and development. During 1992, all operations at the Hanford Site released less than 100 Ci of radionuclides to the atmosphere, most of which consisted of tritium and noble gases (Woodruff et al. 1993). Of that total, fission and activation products (excluding tritium and noble gases) accounted for less than 0.036 Ci, uranium isotopes accounted for less than 1×10^{-6} Ci, and transuranics contributed less than 0.005 Ci. These releases resulted in a dose to the maximally exposed offsite resident of less than 0.005 mrem, which is several orders of magnitude less than the current EPA standard of 10 mrem/year (40 CFR 61) for DOE facilities.

Ambient air monitoring for radionuclides consisted of sampling at 42 onsite and offsite locations during 1992. Total concentrations of alpha- and beta-emitting radionuclides at the Site perimeter were indistinguishable from those at distant locations that are unaffected by Hanford emissions.

4.8 Water Resources

This section summarizes the surface water and groundwater resources and quality at the Hanford Site, specifically at the 100-K and 200 Areas. A more detailed summary of these subjects can be found in Dirkes et al. (1994) and Dresel et al. (1994).

Surface water in the Pasco Basin includes both natural and artificial features. Naturally occurring surface water within the Hanford Site consists of a few natural springs on the western side of the Site, a small pond near Gable Mountain, and the Columbia River. There have also been a number of artificial ponds and ditches used on the Hanford Site over the past 50 years, primarily related to plutonium production and processing activities.

4.8.1 Surface Water

Surface water near the 100-K Area includes the Columbia River and several basins and wastewater disposal trenches. Near the 200 East Area, West Lake is the only natural surface water body, and surface water is found only in a few ponds and ditches that still receive wastewater.

Only 3% of the precipitation over the Pasco Basin ends up as runoff (DOE 1988), approximately 3% recharges the groundwater, and the remainder is recycled to the atmosphere as evapotranspiration (DOE 1988). Natural recharge of the groundwater is highly variable across the Site; depending on soil and vegetation types, long-term average rates can vary from 2.6 to 55.4 mm/year (0.1 to 2.18 in./year) (Fayer and Walters 1995).

The amount of Columbia River water used on the Hanford Site has dropped in the past 7 years because there are no processing activities, and discharges to ground were severely restricted after June 1995. Discharges of wastewater to the ground on the Hanford Site have increased the groundwater levels and changed the direction of groundwater flow. These discharges have been decreasing since the mid 1980s and were severely reduced by June 1995 in response to federal and state regulations. Decreases in the amount discharged will gradually allow the water table to move back toward its original levels and flow directions.

Ecology classifies the Columbia River as Class A (excellent) between Grand Coulee Dam and the mouth of the river near Astoria, Oregon (WAC 173-201A). Currently, eight outfalls are covered by a single National Pollutant Discharge Elimination System (NPDES) permit at the Hanford Site: two at the 100-K Area, five at the 100-N Area, and one at the 300 Area. These discharge locations are monitored by PNL for various water quality, radiological, and nonradiological constituents, and the results are provided in the annual environmental reports (e.g., Dirkes et al. 1994). DOE was issued an additional NPDES permit for the 300 Area Treated Effluent Disposal Facility in 1994. This facility is now fully functional. The Columbia River is sampled by PNL at Vernita (upstream of the Hanford Site), the 300 Area, and the Richland Pumphouse for water quality and radiological constituents, and the U.S. Geological Survey collects river samples for water quality parameters. These results are also reported annually in environmental reports (e.g., Dirkes et al. 1994).

Under the DOE regulations, a base flood is a flood that has a 1% chance of occurrence in any given year, and a critical flood is a flood that has a 0.2% chance of occurrence in any given year (10 CFR 1022.4). The base floodplain is the 100-year (1%) floodplain, and the critical action floodplain is the 500-year (0.2%) floodplain. DOE has determined that the elevation of the dam-regulated 500-year flood will not reach the elevation of the bottom of the K Basins (DOE 1989, Appendix B). A catastrophic flood caused by a 50% failure of Grand Coulee Dam would cause a flood evaluation exceeding the height of the K Basins (DOE 1989, Appendix B). The reference and CSB sites are not within the base or critical action floodplain of the Columbia River nor would Columbia River water reach the sites in the event of a 50% catastrophic failure of Grand Coulee Dam.

Dirkes et al. (1994) reported tritium, strontium-90, iodine-129, uranium-234, and uranium-238 were consistently detected, and cobalt-60, technetium-99, cesium-137, uranium-235, and plutonium-239/240 were occasionally detected in the river water during 1993. Tritium, uranium, and iodine-129 were found in somewhat higher concentrations downstream of the Hanford Site, but were well below federal drinking water standards (DWS). Strontium-90 and plutonium-239/240 were detected at similar levels upstream and downstream from the Hanford Site, and strontium-90 was below DWS (Dirkes et al. 1994). Plutonium-239/240 was below the gross alpha DWS.

Nonradiological water quality monitoring results are fairly consistent over time. Dirkes et al. (1994) report all water quality parameters fell within Washington State Water Quality Standards for 1993. Volatile organic compounds were not routinely detected, and those metals found were at similar levels upstream and downstream.

4.8.2 Groundwater

This section discusses groundwater hydrology, and water quality of the unconfined and confined aquifers.

Groundwater Hydrology

Groundwater occurs as confined, semiconfined, and unconfined aquifers within the Pasco Basin. The confined aquifers occur primarily within the Ellensburg Formation, sedimentary layers interbedded between basalt flows, and the vesicular flow tops and bottoms of the basalt flows themselves. Recharge to the confined aquifers occurs in areas where these layers are at or near the surface, such as the ridges bounding the Pasco Basin, and areas farther to the east and west of the Pasco Basin (DOE 1988). These confined aquifers are used regionally as a source for both domestic and agricultural water. Semiconfined aquifers occur where thick mud layers within the Ringold Formation overlie coarse, water-bearing layers, thus restricting vertical movement of groundwater over parts of the Hanford Site. Recharge to the semiconfined aquifer occurs where the overlying or underlying confining layers are missing.

The unconfined aquifer in the Hanford Site is contained within the Ringold and Hanford formations (Figure 4-5). The uppermost basalt flow, or in places, the Lower Mud Unit of the Ringold Formation forms the bottom of the unconfined aquifer. In the 100-K Area the water table is found approximately 23 m (75 ft) below ground in Unit E of the Ringold Formation. In the 200 East Area the water table occurs approximately 200 m (400 ft) below ground and is primarily in the Hanford formation. On the north side of the 200 East Area, basalt has been eroded, allowing groundwater movement between the confined and unconfined aquifers. The 200 East Area is also an area where groundwater

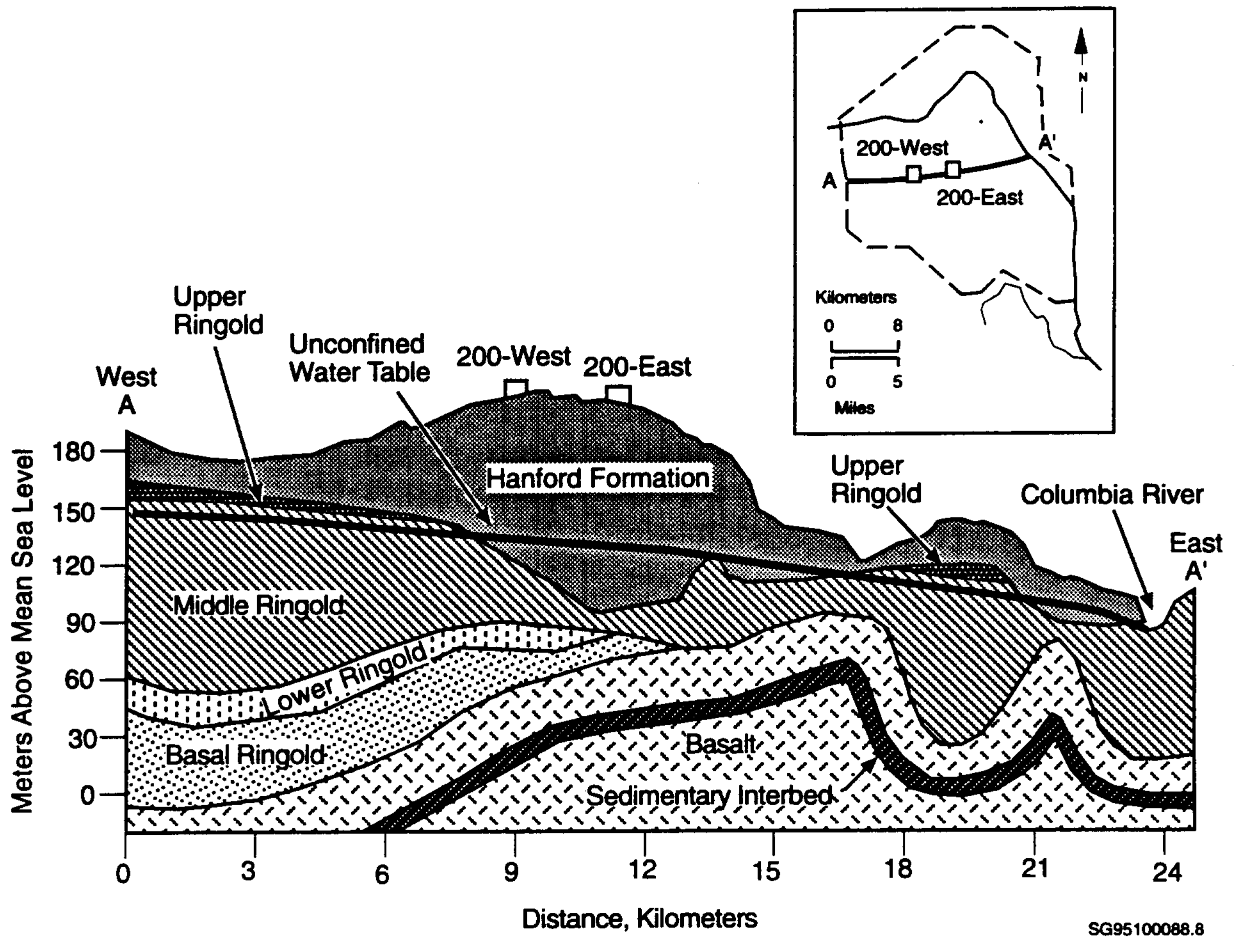


Figure 4-5. Geologic cross section of the Hanford Site (modified from Tallman et al. 1979)

moves between the semiconfined and unconfined aquifers. Approximately 3% of the annual precipitation reaches the unconfined aquifer as natural recharge; the remainder is removed through evapotranspiration. Wastewater discharges to the ground on the Hanford Site have dominated recharge to the unconfined aquifer, but began decreasing in 1984 with the closure of U Pond and are required to decrease significantly by June 1995. As these discharges decrease, the water table is slowly dropping (Kasza et al. 1994). Groundwater flows from the 200 East Area north between Gable Butte and Gable Mountain toward the Columbia River.

Water Quality of the Unconfined Aquifer

The unconfined aquifer has been sampled across the Pasco Basin as a part of the Environmental Surveillance Program, and the results have been provided in annual environmental reports (e.g., Dirkes et al. 1994) and in annual groundwater monitoring reports (e.g., Dresel et al. 1994). Some water quality and radiological constituents are monitored for, and recently nonradiological constituents have been added. In the Pasco Basin outside of the Hanford Site, agricultural practices affect the water quality through irrigation and chemical applications. On the Hanford Site, disposal of wastewater has caused higher water levels and increased contamination.

The Environmental Surveillance Program sampled and/or reviewed analyses from 770 wells in 1993. In 1993 in the 100-K Area, tritium, strontium-90, nitrate, and chromium exceeded the DWS, while tritium and strontium-90 exceeded DWS in the 100-N Area (Dresel et al. 1994). Tritium, cobalt-60, strontium-90, technetium-99, and uranium were detected in springs and seeps along the Columbia River along the 100 Areas, and strontium-90 exceeded the DWS near the 100-N Area (Dirkes et al. 1994).

The unconfined aquifer in the 200 East Area contained tritium, iodine-129, nitrate, technetium-99, strontium-90, cesium-137, and plutonium-239/240 that exceeded the DWS, and strontium-90 and plutonium-239/240 exceeded the DWS in unfiltered samples. Dirkes et al. (1994) reported that tritium, technetium-99, and iodine-129 were found in springs along the east side of the Hanford Site from the old Hanford townsite to the 300 Area. Tritium exceeded the DWS in several springs.

Water Quality of the Confined Aquifer

The uppermost confined aquifer within the basalt is the Rattlesnake Ridge Interbed. Rattlesnake Ridge is monitored by the Environmental

Surveillance Program to determine the extent, if any, of groundwater contamination occurring as a result of interaction between the confined and unconfined aquifers. One well in the 200 East Area and one near B Pond contained tritium; both cases are attributable to movement of water from the unconfined into the confined aquifer along well casing or through the basalt/sediments. Another well just north of the 200 East Area near an erosional window through the basalt contained nitrate.

4.8.3 Water Rights

The Hanford Site, situated along the Columbia River and near the Yakima River, lies within a region traditionally concerned about water rights. Typical water uses in this region include cooling a commercial nuclear power plant, irrigation, and municipal and industrial uses. The DOE continues to assert a federally reserved water withdrawal right with respect to its Hanford operations.

4.9 Ecological Resources

The Hanford Site is a relatively large, undisturbed area [1,450 km^2 (560 mi^2)] that contains numerous plant and animal species adapted to the region's semiarid environment.

4.9.1 Terrestrial Resources

The Hanford Site, located in southcentral Washington, has been botanically characterized as a shrub-steppe. Because of the Site's aridity, the productivity of both plants and animals is relatively low compared with that of other natural communities. In the early 1800s, the dominant plant in the area was big sagebrush with an understory of perennial bunchgrasses, especially Sandberg's bluegrass and bluebunch wheatgrass. With the advent of settlement that brought livestock grazing and crop raising, the natural vegetation mosaic was opened to a persistent invasion by alien annuals, especially cheatgrass. Today cheatgrass is the dominant plant on fields that were cultivated 50 years ago. Cheatgrass is also well established on rangelands at elevations less than 244 m (800 ft). Wildfires in the area are common; the most recent extensive fire in 1984 significantly altered the shrub component of the vegetation. The dryland areas of the Hanford Site were treeless in the years before land settlement; however, for several decades before 1943, trees were planted and irrigated on most of the farms to provide windbreaks and shade. When the farms were abandoned in 1943, some of the trees died but others have persisted, presumably because their roots are deep enough to contact groundwater. Today these trees serve as nesting platforms for several species of birds, including hawks, owls, ravens, magpies, and great blue herons, and as night roosts for wintering bald eagles (Rickard and Watson 1985). The vegetation mosaic of the Hanford Site currently consists of 10 major kinds of plant communities; these are described and their distribution shown in Cushing (1995).

4.9.2 Wetlands

DOE has determined that no wetlands are present on land that would be occupied if any alternative is implemented.

Several habitats on the Hanford Site could be considered as wetlands. The largest wetland habitat is the riparian zone bordering the Columbia River. The extent of this zone varies, but it includes extensive stands of willows, grasses, various aquatic macrophytes, and other plants. The zone is extensively impacted by both seasonal water level fluctuations and daily variations related to power generation at Priest Rapids Dam immediately upstream from the Site.

Other extensive areas of wetlands can be found within the Saddle Mountain National Wildlife Refuge and the Wahluke Wildlife Refuge Area. These two areas encompass all the lands extending from the north bank of the Columbia River northward to the Site boundary and east of the Columbia River down to Ringold Springs. Wetland habitat in these areas consists of fairly large ponds resulting from irrigation runoff. These ponds have extensive stands of cattails (*Typha* sp.) and other emergent aquatic vegetation surrounding the open water regions. They are extensively used as resting sites by waterfowl.

4.9.3 Aquatic Resources

The Columbia River is the dominant aquatic ecosystem on the Hanford Site and supports a large, diverse community of plankton, benthic invertebrates, fish, and other communities. The Columbia has been dammed both upstream and downstream from the Hanford Site, and the reach flowing through the area is the last free-flowing, but regulated, reach of the Columbia River in the United States. Plankton populations in the Hanford Reach are influenced by communities that develop in the reservoirs of upstream dams, particularly Priest Rapids Reservoir, and by manipulation of water levels by dam operations in downstream reservoirs. Phytoplankton and zooplankton populations at Hanford are largely transient, flowing from one reservoir to another. No tributaries enter the Columbia during its passage through the Hanford Site. Chinook salmon, sockeye salmon, coho salmon, and steelhead trout use the river as a migration route to and from upstream spawning areas and are of the greatest economic importance. Details of the various aquatic components of the Columbia River ecosystem and references to studies of those components can be found in Cushing (1995).

The small spring streams, such as Rattlesnake and Snively springs, contain diverse biotic communities and are extremely productive. Dense blooms of watercress occur and are not lost until one of the major flash floods occurs. The aquatic insect production is fairly high, compared to that in mountain streams. The macrobenthic biota varies from site to site and is related to the proximity of colonizing insects and other factors. Cushing (1995) presents details on the ecological characteristics of these sites.

4.9.4 Threatened, Endangered, and Sensitive Species

Threatened and endangered plants and animals identified on the Hanford Site, as listed by the federal government (50 CFR 17) and Washington State (Washington Natural Heritage Program 1994), are shown in Table 4-4. No plants or mammals on the federal list of endangered and threatened wildlife and plants (50 CFR 17.11, 17.12) are known to occur on the Hanford Site. However, three birds and a number of other species of both plants and animals are under consideration for formal listing by the federal and state governments.

Five species of plants are included in the Washington State listing. Columbia milk-vetch (*Astragalus columbianus* Barneby), dwarf evening primrose (*Oenothera pygmaea*), and Hoover's desert parsley (*Lomatium tuberosum*) are listed as threatened, and Columbia yellow cress (*Rorippa columbiae* Suksd.) and northern wormwood (*Artemisia campestris* ssp. *borealis* var. *wormskioldii*) are designated as endangered. Columbia milk-vetch occurs on dry land benches along the Columbia River near Priest Rapids Dam, Midway, and Vernita. It also has been found on top of Umtanum Ridge and in Cold Creek Valley near the present vineyards. Dwarf evening primrose has been found on mechanically disturbed areas (i.e., the gravel pit near the Wye Barricade). Hoover's desert parsley grows on steep talus slopes near Priest Rapids Dam, Midway, and Vernita. Yellow cress occurs in the wetted zone of the water's edge along the Columbia River. Northern wormwood is known to occur near Beverly and could inhabit the northern shoreline of the Columbia River across from the 100 Areas.

Table 4-4. Threatened (T) and endangered (E) species known or possibly occurring on the Hanford Site

Common name	Scientific name	Federal	State
Plants			
Columbia milk-vetch	*Astragalus columbianus*		T
Columbia yellow cress	*Rorippa columbiae*		E
Hoover's desert parsley	*Lomatium tuberosum*		T
Northern wormwood	*Artemisia campestris borealis* var. *wormskioldii*		E
Dwarf evening primrose	*Oenothera pygmaea*		T
Birds			
Aleutian Canada goose	*Branta canadensis leucopareia*	T	E
Peregrine falcon	*Falco peregrinus*	E	E
Bald eagle	*Haliaeetus leucocephalus*	T	T
American white pelican	*Pelecanus erythrorhychos*		E
Sandhill crane	*Grus canadensis*		E
Ferruginous hawk	*Buteo regalis*		T
Mammals			
Pygmy rabbit	*Brachylagus idahoensis*		E
Insects			
Oregon silverspot butterfly	*Speyerra zerone hippolyta*	T	T

The federal government lists the Aleutian Canada goose (*Branta canadensis leucopareia*) and the bald eagle (*Haliaeetus leucocephalus*) as threatened and the peregrine falcon (*Falco peregrinus*) as endangered. In addition to the peregrine falcon, Aleutian Canada goose, and bald eagle, the state government lists the American white pelican (*Pelecanus erythrorhynchos*) and sandhill crane (*Grus canadensis*) as endangered and the ferruginous hawk (*Buteo regalis*) as threatened. The Oregon silverspot butterfly (*Speyerra zerene hippolyta*) has recently been classified as a threatened species by both the state and federal governments, although it has not been observed on the Site. The peregrine falcon is a casual migrant to the Hanford Site and does not nest here. The bald eagle is a regular winter resident and forages on dead salmon and waterfowl along the Columbia River; it does not nest on the Site, although it has attempted to for the past several years. Access controls are in place along the river at certain times of the year. Washington

State Bald Eagle Protection Rules were issued in 1986 (WAC-232-12-292). DOE has prepared a Site Management Plan (Fitzner and Weiss 1994) to mitigate eagle disturbance in response to the rules. The Endangered Species Act of 1973 also requires that Section 7 consultation be undertaken when any action is taken that may jeopardize the existence of, destroy, or adversely modify habitat of the bald eagle or other threatened or endangered species. Increased use of power poles for nesting sites by the ferruginous hawk on the Hanford Site has been noted.

Shrub-steppe habitat is considered priority habitat by Washington State because of its relative scarcity in the state and its requirement as nesting/ breeding habitat by loggerhead shrikes (federal and state candidate species), sage sparrows (state candidate), burrowing owls (federal and state candidate), pygmy rabbits (federal candidate and state endangered), sage thrashers (state candidate), western sage grouse (federal and state candidate), northern sagebrush lizard (federal candidate) and sagebrush voles (state monitored). Although the last five species were not found during the present survey of the reference site, the habitat should be considered potentially suitable for their use. Pygmy rabbits and western sage grouse have been seen rarely on the Hanford Site, and then primarily in upland regions.

Loggerhead shrikes have been seen frequently on the reference site and are known to select tall big sagebrush as nest sites (Poole 1992). One shrike was observed during the present survey of the reference site. However, no nests were located. Ground squirrel burrows used by burrowing owls and owl pellets were observed during the present survey of the reference site. Numerous sage sparrows were also observed. Pygmy rabbits would not have been observed during this survey because they primarily become active at twilight and are nocturnal; they may also have been in hibernation. However, this species is not known to inhabit lowland portions of the Hanford Site. The closest known nest of the ferruginous hawk (federal candidate and state threatened species) is approximately 8.9 km (5.3 mi) northwest of the reference site. The reference site should be considered as comprising a portion of the foraging range of this species. No other species listed as endangered or threatened, or candidates for such listing by Washington State or the federal government, or species listed as monitor species by Washington State, were observed on the reference site.

4.10 Noise

Sound waves are characterized by frequency and measured in hertz (Hz); pressure is expressed as decibels (dB). Noise levels are often reported as the equivalent sound level (Leq), which normally refers to the equivalent continuous sound level for an intermittent sound, such as traffic noise. The Leq is expressed in A-weighted decibels [dB(A)] and is averaged over a specified period of time. The A-weighted sound level relates to human hearing characteristics.

Most industrial facilities on the Hanford Site are located far enough away from the Site boundary that noise levels at the boundary are not measurable or are barely distinguishable from background noise levels. Two studies of environmental noise were done at Hanford: a study of the Skagit/Hanford Nuclear Power Plant Site (NRC 1982) and a series of Site characterization studies performed in 1987 that included five background environmental noise level measurements.

Environmental noise measurements were taken in June 1981 at 15 sites on the Hanford Site (NRC 1982). Noise levels ranged from 30 to 60.5 dB(A). Values for more isolated areas ranged from 30 to 38.8 dB(A). Measurements taken close to a Washington Public Power Supply System nuclear power plant (WNP-2) ranged from 50.6 to 64 dB(A), resulting from construction equipment. Measurements taken along the Columbia River near the intake structures for WNP-2 were 47.7 and 52.1 dB(A), compared to more remote river noise levels of 45.9 dB(A). Community noise levels taken in North Richland [3000 Area at Horn Rapids Road and Stevens Road (Route 240)] were 60.5 dB(A) and were largely attributed to traffic.

Background noise levels (24 h Leq) were determined at five sites located within the Hanford Site. The mean noise level for these five sites was 38.8 dB(A). Wind was the primary contributor to background noise levels. Winds exceeding 5.4 m/s (12 mph) significantly increased noise levels. Mean background noise levels (24 h Leq) in undeveloped areas range from 24 to 36 dB(A) (Cushing 1995).

The Hanford Environmental Health Foundation has monitored noise levels resulting from several routine operations performed in the field at Hanford. These included well drilling, pile driving, compressor operations, and water wagon operation. Occupational sources of noise propagated in the field from outdoor activities ranged from 93.4 to 96 dB(A).

4.11 Traffic and Transportation

This section discusses transportation at and around the Hanford Site. Bulk materials or large items are shipped by barge. Rail and truck transportation are used to move irradiated fuel, radioactive solid and liquid wastes, equipment, and materials (primarily coal).

4.11.1 Regional Infrastructure

The regional transportation network near Hanford includes the areas in Benton and Franklin counties from which 93% of the commuter traffic associated with the Site originates. Interstate highways that serve the area are I-82, I-182, and I-90. State Route (SR) 243 exits the northwestern boundary of the Site. State Route 24 enters the Site from the west and continues eastward across the northernmost portion of the Site. State Route 240 enters the northern boundary and continues southeast, exiting the Site to the north of Richland.

General weight, width, and speed limits have been established for highways near Hanford. However, no unusual laws or restrictions have been identified that would significantly influence general regional transportation.

Airline passenger and air freight service is provided at the Tri-Cities Airport owned and operated by the Port of Pasco, at Pasco, Washington. The air terminal is located approximately 16 km (10 mi) from the Hanford Site.

4.11.2 Hanford Site Infrastructure

Hanford's onsite road network consists of rural arterial routes (see Figure 4-6). Only 104 of the 461 km (65 of the 288 mi) of paved roads at Hanford are accessible to the public. Most onsite employee travel occurs along Route 4, with controlled access at the Yakima and Wye Barricades. State Route 240 is the main public route through the Site. Public highways SR 24 and SR 243 also traverse the Site.

A recently completed major highway improvement project involved repavement and widening of the four-lane access route to the Wye Barricade. The highway network has been used extensively for transporting large equipment items, construction materials, and radioactive materials. Resurfacing, sealing, and restoration programs are currently planned for segments of other regional highways.

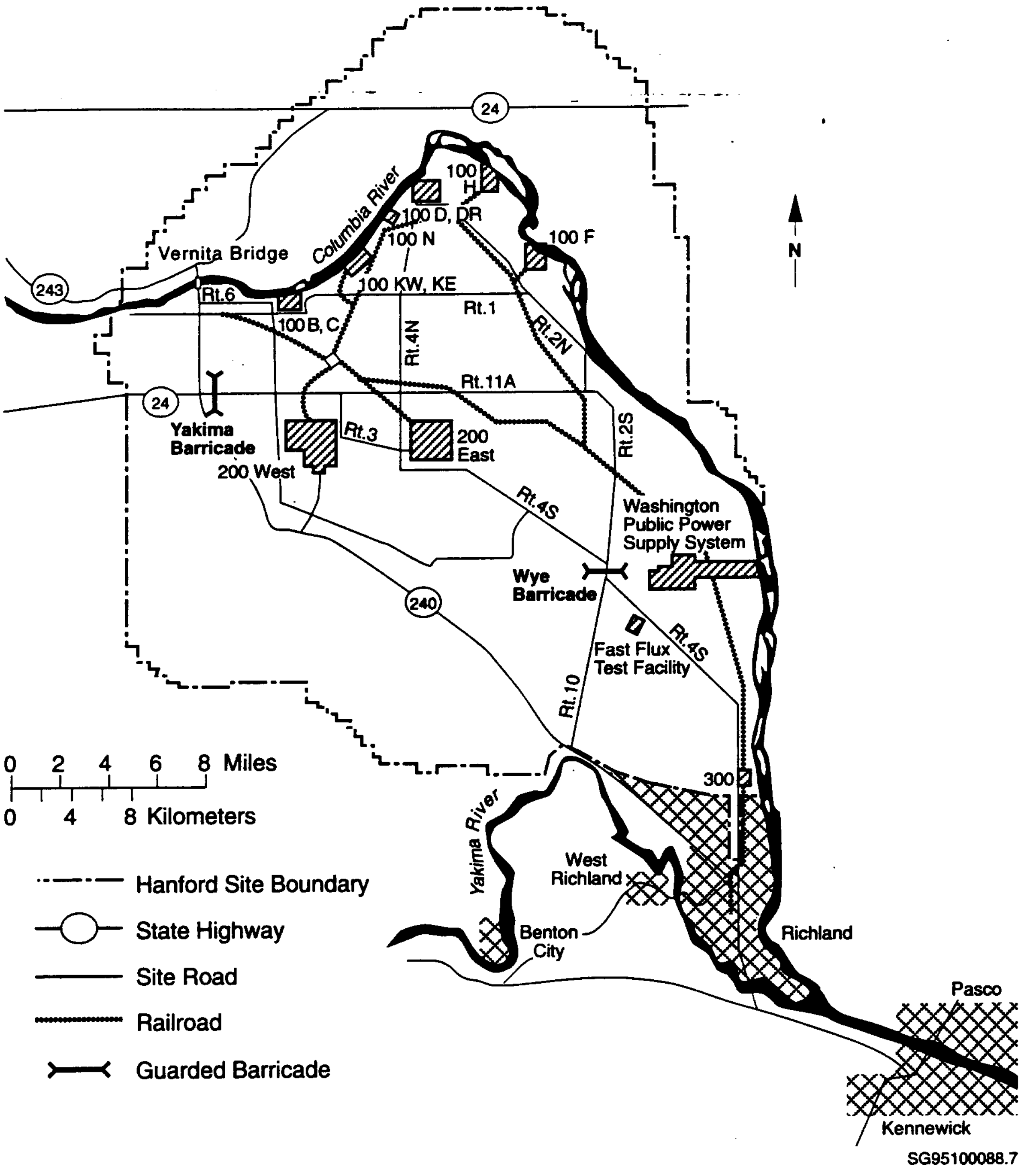


Figure 4-6. Transportation routes on the Hanford Site

Approximately 13 to 16 million km (8 to 10 million mi) are logged annually by DOE vehicles at Hanford (Green and Flanagan 1995). In addition, an estimated 3,300 privately owned vehicles were driven onsite each weekday, and 560 were driven onsite each weekend day. Assuming a round-trip distance of 48 km (30 mi) onsite for each of these vehicles, a total of about 64 million km (40 million mi) were driven annually by workers onsite.

The primary highways used by commuters are SR 24, SR 240, and I-182; 10, 90, and 10% of the work force use these routes, respectively (totals to more than 100% because some commuters use two of the routes). With these commuting patterns, workers annually travel about 43 millon km (27 million mi) offsite. Trucks used for material shipment to Hanford compose about 5% of the vehicular traffic on and around the Site.

During 1988, 169 accidents were reported onsite, with 20 involving DOE vehicles. The other accidents involved privately owned vehicles and included seven injury accidents and one fatal accident on SR 240. Among offsite highway segments of concern, most accidents occurred along I-82. According to available data, the 15 accidents involving trucks in 1987 in the Benton/Franklin county study area resulted in 13 injuries and 3 fatalities.

Onsite rail transport is provided by a short-line railroad owned and operated by DOE. This line connects just south of the Yakima River with the Union Pacific line, which in turn interchanges with the Washington Central and Burlington Northern railroads at Kennewick. AMTRAK passenger rail service is provided in the Tri-Cities at the Burlington Northern depot at Pasco. Approximately 145,000 rail miles (232,000 km) were logged at Hanford in 1988, primarily transporting coal to steam plants. Two noninjury rail accidents occurred at Hanford in 1988.

The Hanford Site infrequently uses the Port of Benton dock facilities on the Columbia River for off-loading large shipments. Overland wheeled trailers are then used to transport those shipments to the Site. No barge accidents were reported in 1988.

4.12 Occupational and Public Health and Safety

This section summarizes the Hanford Site programs designed to protect the health and safety of workers and the public. It also describes existing radiological and nonradiological conditions and provides a historical perspective on worker and public exposures and potential health effects.

4.12.1 Occupational Health and Safety

Programs are in place at the Hanford Site to protect workers from radiological and nonradiological hazards. Radiological protection (health physics) programs are based on requirements in regulations and DOE Orders, and on guidance in radiological control manuals. Occupational nonradiological health and safety programs are composed of industrial hygiene programs and occupational safety programs.

Radiological Health and Safety

The current radiation dose limits were promulgated in 10 CFR 835, "Occupational Radiation Protection." This regulation includes limits on total effective dose equivalent to workers, dose to individual organs, and dose to members of the public (including minors and unborn children of workers) that may be incidentally exposed while at DOE facilities. In addition, it establishes a policy of keeping doses as low as reasonably achievable, specifies training requirements for radiation protection personnel and other workers, and requires monitoring and reporting of radiation exposure records for individual workers and certain visitors.

Radiation Doses to Workers

Cumulative doses to all Hanford Site workers and visitors for all activities provide a baseline for Site operations. In 1994, about 22,000 workers (including offsite contractors) were monitored at the Hanford Site. Of those monitored, 13,000 were classified as radiation workers, with an average annual dose equivalent of 0.02 rem/year per individual. This dose is well below the 10 CFR 835 dose limit of 5 rem/year and the DOE Administrative Control Level of 2 rem/year for occupational exposure. For 1994 the estimated collective dose-equivalent was 220 person-rem for all Hanford Site workers. Based on standard dose-to-health effects conversion factors (ICRP 1991), no health effects would be expected to result among this exposed population.

A relatively small fraction of the Hanford Site worker exposure was directly related to SNF storage activities, of which operation of the KE Basin was the major contributor. The collective radiation dose to K Basin workers over the 2-year period 1991 and 1992 averaged 22 person-rem/year, or approximately 0.4 rem/year for each worker. An average of 58 workers were assigned to the K Basins during this period (Holloman and Motzco 1992, 1993).

Industrial Hygiene Program

Occupational nonradiological health and safety programs at Hanford are composed of industrial hygiene and occupational safety programs, which are implemented to meet the requirements of state and federal health and safety standards. Industrial hygiene programs address such subjects as toxic chemicals and physical agents, carcinogens, noise, biological hazards, lasers, asbestos, and ergonomic factors. Occupational safety programs address such subjects as machine safety, hoisting and rigging, electrical safety, building codes, welding safety, and compressed gas cylinders.

Worker Safety and Accidents

No incidents of overexposure to radiation were reported to DOE during 1990 and 1991 in association with SNF storage activities at the Hanford Site. Overexposures are defined as any exposure over regulatory limits established by the DOE (Lansing et al. 1992; WHC 1990). In the 4-year period from 1991 through 1994, industrial-type accidents resulted in 98 lost working days at the K Basins out of a total of approximately 70,000 days worked.

4.12.2 Public Health and Safety

The DOE has the responsibility under the Atomic Energy Act to establish the necessary standards to protect members of the public from radiation exposures resulting from DOE activities. For 1994, Dirkes and Hanf (1995) report that the Hanford Site is in compliance with requirements and standards established by DOE and other federal agencies.

Environmental Programs

DOE Order 5400.1, "General Environmental Protection Program," establishes the requirement for environmental protection programs. Environmental programs are conducted at the Hanford Site to restore environmental quality, manage waste, develop appropriate technology for cleanup activities, and monitor levels of potentially hazardous materials in the environment.

Environmental Monitoring/Surveillance Information

Environmental monitoring at the Hanford Site consists of effluent monitoring and environmental surveillance, including groundwater monitoring. Effluent monitoring is performed by the operators at the facility or at the point of release to the environment. Environmental surveillance consists of sampling and analyzing environmental media on and off the Hanford Site to detect and quantify potential contaminants and to assess their environmental and human health significance. The annual Hanford Site environmental report (e.g., Dirkes and Hanf 1995) summarizes this information for the Hanford Site.

Potential Radiation Doses

Potential radiation doses and exposures to members of the public from releases of radionuclides to air and water at the Hanford Site are calculated and reported annually. The potential radiation doses to a maximally exposed individual (MEI) have been published in annual Hanford Site environmental reports since 1957. For 1994 the total potential dose (via air and water pathways) to the MEI from Hanford operations was calculated to be 0.05 mrem. The collective dose to the 380,000 people living within 80 km (50 mi) of the Hanford Site was 0.6 person-rem in 1994 (Dirkes and Hanf 1995). By comparison, the total dose received in a year by this same population from natural background radiation was about 110,000 person-rem.

The potential cumulative effective dose equivalent to members of the public from both air and water sources for the 28-year period 1944 through 1972 was estimated by the Hanford Environmental Dose Reconstruction Project (TSP 1994). The highest cumulative dose to an adult resident for the years 1944 through 1972 from pathways associated with releases to both air and water was about 2.5 rem, essentially all of which occurred before 1964. For comparison, the dose received by an average resident during this 28-year period from natural background radiation was approximately 9 rem. The cumulative population dose during 1944 through 1972 was 100,000 person-rem, essentially all of which was received through air pathways in 1945. Radiation doses received by the public from Hanford releases after 1972 were much smaller.

4.13 Site Services

This section discusses water consumption, electrical consumption and wastewater disposal for the Hanford Site and local areas.

4.13.1 Water Consumption

The principal source of water in the Tri-Cities and the Hanford Site is the Columbia River, from which approximately of 4.3 x 10^7 m^3 (11.38 billion gal) was drawn in 1991. Each city operates its own supply and treatment system. The Richland water supply system derives about 67% of its water from the Columbia River, approximately 15 to 20% from a well field in North

Richland, and the remaining from groundwater wells. The city of Richland's total usage in 1991 was 2.1 x 10^7 m^3 (5.65 billion gal). The city of Pasco system also draws from the Columbia River for its water needs; the 1991 estimate of consumption was 1.1 x 10^7 m^3 (2.81 billion gal). The Kennewick system uses two wells and the Columbia River for its supply. These wells serve as the sole source of water between November and March and can provide approximately 62% of the total maximum supply of 2.8 x 10^7 m^3 (7.3 billion gal). Total usage of those wells in 1991 was 1.1 x 10^7 m^3 (2.92 billion gal).

4.13.2 Electrical Consumption

Electricity is provided to the Tri-Cities by the Benton County Public Utility District, Benton Rural Electrical Association, Franklin County Public Utility District, and City of Richland Energy Services Department. All the power that these utilities provide in the local area is purchased from the Bonneville Power Administration. The average rate for residential customers served by the three local utilities is approximately $0.046 per kilowatt hour. Electrical power for the Hanford Site is purchased wholesale from the Bonneville Power Administration.

In the Pacific Northwest, hydropower, coal, and nuclear power constitute the region's electrical generation system. Total generating capacity is about 40,270 megawatts. Approximately 74% of the region's installed generating capacity is hydroelectric, which supplies approximately 65% of the electricity used by the region. Coal-fired generating capacity is 6,702 megawatts in the region, 16% of the region's electrical generating capacity. One commercial nuclear power plant is in service in the Pacific Northwest, with a 1170-megawatt capacity of 3% of the region's generating capacity. Oil and natural gas account for about 3% of capacity.

Throughout the 1980s, the Northwest had more electric power than it required and was operating with a surplus. This surplus has been exhausted, however, and there is only approximately enough power supplied by the existing system to meet the current electricity needs. Hydropower improvement projects currently under construction in the Northwest include about 150 megawatts of new capacity. The cost and availability of several other resources are currently being studied. Approximate rates for current consumption of electricity, coal, propane, natural gas, and other utilities at the Hanford Site are shown in Table 4-5.

Table 4-5. **Approximate annual consumption of utilities and energy on the Hanford Site (1992)**

Utility	Consumption	
Energy		
Electricity	340,000 MWhr	
Coal	45,000 metric tons	(50,000 tons)
Fuel oil	83,000 m^3	(22,000,000 gal)
Natural gas	680,000 m^3	(24,000,00 ft^3)
LPG-propane	110 m^3	(29,000 gal)
Gasoline	3,600 m^3	(950,000 gal)
Diesel	1,700 m^3	(450,000 gal)
Water		
Columbia River		
Tri-Cities	43,000,000 m^3	(11,400,000,000 gal)
Hanford Site		
Intake	12,693,760 m^3	(3,376,000,000 gal)
Discharge	7,589,372 m^3	(2,018,450,000 gal)
Net Use	5,104,388 m^3	(1,357,550,000 gal)
Groundwater	11,000,000 m^3	(292,000,000 gal)
Power Demand	57 MW	

4.13.3 Wastewater Disposal

The major incorporated areas of Benton and Franklin counties are served by municipal wastewater treatment systems, whereas the unincorporated areas are served by onsite septic systems. Richland's wastewater treatment system is designed to treat a total capacity of 27 million m^3/year (a daily average flow of 8.9 million gal/d with a peak flow of 44 million gal/d). In 1991 the system processed an average of 6.7 million m^3/year (4.83 million gal/d). The Kennewick system similarly has significant excess capacity, with a treatment capability of 12 million m^3/year (8.7 million gal/d); 1991 usage was 4.8 million gal/d. Pasco's waste treatment system processes an average of 3.1 m^3/year (2.22 million gal/d), while the system could treat 16.2 million L/d (4.25 million gal/d).

4.14 Waste Management

The Site contains a variety of waste types, including waste that historically was generated at Hanford, waste that was generated offsite and then shipped to Hanford, and waste that is currently being generated and stored onsite. This section discusses the management of these wastes and provides the current status of various waste types being generated, stored, and/or disposed at the Hanford Site. These wastes include radioactive waste, mixed waste, hazardous waste, industrial and sanitary solid waste, and hazardous materials.

The total amount of waste generated and disposed at the Hanford Site has been reduced and continues to be reduced through the Hanford Waste Minimization (and Pollution Prevention) Program, which is aimed at source reduction, product substitution, recycling, surplus chemical exchange, and waste treatment. All waste classes including radioactive, mixed, hazardous, and nonhazardous regulated wastes are included in the Hanford Waste Minimization Program.

4.14.1 Radioactive Waste

Radioactive wastes generated and/or stored at Hanford include tank wastes, low-level wastes, transuranic wastes, and mixed wastes (i.e., mixtures containing both radioactive and hazardous constituents). Mixed waste is discussed in Section 4.14.2. For a more detailed historical account of radioactive high-level waste generation and accumulation at the Hanford Site, refer to Appendix A of the DOE SNF PEIS (DOE 1995a).

Double-Shell Tank Waste

The 28 double-shell tanks currently contain about 80 million L (21 million gal) of waste, with required space capacity of approximately 8.7 million L (2.3 million gal) (DOE and Ecology 1995). Additional information on the mixed waste component of these totals is given in Section 4.14.2. Alternatives for the treatment and disposal of the tank wastes will be evaluated in a future EIS on the Tank Waste Remediation System (TWRS). No high-level wastes are expected to be generated in 1995 from SNF management activities (DOE 1995a).

Transuranic Waste

Transuranic (TRU) waste consists of material contaminated with elements that have an atomic number greater than 92. TRU waste at the Hanford Site exists mostly in solid form. From 1970 to 1986, TRU waste was segregated and disposed of as retrievable waste in special trenches. Currently, all TRU and mixed-TRU wastes are stored in above-grade storage facilities in the Hanford Central Waste Complex located in the 200 West Area, and the Transuranic Waste

Storage and Assay Facility within the Solid Waste Operations Complex. As of 1993, there were about 124,800 m^3 (168,500 yd^3) of TRU wastes buried or in retrievable storage (DOE 1994b). From 1996 through 2000, approximately 10 m^3 (13.5 yd^3) of TRU waste is expected to be generated by SNF management activities.

Low-Level Waste

Solid low-level waste is currently placed in unlined, near-surface trenches at the 200 Area low-level waste burial grounds. Approximately 558,916 m^3 (731,034 yd^3) of low-level waste are buried at Hanford and another 130 m^3 (170 yd^3) placed into storage (DOE 1995a) before 1991. The average annual volume of low-level wastes received at the Hanford Site from offsite generators from 1987 through 1991 was 5,760 m^3 (7,416 yd^3). From 1992 through 1994, Hanford received the following volumes of low-level waste from offsite generators: 1992 - 1,285.3 m^3 (1,735 yd^3); 1993 - 2,020.2 m^3 (2,727 yd^3); 1994 - 2,036.5 m^3 (2,749.3 yd^3).

These numbers exclude volumes received at a licensed commercial low-level burial ground on the Hanford Site, which is leased to the State of Washington and operated by U.S. Ecology for disposal of non-Hanford waste. Through 1991, 338,500 m^3 (442,741 yd^3) of low-level non-Hanford wastes had been disposed of at the U.S. Ecology site (DOE 1992b). U.S. Ecology has projected a volume of 4,816 m^3 (6,300 yd^3) of low-level non-Hanford waste will be disposed of in 1995.[a]

An inventory of radioactive waste (excluding mixed waste) generated on the Hanford Site from 1988 through 1994 is given in Table 4-6. In 1995 174.5 m^3 (228.3 yd^3) of low-level wastes will be generated from SNF management activities.

4.14.2 Mixed Waste

Mixed waste is defined as mixtures containing both radioactive materials and hazardous (chemically and/or physically) wastes. Special nuclear material production and site restoration activities have generated and may continue to generate mixed waste.

(a) Letter from J. M. Van Nostrand to S. McLellan, November 1994. U.S. Ecology, Inc. Docket Nos. TG-920234, UR-930711, and UR-930890; Calculation of Temporary Rates for 1995.

Table 4-6. Radioactive waste (excluding mixed waste) generated on the Hanford Site from 1988 through 1994

Calendar year[a]	Low-level waste (kg)	Transuranic waste (kg)	High-level waste (kg)
1988	3,800,000	21,900	0
1989	8,300,000	27,200	0
1990	3,600,000	24,500	0
1991	1,100,000	4,400	0
1992	700,000	27,300	0
1993	1,100,000	24,100	0
1994	1,400,000	27,300	0

(a) Source of 1988 to 1990 data is DOE (1991a). Post-1990 data are from Solid Waste Information Tracking System (SWITS) database, which is maintained by PNL for the Hanford Site.

Mixed Low-Level Waste

All buried low-level wastes before 1986 are discussed in Section 4.14.1. Between 1987 and 1991, 16,745 m^3 (21,902 yd^3) of mixed low-level wastes were buried at the Hanford Site. Another 4,225 m^3 (5,526 yd^3) of mixed wastes have been accumulating in storage in the Central Waste Complex. Additionally, as of November 1994, there were a total of 43 submarine reactor compartments stored in Trench 94 of the 200 East Area low-level burial grounds (Dirkes and Hanf 1995).

The 78 mixed low-level waste streams (primarily liquid) at Hanford make up a total of 85,000 m^3 (111,176 yd^3) of waste (101,315,000 kg or 223,361,000 lb). For more detailed waste characterization of low-level wastes at Hanford, refer to DOE (1995a).

Mixed low-level wastes generated in 1995 from SNF management activities are expected to total 0.4 m^3 (0.6 yd^3). Solid mixed low-level wastes expected to be generated by K Basin management activities from 1996 through 2000 are forecasted at approximately 10 m^3 (7.6 yd^3), excluding solid waste forecasts for any of the engineered alternatives for expedited removal described in this EIS.

Mixed High-Level and Mixed Transuranic Waste

Tank wastes constitute 99% of the mixed wastes at the Hanford Site. In 1993, DOE reported an inventory of 233,689 m^3 (305,654 yd^3) of mixed wastes is stored in Hanford tanks: 145,952 m^3 (190,898 yd^3) of high-level mixed waste, 3,935 m^3 (5,147 yd^3) of mixed TRU waste, and 84,802 m^3 (110,917 yd^3) of mixed low-level waste.

4.14.3 Hazardous Waste

Hazardous waste, as defined by RCRA, is a solid waste, or a combination of solid wastes, which because of its quantity, concentration, or physical, chemical or infectious characteristic, may potentially pose a hazard to human health or the environment. Hazardous wastes are generated during normal facility operations.

In 1992, approximately 619,000 kg (1,365,000 lb) of hazardous waste was generated on the Hanford Site. Currently, the principal waste management practice for newly generated hazardous waste (nonradioactive) is to ship it offsite. Hazardous wastes generated in 1995 from SNF management activities will total 2.2 m^3 (2.9 yd^3).

4.14.4 Industrial and Sanitary Solid Waste[a]

Nondangerous, nonradioactive solid wastes are generated in almost all areas of and in most operations at the Hanford Site. The active Hanford Site Solid Waste Landfill is located in the 200 Areas and has operated since 1973. Nondangerous wastes, as defined by Washington State Dangerous Waste Regulations (WAC 173-303), are buried in the solid waste section of the Solid Waste Landfill. The landfill is currently scheduled for closure in 1997 (WHC 1993a). Some solid waste generated at Hanford has also been sent to the City of Richland landfill.

4.15 Hazardous Materials

A hazardous chemical is one that poses a physical or health hazard, as defined in 29 CFR 1910.1200(c). Hazardous materials are not waste, but when the materials are no longer useful, they may become waste. Hazardous chemicals are used throughout the Hanford Site in facility and environmental

(a) In this context "sanitary" denotes wastes that are nonhazardous, for the most part, such as industrial and municipal solid wastes.

restoration operations. Maintaining inventories of such materials requires reporting under the Emergency Planning and Community Right-to-Know Act.

As of April 1995, approximately 1,490 hazardous chemicals were inventoried at more than 570 locations on the Hanford Site. These 1,490 chemicals are contained in approximately 2,700 different hazardous materials. The DOE has prepared chemical inventory reports required under Section 313 of the Act since 1988. At the Hanford Site, the minimum reporting threshold was exceeded for 53 hazardous chemicals in 1992, 49 chemicals in 1993, and 53 chemicals in 1994.

5.0 ENVIRONMENTAL CONSEQUENCES

The following subsections describe various potential environmental consequences as a result of implementing alternatives for management of SNF at the Hanford Site K Basins. The seven alternatives analyzed were 1) no action, 2) enhanced K Basins storage, 3) new wet storage, 4) drying/passivation (conditioning) with dry storage, 5) calcination with dry storage, 6) onsite processing, and 7) foreign processing. Each of these alternatives contains several different options that represent alternative means of managing the K Basins fuel for the next 40 years or until a decision on its ultimate disposition has been made.

These analyses were undertaken with an incomplete knowledge of the condition of SNF in the K Basins. Information needed to determine the properties of the stored fuel is currently being obtained through laboratory characterization studies. The results of these studies are not necessary to develop the environmental consequence analyses in this document but may be necessary to refine the process design for the alternative ultimately selected by DOE. Therefore, the analyses in the following sections encompass a range of options for management of the K Basins SNF. The analyses performed for this environmental impact statement (EIS) are relatively conservative in order to bound the actions that may be undertaken during SNF management activities. A safety analysis would be performed for the specific option ultimately selected before implementing any alternative.

5.1 Overview

Section 5.1 contains a brief summary of the potential environmental consequences of interest and an overview of activities associated with the various alternatives that may result in environmental consequences. For this analysis, all new facilities were assumed to be constructed adjacent to the 200 East Area (the reference site) or within the 200 East Area on, or adjacent to, the partially completed Canister Storage Building (CSB) site for the Hanford Waste Vitrification Plant (see Figure 1-3). Use of the partially completed facility for storage of K Basins SNF would save part of the cost of designing and constructing new facilities and would minimize additional land disturbance. Commitment of the required land within the 200 East Area would be consistent with the Site mission and would not represent a conflict on land use. Up to 8.1 ha (20 acres) of additional land would be disturbed during construction of process, storage, and support facilities at the reference site. Other alternatives would disturb smaller areas, and use of the CSB site would result in essentially no new land disturbance for any alternative. A survey of the reference site revealed no threatened or endangered species or cultural resources that would be directly affected by construction activities.

Routine operations under any of the alternatives would not add substantially to cumulative occupational or public exposures to radiation. However, specific short-term activities associated with removal and stabilization of the fuel could temporarily increase worker and public exposures during these activities. Major increases in current emission levels of criteria pollutants or other hazardous materials would not be expected from implementing any of the alternatives. Implementation of alternatives requiring new construction would result in a small increase in Hanford's electrical power consumption; the largest increase would be associated with the onsite processing alternative. The foreign processing alternative would result in the greatest expenditures over the 40-year storage period and for the entire life cycle. The temporary influx of workers under any of the alternatives would not likely have an adverse impact on community services in the current economic climate.

5.1.1 No Action Alternative

The no action alternative identifies the minimum actions deemed necessary for continued safe and secure storage of SNF at the Hanford Site. Under this alternative, only necessary safety and security upgrades would be performed at the K Basins, and the fuel would continue to be stored in its current configuration. Ongoing operation of the K Basins is the only activity associated with this alternative that may result in environmental consequences.

5.1.2 Enhanced K Basins Storage Alternative

Activities associated with the enhanced K Basin storage alternative include upgrade of the existing K Basins facilities to provide safe and secure storage of the SNF. Fuel would be containerized at the K East (KE) Basin, and the containerized fuel would be moved to the K West (KW) Basin for continued storage. The fuel currently in the KW Basin would be rearranged to provide the necessary additional storage space. Sludge, water, and debris would be removed from the KE Basin, and the facility would be deactivated.

5.1.3 New Wet Storage Alternative

Activities evaluated under this alternative include repackaging and removal of K Basins SNF, transport to a storage site on the 200 Areas plateau, and placement in a new wet storage facility. The wet storage options evaluated include storage of SNF in water-filled multicanister overpacks (MCOs) in either a water-filled pool or a vault. Sludge, water, and debris would also be removed from the K Basins and the facilities deactivated.

5.1.4 Drying/Passivation (Conditioning) with Dry Storage Alternative

Activities evaluated under the preferred alternative include repackaging, removal, and drying of K Basins SNF; transport to a new staging/storage site on the 200 Areas plateau; conditioning or passivation for storage as needed; and placement of the SNF into dry storage. Sludge, water, and debris would also be removed from the K Basins and the facilities deactivated.

5.1.5 Calcination with Dry Storage Alternative

Activities considered under this alternative include repackaging and removal of K Basins SNF, transport to a new staging/storage site on the 200 Areas plateau, dissolution and calcination of the SNF, and placement in a dry storage facility. Sludge, water, and debris would also be removed from the K Basins and the facilities deactivated.

5.1.6 Onsite Processing Alternative

Activities included in the onsite processing alternative are removal of SNF from the K Basins; transport to a new staging/storage facility on the 200 Areas plateau before processing; separation of plutonium, uranium, and fission products at a new facility; and storage of the separated uranium oxide at a new facility. For the purposes of this analysis, plutonium and high-level waste resulting from the process were also assumed to be stored in onsite facilities. As with the other alternatives, sludge, debris, and water would ultimately be removed from the K Basins and the facilities would be deactivated.

5.1.7 Foreign Processing Alternative

Activities that would be conducted as part of the foreign processing alternative include transloading K Basin SNF into shipping casks at the K Basins, onsite transfer of the shipping casks to a new staging facility and shipment of the SNF to an overseas location for separation into uranium, plutonium, and high-level waste, after which these materials would be returned to Hanford for storage. Deactivation of the K Basins and management of the returned uranium and plutonium were assumed to be the same as in the onsite processing alternative. The high-level waste was assumed to be returned in a vitrified form and stored with treated tank wastes at the Hanford Site. The consequences presented in this EIS do not include the impacts of transportation or processing at the foreign location. They are assumed to be similar to those for transportation from the Hanford Site to a U.S. port, and for processing at the Hanford Site, respectively.

5.2 Land Use

Consequences of implementing the alternatives for management of K Basins SNF on land use at the Hanford Site are discussed in the following subsections.

5.2.1 No Action and Enhanced K Basins Storage Alternatives

The no action and enhanced K Basins storage alternatives would not require construction of new facilities; therefore, no land use consequences would be associated with either alternative.

5.2.2 Wet Storage, Passivation or Calcination with Dry Storage, and Processing Alternatives

All new construction associated with the wet storage, dry storage, and processing alternatives would be located on or adjacent to land already dedicated to nuclear facilities. Up to 8.1 ha (20 acres) would be disturbed by construction of facilities associated with the onsite processing alternative at the reference site. If the facilities were constructed at the CSB site, they would be on land that has been previously disturbed. The land use associated with each alternative is shown in Table 5-1.

Table 5-1. Land use for alternatives including construction of new facilities

Alternative	Facility	Area Disturbed (ha [acre])	Area Occupied (ha [acre]
Wet storage	Storage facility	2.8 [6.9]	0.9 [2.2]
Drying/passivation with dry storage	Passivation facility	0.7 [1.7]	0.5 [1.3]
	Storage facility	2.8 [6.9]	0.9 [2.2]
	Total	3.5 [8.6]	1.4 [3.5]
Calcination with dry storage	Calcination facility	2.4 [5.9]	0.6 [1.5]
	Storage facility	2.8 [6.9]	0.9 [2.2]
	Total	5.2 [13.0]	1.5 [3.7]
Onsite processing	Wet staging facility	2.8 [6.9]	0.9 [2.2]
	Process facility	4.9 [12.0]	1.0 [2.5]
	Uranium trioxide storage	0.4 [1.0]	0.4 [1.0]
	Plutonium dioxide storage	NA	
	High-level waste storage	NA	
	Total	8.1 [20.0]	2.3 [5.7]
Foreign processing	K Basin transloading facility	0.4 [1.0]	
	Staging facility	2.8 [6.9]	0.9 [2.2]
	Uranium trioxide storage	0.4 [1.0]	
	Plutonium dioxide storage	NA	
	High-level waste storage	NA	
	Total	3.6 [8.9]	

NA = Not applicable to this analysis. Facilities are either existing or would be covered under separate National Environmental Policy Act analyses.

5.3 Socioeconomics

The following section describes the socioeconomic impacts of the SNF alternatives at the Hanford Site. For this analysis, the 10-county region of influence identified in the DOE Spent Nuclear Fuel Programmatic Environmental Impact Statement (DOE SNF PEIS) (DOE 1995a) was narrowed to the Benton-Franklin County area. The primary area of interest is the Tri-Cities

(Richland, Kennewick, and Pasco), where the vast majority of the impacts can be expected. The socioeconomic impacts are classified in terms of primary and secondary effects. Changes in Hanford employment and subcontracts, materials, and services expenditures associated with the various alternatives for dealing with K Basins SNF are classified as primary effects, while the additional changes that result in the general regional economy and community as a result of these primary changes are classified as secondary effects. Examples of secondary impacts include such things as changes in retail and service employment or changes in demand for housing. The total socioeconomic impact in the region is the sum of the primary and secondary impacts.

Estimates of total employment impacts were calculated using the IMPLAN regional economic model (MIG 1993) for the Tri-Cities region. These estimates were checked for consistency with the less-detailed estimates produced for the DOE SNF PEIS using the Regional Input-Output Modeling System (RIMS) of the U.S. Bureau of Economic Analysis. Allowing for differences in methods, the more-detailed estimates produced for this EIS are in general agreement with those produced by the earlier, less-detailed analysis. This estimate reports the changes in employment and earnings based on historical data, which indicate that 93% of Hanford employees reside in the Benton-Franklin County area and that about 13.5% of all subcontracts, materials, and services procurements by Hanford's management and operations contractor occur in the same region.

Impacts other than employment and income are largely based on changes in population, in view of current capacities of the local roads, schools, waste and water treatment, and other elements of local infrastructure. Historical geographic patterns of settlement are assumed to persist.

5.3.1 No Action Alternative, Enhanced K Basins Storage Alternative, and Foreign Processing Alternative

Under the no action alternative, only the minimum actions required for continued safe and secure storage of SNF would occur. No new facilities would be constructed, and only minimum facility upgrades or replacements would take place. In the case of the K Basins enhancements, the investment necessary to consolidate KE Basin fuel at KW Basin would result in an increase of $5 million to $20 million in annual budgets between 1996 and 2002, which would generate no extra jobs onsite and only a few extra (less than 200) total jobs. After this K Basin operations employment and budgets would fall to about two thirds of the baseline value shown in Table 5-2. It is assumed that existing personnel would be used to perform the enhancements, and therefore, few incremental consequences would occur. Overall, Tri-Cities socioeconomic conditions would continue as they currently are, with employment fluctuating but generally declining over the long term. Impacts are difficult to judge because they will depend to a large degree on total Hanford employment. Other Hanford projects may increase Hanford employment during the period 1996 to 2010 and therefore may affect the socioeconomic context in which the effects of any SNF-related activity must be judged. The timing and budgets for these other activities are currently uncertain. Because of this uncertainty, the no action alternative has been used as the basis for comparison.

Table 5-2 shows the current level of K Basins operating budget, employment, and estimated subcontracts, materials, and services procurements, which would continue under the no action alternative.

Table 5-2. No action alternative annual K Basins budget, employment, and subcontracts, materials, and services procurements (fiscal year 1995)

No action alternative (current status)	Amount
Operating budget	$39 Million
Hanford jobs	280
Subcontracts, materials, services	$22.8 Million

The foreign processing alternative requires increases in the K Basins annual budget ranging from about $6 million to $42 million per year between the years 1996 and 2007. The highest year, 1999, shows only about 25 extra employees needed, however, and the largest community impact is only about 125 workers. This impact is insignificant. After 2007, employment at the K Basins declines to less than 10 personnel, resulting in a decline of Tri-Cities employment of about 600 and population loss of about 800 relative to the no action alternative.

5.3.2 New Wet Storage Alternative

Under the new wet storage alternative, significant facility development and upgrades are required. Table 5-3 shows the employment and population impacts related to construction and operations of these facilities, relative to those expected under the no action alternative shown in Table 5-2. For purposes of this analysis, the general level of employment and budget at the Hanford Site is assumed to otherwise follow the baseline discussed above. Population impacts were calculated at 1.3 times total employment impacts, consistent with the DOE SNF PEIS (DOE 1995a). An unknown number of current Hanford workers could be reassigned to operations activities, reducing immigration to the area below the estimates shown in this section. Construction activity is assumed to require new construction workers coming into the area.

Table 5-3. Socioeconomic impacts associated with the new wet storage alternative, relative to no action

Wet Storage Impact	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005-2035
Hanford jobs[a]	93	223	129	129	123	75	-78[b]	-78	-78	-203
Subcontracts, materials, services (million $)	46.3	64.3	81.8	49.2	19.1	13.7	-4.4	-8.2	-8.2	-17.3
Area jobs[c]	300	600	650	400	150	50	-200	-200	-200	-450
Population change[c]	450	800	850	500	150	50	-250	-250	-250	-600

(a) Hanford job impacts are shown relative to the current employment of 280 jobs shown in the no action alternative. Other impacts are similarly calculated.
(b) Completion of the wet storage alternative results in lower direct employment and lower costs relative to the no action alternative in the years after 2001.
(c) Employment and population impacts are rounded to the nearest 50.

Estimates of Hanford primary jobs and budget are provided in Bergsman et al. (1995). For construction activity, Bergsman et al. (1995) report jobs in the peak year, total person-years required, and schedule. For this section, employment was assumed to ramp up to a peak, then ramp down for each major facility built. This procedure results in the number of jobs by year, consistent with the peak year and total person-years required. Increases in activity levels could strain the local community infrastructure housing market if they were near capacity and a number of projects discussed for Hanford were all built at the same time, even though the impact of the wet storage alternative by itself would be insignificant. However, the current projected baseline for Hanford shows a declining Hanford budget and employment, which should mean that, other things equal, most community infrastructure will be adequate to accommodate any new population associated with this alternative. Local schools currently are crowded, but it is unclear whether this condition will persist with declining Hanford employment.

All construction activity is assumed to peak in 1997 to 1998, with employment of 223 and subcontracts, materials, and services procurements of $82 million. Construction activity occurs between 1996 and 2001. The maximum increase in area total employment is about 650, less than 1% over baseline population projections. Population is expected to peak in 1998, with an increase in population of about 850. This equates to an increase of less than 0.6% over the projected baseline population and implies that the effects on demand for community infrastructure and services likely would be insignificant.

5.3.3 Drying/Passivation, Calcination, and Onsite Processing Alternatives

Three alternatives (drying/passivation, calcination, and onsite processing) result in storage of the K Basins SNF in a dry form that will require less maintenance in the long run but significant facility development and upgrades in the short run. The employment and population impacts related to construction and operations of the facilities under each alternative are shown in Table 5-4. As with wet storage, the impacts shown in the table are differences from current (no action) conditions. Employment impacts were analyzed in the same manner as for the wet storage alternative. Increases in activity levels likely would not have significant socioeconomic effects in themselves, although they might be sufficient to strain community infrastructure and housing if they were near capacity and if a number of other projects discussed for Hanford were all built at the same time, and if Hanford budgets remained at current levels. However, the projected baseline for the Tri-Cities area currently shows a declining Hanford budget and employment, which should mean that, other things equal, most community infrastructure will be adequate to

Table 5-4. Socioeconomic impacts associated with drying/passivation, calcination, and onsite processing alternatives, relative to no action

Alternative and Impact	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006-2007	2008-2009	2010-2013	2014-2035
Drying/Passivation														
Hanford jobs[a]	180	408	291	259	193	203	-26[b]	-26	-26	-268	-268	-268	-268	-268
Subcontracts, materials, services (million $)	91.3	121.7	137.6	55.8	18.3	18.8	-3.6	-3.6	-3.6	-21.3	-21.3	-21.3	-21.3	-21.3
Area jobs[c]	800	1,300	1,300	600	200	200[d]	-50	-50	-50	-600	-600	-600	-600	-600
Population change[c]	1,050	1,650	1,700	750	250	250	-100	-100	-100	-800	-800	-800	-800	-800
Calcination														
Hanford jobs[a]	93	223	129	129	440	570	417	568	417	437	467	467	332	-268
Subcontracts, materials, services (million $)	46.3	64.3	81.8	42.1	52.2	75.5	57.5	77.6	57.5	78.5	20.7	20.7	52.9	-21.3
Area jobs[c]	350	600	650	350	700	1,050	750	1,050	750	950	1,050	1,050	800	-600
Population change[c]	450	800	850	450	950	1,350	950	1,400	950	1,250	1,350	1,350	1,050	-800
Onsite Processing														
Hanford jobs[a]	93	223	129	129	512	464	848	794	570	448	892	892	1,041	-265
Subcontracts, materials, services (million $)	46.3	64.3	81.8	49.2	83.8	78.4	125.4	136.9	99.8	71.6	30.3	30.3	73.9	-21.3
Area jobs[c]	350	600	650	400	1,050	950	1,750	1,800	1,250	900	1,950	1,950	2,350	-600
Population change[c]	450	800	850	500	1,400	1,250	2,300	2,350	1,650	1,150	2,550	2,550	3,050	-800

(a) Hanford impacts are shown relative to the current employment of 280 jobs contained in the no action alternative. Other impacts are similarly calculated.

(b) Completion results in cost savings and lower employment relative to the no action alternative.

(c) Employment and population impacts are rounded to the nearest 50.

(d) In the passivation alternative, the local offsite impact of procurements for the relatively small construction spending is smaller than the impact of offsite procurements characteristic of normal Hanford operations. Consequently, the impact on total employment can be smaller than the impact on direct employment.

accommodate any new population associated with these alternatives. As noted in Section 5.3.2, the exception may be schools, but this is currently unclear.

Construction activity achieves its peak impact at different times in the three alternatives, with peak total area employment reaching about 1,300 jobs in 1998 with drying/passivation, about 1,050 in 2003 with calcination, and almost 1,800 in 2003 with onsite processing. However, in the case of onsite processing, overall maximum primary employment actually occurs during the 2010 to 2013, when it assumed that $250 million is spent to deactivate the separations processing facility and $450 million is spent to decontaminate and decommission it (Bergsman et al. 1995). The area employment impact is 2,350 jobs. Construction activity occurs between 1996 and 2000 with drying/passivation, and between 1996 and 2005 for the other two alternatives. Peak employment increases amount to less than a 3% increase over baseline projections.

Corresponding population increases range from 1,750 to 3,050, an increase of just over 1% to 1.6% above baseline projected population, which implies that the incremental effects on demand for community infrastructure and services likely would be insignificant.

5.4 Cultural Resources

The potential impacts on cultural resources of removing SNF from the K Basins and storing and processing it were assessed by reviewing three factors. These factors are 1) identifying project activities that could directly or indirectly impact significant resources, 2) identifying the known or expected significant resources in areas of potential impact, and 3) determining whether a project activity would have no effect, no adverse effect, or an adverse effect on significant resources.

Two sites near the 200 East Area are candidates for storage and processing facilities. The reference site, discussed in Section 5.4.4 of the DOE SNF PEIS (DOE 1995a), is located just northwest of the 200 East Area. As part of the DOE SNF PEIS analysis, this site was intensively inventoried to locate possible cultural resources (HCRC 94-600-017). No cultural resource sites were recorded by this inventory. The CSB site, located in the west-central portion of the 200 East Area, has also been previously inventoried for cultural resources (Chatters and Cadoret 1990). Similar to the reference site, no known archaeological or historical sites are located within the CSB site.

Direct or indirect impacts are not anticipated to any known traditional cultural properties that are significant to members of the Yakama Indian Nation, the Confederated Tribes of the Umatilla Indian Reservation, or the Wanapum people. This conclusion is based on comparing the proposed location of facilities to known sacred or culturally important areas previously identified through ethnographic research and past interviews with elders of groups that formerly used the Hanford Site (Chatters 1989).

5.5 Aesthetic and Scenic Resources

Implementation of any of the alternatives would be highly unlikely to adversely impact the present aesthetics of the area. All postulated construction of new facilities would be within or adjacent to already disturbed areas dedicated to nuclear facilities and would not be located where they can be seen by the general public. Up to 8.1 ha (20 acres) would be disturbed in construction of facilities associated with the onsite processing alternative.

5.6 Geologic Resources

No potential impacts to the geologic resources of the Hanford Site have been identified under any of the alternatives.

5.7 Air Quality and Related Consequences

The consequences of the alternatives on ambient air quality at the Hanford Site are presented in the following subsections. For radiological emissions, the consequences are compared to current Hanford Site operations and to regulatory standards. For nonradiological emissions, projected ambient concentrations at key receptor locations are compared with current concentrations at the Hanford Site and with state and federal air quality standards.

5.7.1 Radiological Consequences

The radiological consequences of airborne emissions during normal operation have been estimated for the K Basins SNF alternatives considered in this document. The radiological doses were evaluated using the GENII computer code package (Napier et al. 1988). Three separate analyses were performed for each facility included in an alternative. The receptors evaluated in these cases were 1) the collective offsite population within 80 km (50 mi), about 380,000 people; 2) the collective population of onsite workers, about 14,000 people; 3) the maximally exposed offsite resident; and 4) the location of maximum exposure representing a potential onsite worker outside of the SNF facility. Standard parameters for radiological dose calculations at the Hanford Site were used for these estimates (Schreckhise et al. 1993).

The health consequences in terms of latent cancer fatalities were calculated based on collective population dose using recommendations from the International Commission on Radiological Protection (ICRP) in its Publication 60 (ICRP 1991). The estimated rate of latent cancer fatalities for the general population was taken to be 5×10^{-4} per person-rem; and the corresponding rate for workers was 4×10^{-4} per person-rem. The higher rate for the general public accounts for the presence of more sensitive members of the population (for example, children) compared to the relatively homogeneous population of healthy adult workers. Other long-term effects, including nonfatal cancers and severe hereditary effects, generally occur at lower rates (1×10^{-4} and 1.3×10^{-4} per person-rem, respectively, for the general population; 8×10^{-5} and 8×10^{-5} per person-rem respectively for adult workers).

None of the alternatives would result in a dose to the maximally exposed offsite resident that exceeds 1% of the current U.S. Environmental Protection Agency (EPA) standard of 10 mrem/year. The consequences of the no action alternative result from emissions at existing facilities in the 100-K Area. The facilities contribute a relatively small fraction of the total dose from airborne emissions at current Hanford Site operations. The consequences of the alternatives vary depending on which storage and fuel stabilization options are considered. Alternatives including stabilization of K Basin SNF result in the highest annual doses during the periods when the conditioning or processing facilities are operating; however, dry storage of the stabilized fuel over the remainder of the period has the lowest consequences to workers and the public.

No Action Alternative

Projected radionuclide emissions to the air for the K Basins in the no action alternative are based on operation of the facilities during 1993 (Bergsman et al. 1995). The 1993 emissions were assumed to represent operations at existing SNF storage facilities over the EIS evaluation period and are listed in Table 5-5.

The dose consequences of air emissions from these facilities are summarized in Table 5-6. The peak collective dose to the population within 80 km (50 mi) is 0.0051 person-rem/year, which is predicted to result in less than one (1×10^{-4}) fatal cancer over 40 years of storage.

Table 5-5. Air emissions from K Basins for 1993 (Bergsman et al. 1995, Table 3-2)

Radionuclide	KE Basin (Ci)	KW Basin (Ci)	Combined KE and KW Basins (Ci)
^{3}H			(a)
^{60}Co	$2.2x10^{-6}$		$2.2x10^{-6}$
^{90}Sr	$5.0x10^{-5}$	$1.7x10^{-6}$	$5.2x10^{-5}$
^{106}Ru	$7.6x10^{-6}$	$1.6x10^{-6}$	$9.2x10^{-6}$
^{125}Sb	$7.6x10^{-7}$	$1.2x10^{-6}$	$2.0x10^{-6}$
^{137}Cs	$1.4x10^{-4}$	$2.1x10^{-5}$	$1.6x10^{-4}$
^{154}Eu	$3.9x10^{-6}$	$1.9x10^{-6}$	$5.8x10^{-6}$
^{155}Eu	$1.1x10^{-6}$		$1.1x10^{-6}$
^{238}Pu	$9.9x10^{-7}$	$7.5x10^{-9}$	$1.0x10^{-6}$
^{239}Pu	$7.7x10^{-6}$	$5.3x10^{-8}$	$7.7x10^{-6}$
^{241}Am	$5.2x10^{-6}$	$4.0x10^{-8}$	$5.2x10^{-6}$

(a) Tritium emissions from the K Basins are not routinely monitored; however, the levels of tritium released to the atmosphere from evaporation of basin water have been estimated at 1 to 2 Ci/year. The dose from these emissions is a relatively small fraction of the total dose from the basins radioactive effluents.

Table 5-6. Dose and consequences from routine air emissions from K Basins for 1993

Receptor	Routine Dose	Fatal Cancers (per year of operation)
Offsite population	0.0051 person-rem	None ($3x10^{-6}$)
Collective workers	$9.6x10^{-4}$ person-rem	None ($4x10^{-7}$)
Offsite resident	$1.7x10^{-7}$ rem	NA[(a)]
Onsite worker	$8.5x10^{-6}$ rem	NA

(a) NA = Not Applicable

Enhanced K Basins Storage Alternative

Projected radionuclide emissions to the air for the enhanced K Basins storage alternative are listed in Table 5-7. Emissions for containerization of SNF in the KE Basin are based on historical experience during encapsulation of the fuel currently in KW Basin (see Table 5-7). Similar releases would result from other activities, including removal of fuel, sludge, water, and debris. Emissions from these activities are approximated by the releases described for fuel containerization, listed in Table 5-7. After consolidation, the air emissions should be approximately twice the current emissions from the KW Basin, as listed in Table 5-5. The dose consequences of air emissions from facilities are summarized in Table 5-8.

Table 5-7. Projected radionuclide air emissions from the KE Basin during containerization, SNF consolidation, and removal of sludge and debris (Bergsman et al. 1995, Table 3-7)

Radionuclide	Projected Air Emissions (Ci/yr)[a]
^{3}H	1.2
^{60}Co	1.1×10^{-5}
^{90}Sr	5.6×10^{-4}
^{106}Ru	2.4×10^{-5}
^{137}Cs	4.8×10^{-4}
^{238}Pu	5.2×10^{-6}
^{239}Pu	3.1×10^{-5}
^{241}Pu	4.0×10^{-5}
^{241}Am	1.4×10^{-5}

(a) Data based upon engineering judgement using related historical data.

Table 5-8. Dose and consequences from the enhanced K Basins storage alternative

Receptor	Routine Dose from Enhanced Storage		Fatal Cancers (per year of operation)	
	Containerization	After Containerization[a]	Containerization	After Containerization
Population	0.019 person-rem	1.1×10^{-4} person-rem	None (1×10^{-5})	None (6×10^{-8})
Collective workers	0.0035 person-rem	4.6×10^{-4} person-rem	None (1×10^{-6})	None (2×10^{-7})
Offsite resident	6.6×10^{-7} rem	4.2×10^{-9} rem	NA[b]	NA
Onsite worker	3.0×10^{-5} rem	1.4×10^{-7} rem	NA	NA

(a) The source term is twice the KW Basin release for 1993 (see Table 5-5).
(b) NA = Not applicable

Wet Storage Alternative

The wet storage alternative includes two basic options: storage of SNF in water-filled MCOs in a vault, or pool storage with MCOs in underwater racks. Estimated radiological air emissions during the combined activities of fuel, sludge, and debris removal and water treatment at the K Basins would be equivalent to the releases for the enhanced K Basins alternative, listed in Table 5-7. Emissions during normal operations of a new storage vault or wet pool storage facility are estimated in Table 5-9.

The dose consequences of removing fuel and wastes from the K Basins, and of air emissions from a new wet storage facility (conservatively based on a storage temperature of 100°F), are summarized in Table 5-10. The peak collective dose to the population within 80 km (50 mi) is 0.31 person-rem/year, which is predicted to result in less than one (0.006) fatal cancer over 40 years of storage.

Drying/Passivation With Dry Storage Alternative

Emissions of radionuclides from the storage facility during fuel removal and staging before stabilization would be the same as in the wet storage alternative (Table 5-9). Estimated radiological emissions to the atmosphere from an SNF drying or passivation facility are listed in Table 5-11. After the fuel is conditioned, the dry storage facilities are assumed to have no

Table 5-9. Routine emissions from wet storage facilities (Bergsman et al. 1995, Table 3-14)

Radionuclide	Release (Ci/yr) 50°F	Release (Ci/yr) 100°F
^{3}H	8.9	89
^{14}C	0.13	1.3
^{60}Co	2.8×10^{-6}	2.8×10^{-6}
^{85}Kr	130	1300
^{90}Sr	3.4×10^{-6}	3.4×10^{6}
^{106}Ru	3.2×10^{-6}	3.2×10^{-6}
^{125}Sb	2.4×10^{-6}	2.4×10^{-6}
^{129}I	0.0012	0.012
^{137}Cs	4.2×10^{-5}	4.2×10^{-5}
^{154}Eu	3.8×10^{-6}	3.8×10^{-6}
^{238}Pu	1.5×10^{-8}	1.5×10^{-8}
$^{239/240}Pu$	1.1×10^{-7}	1.1×10^{-7}
^{241}Am	8.0×10^{-8}	8.0×10^{-8}

Table 5-10. Dose and consequences from the new wet storage alternative

Receptor	Routine Annual Dose: Fuel, Sludge, Water, and Debris Removal[a]	Routine Annual Dose: New Wet Storage[b]	Fatal Cancers (per year of operation): Fuel, Sludge, Water, and Debris Removal	Fatal Cancers (per year of operation): New Wet Storage
Offsite population	0.019 person-rem	0.31 person-rem	None (1×10^{-5})	None (2×10^{-4})
Collective workers	0.0035 person-rem	0.0011 person-rem	None (1×10^{-6})	None (4×10^{-7})
Offsite resident	6.6×10^{-7} rem	8.9×10^{-6} rem	NA[c]	NA
Onsite worker	3.0×10^{-5} rem	4.5×10^{-7} rem	NA	NA

(a) Dose based on source term from Table 5-7.
(b) Dose based on source term for storage at 100°F, Table 5-9.
(c) NA = Not applicable.

Table 5-11. Estimated annual airborne radionuclide emissions from a drying/passivation facility (Bergsman et al. 1995, Table 3-21)

Radionuclide	Emissions (Ci/yr)	Radionuclide	Emissions (Ci/yr)
^{3}H	83.0	^{144}Ce	1.44×10^{-8}
^{14}C	5.30×10^{-10}	^{144}Pr	1.42×10^{-8}
^{55}Fe	3.49×10^{-9}	^{144m}Pr	1.73×10^{-10}
^{60}Co	1.18×10^{-7}	^{147}Pm	8.64×10^{-7}
^{63}Ni	3.53×10^{-9}	^{151}Sm	1.38×10^{-7}
^{85}Kr	4220	^{152}Eu	8.16×10^{-10}
^{90}Sr	8.40×10^{-6}	^{154}Eu	1.02×10^{-7}
^{90}Y	8.40×10^{-6}	^{155}Eu	2.65×10^{-8}
^{93}Zr	3.04×10^{-10}	^{234}U	7.02×10^{-10}
^{93m}Nb	1.69×10^{-10}	^{235}U	2.72×10^{-11}
^{99}Tc	2.18×10^{-9}	^{236}U	1.02×10^{-10}
^{106}Rh	1.39×10^{-8}	^{238}Pu	1.00×10^{-7}
^{106}Ru	1.39×10^{-8}	^{238}U	5.57×10^{-10}
^{113m}Ca	3.01×10^{-9}	^{239}Pu	1.80×10^{-7}
^{125}Sb	5.73×10^{-8}	^{240}Pu	1.04×10^{-7}
^{125m}Te	1.40×10^{-8}	^{241}Am	2.52×10^{-7}
^{126}Sn	1.14×10^{-10}	^{241}Pu	5.90×10^{-6}
^{126m}Sb	1.14×10^{-10}	^{242}Am	2.80×10^{-10}
^{129}I	0.0356	^{242}Cm	2.32×10^{-10}
^{134}Cs	3.70×10^{-8}	^{242m}Am	2.82×10^{-10}
^{137}Cs	1.08×10^{-5}	^{244}Cm	1.21×10^{-8}
^{137m}Ba	1.02×10^{-5}		

radiological emissions under normal operating conditions because all fuel is contained in sealed decontaminated MCOs within storage tubes or casks. Therefore, no mechanism exists for routine release of radionuclides from dry storage facilities over the time period covered in this document.

The consequences of removing SNF, sludge, debris, and water from the K Basins and staging the fuel in the 200 Area would be as described for the wet storage alternative. The dose consequences for the drying or passivation facility are listed in Table 5-12. Collective dose to the surrounding population would be 0.59 person-rem, and no latent fatal cancers (6×10^{-4}) would be expected to result from 2 years of normal operation.

Calcination with Dry Storage Alternative

Emissions of radionuclides from the K Basins during removal of fuel and wastes from the K Basins, and from the storage facility during fuel staging before stabilization, would be the same as those described for the wet storage

Table 5-12. Dose and consequences of routine air emissions from a drying/passivation facility

Receptor	Routine Annual Dose	Fatal Cancers (per year of operation)
Offsite population	0.59 person-rem	None ($3x10^{-4}$)
Collective workers	0.0016 person-rem	None ($6x10^{-7}$)
Offsite resident	$1.7x10^{-5}$ rem	NA[a]
Onsite worker	$6.2x10^{-7}$ rem	NA

(a) NA = Not applicable.

alternative (Tables 5-7 and 5-9, respectively). Radiological emissions to the atmosphere from a calcination facility are listed in Table 5-13.

The dose consequences of SNF and waste removal and staging activities would be the same as those listed in Table 5-10; those for normal operation of the calcination facility are shown in Table 5-14. Collective dose to the surrounding population would be 30 person-rem for the calcination facility. The corresponding number of latent fatal cancers would be less than 1 (0.06) for 4 years of operation.

Onsite Processing Alternative

The initial activities associated with the onsite processing alternative are similar to those described previously. Removal of fuel from the K Basins, deactivation of the K Basins, staging in the 200 Area, and the initial shearing and dissolution of SNF in the process facility would be identical to activities undertaken in the calcination alternative. The final steps in the chemical separation process were assumed to result in air emissions that are no greater than those from the final calcination step. Therefore, the estimated air emissions dose and consequences for the processing alternative are assumed to be bounded by the estimates for calcination in Table 5-14.

Foreign Processing

Loading of K Basin SNF into transport casks for shipment offsite would take place in a transloading facility within, or adjacent to, the existing K Basin facilities. Because the transloading facility would be equipped with an emission control system, air emissions from the cask loading operation would not be expected to add measurably to those estimated for K Basin operations as described in the no action and enhanced K Basin storage alternatives.

Table 5-13. Estimated airborne radionuclide releases from an SNF calcination or processing facility as a result of normal operation (Bergsman et al. 1995, Table 3-25)

Radionuclide	Current Estimate of Normal Process Facility Release (Ci/yr)
^{3}H	$1.04x10^{4}$
^{14}C	6.50
^{85}Kr	$1.76x10^{5}$
^{90}Sr	0.024
^{106}Ru	$5.07x10^{-4}$
^{125}Sb	$4.63x10^{-4}$
^{125m}Te	$2.43x10^{-4}$
^{129}I	1.48
^{134}Cs	$5.13x10^{-4}$
^{137}Cs	0.0301
^{144}Ce	$1.16x10^{-4}$
^{147}Pm	0.0081
^{151}Sm	$7.43x10^{-9}$
^{154}Eu	$4.19x10^{-4}$
^{155}Eu	$1.72x10^{-4}$
^{238}Pu	0.00155
$^{239,240}Pu$	0.008
^{241}Am	0.00441
^{241}Pu	0.019

Table 5-14. Dose and consequences of routine air emissions from a calcination or processing facility

Receptor	Routine Annual Dose	Fatal Cancers (per year of operation)
Offsite population	30 person-rem	None (0.02)
Collective worker	0.50 person-rem	None ($2x10^{-4}$)
Offsite resident	$8.2x10^{-4}$ rem	NA[(a)]
Onsite worker	$1.6x10^{-4}$ rem	NA

(a) NA = Not applicable.

During most of the transloading operations, emissions, dose, and consequences would continue as described under no action (Tables 5-5 and 5-6). Short-term increases during active removal of SNF, sludge, and debris would be expected, similar to those estimated for the enhanced K Basin storage alternative (Tables 5-7 and 5-8). No additional radionuclide emissions would be expected after the SNF is packaged for transport and the K Basins are deactivated.

5.7.2 Nonradiological Consequences

The impact of emissions of nonradiological air pollutants from the alternatives is examined in the following subsections. The focus is on emission of nitrogen oxides (NO_x) modeled as nitrogen dioxide (NO_2), oxides of sulfur modeled as sulfur dioxide (SO_2), and particulate matter with a 10-micron-or-less aerodynamic diameter (PM_{10}). Increases above ambient levels in the airborne concentration of these pollutants can result from construction activities and operation of the facilities as described for each alternative in Chapter 3.0. No significant nonradiological air quality impacts would occur from the fuel retrieval or cleanup of the sludge, debris, and water in the K Basins. As a result of the nature and small inventory or based on process knowledge, there would be no significant routine releases of nonradiological hazardous air pollutants (Bergsman et al. 1995); nonradiological hazardous air pollutants could be released during an accident (see Section 5.15.7). For criteria pollutants, concentration levels are regulated by the provisions of the Clean Air Act; Washington State standards for these criteria pollutants are at least as stringent as the federal standards.

Two Industrial Source Complex (ISC2) models were selected to estimate routine nonradiological air quality impacts for NO_2, SO_2, and PM_{10}. The ISC2 models are the ISC2 short-term model (ISCST2) and the ISC2 long-term model (ISCLT2) (EPA 1992). The ISC2 models have been approved by the EPA for specific regulatory applications and are designed for use on personal computers.

The maximum ground-level pollutant concentrations for time periods defined by the regulations are reported at the maximally impacted receptor location. To determine short-term impacts (i.e., exposure periods of 1- to 24-hours), the pollutant concentrations are assessed at the nearest point of unrestricted public access (e.g., receptors located along State Route 240, the Columbia River, and the Site boundary). For long-term impacts (i.e., annual exposures), pollutant concentrations are assessed along and outside of the Hanford Site boundary. Onsite points of public access are not considered because of the severely limited time any member of the public would spend at an onsite location over the course of a year.

Because the details of the construction process are not available for the alternatives, various assumptions are made. Most of these assumptions are conservative and would tend to produce significantly greater impacts than would be expected for an alternative were it selected for implementation.

No Action Alternative

The no action alternative involves no significant new construction, and, during operation, the K Basins do not have any significant routine releases of nonradiological pollutants.

Enhanced K Basins Storage Alternative

The enhanced storage alternative involves no major new construction, and, during operation, the K Basins do not have any significant routine releases of nonradiological pollutants.

New Wet Storage Alternative

Emissions from construction activities would contribute to the nonradiological consequences in the wet storage alternative. However, during operation, neither the wet storage nor the existing K Basins would have any significant releases of nonradiological pollutants.

Four different construction possibilities exist under the wet storage alternative: 1) construction of a vault facility at the CSB site, 2) construction of a vault facility at the reference site, 3) construction of a storage pool at the CSB site, and 4) construction of a storage pool at the reference site. Construction activities in each of the possibilities would emit NO_2, SO_2, and PM_{10}. As a byproduct of construction activities, PM_{10} would be emitted in the form of fugitive dust from a total of 2.8 ha (6.9 acres). Table 5-15 provides an estimate of the PM_{10} emission rates from fugitive dust. Emission rates from diesel- and gasoline-powered construction equipment for all four possibilities are presented in Table 5-16. Table 5-17 presents the resulting air quality impacts if the vault facility were constructed at the reference site, which would produce the largest nonradiological air quality impacts.

During the construction phase, the maximum offsite increases in ambient NO_2, SO_2, and PM_{10} from both fugitive dust and construction equipment emission would be below the state and federal regulatory limits. The offsite increases would be temporary and would not adversely affect the regional air quality on a continuing basis.

Table 5-15. Source term for fugitive dust from construction in the wet storage alternative

Pollutant	Averaging Time	Mass of Pollutant per Unit Area (kg/m^2)	Area of Source (ha)	Maximum Emission Rate ($g/[m^2 \cdot s]$)
PM_{10}	Annual	4.4	2.8	$1.4x10^{-4}$
	24 hr	0.012	2.8	$1.4x10^{-4}$

Table 5-16. Source term for the construction equipment emissions for each construction possibility in the wet storage alternative

Facility/Site	Pollutant	Averaging Time	Mass of Pollutant (kg)	Maximum Emission Rate (g/s)
Vault/CSB	NO_2	Annual	$9.3x10^4$	3.0
	SO_2	Annual	6700	0.21
		24 hr or less	180	2.1
	PM_{10}	Annual	9900	0.31
		24 hr or less	270	3.1
Vault/Reference	NO_2	Annual	$1.1x10^5$	3.3
	SO_2	Annual	7500	0.24
		24 hr or less	210	2.4
	PM_{10}	Annual	$1.1x10^4$	0.35
		24 hr or less	310	3.5
Pool/CSB	NO_2	Annual	$6.7x10^4$	2.1
	SO_2	Annual	4800	0.15
		24 hr or less	130	1.5
	PM_{10}	Annual	7200	0.23
		24 hr or less	200	2.3
Pool/Reference	NO_2	Annual	$8.7x10^4$	2.8
	SO_2	Annual	6200	0.20
		24 hr or less	170	2.0
	PM_{10}	Annual	9200	0.29
		24 hr or less	250	2.9

Table 5-17. Results from construction equipment and fugitive dust emissions for the wet storage alternative using vault storage at the reference site

Pollutant	Averaging Time	Maximum Concentration at Maximally Impacted Point of Unrestricted Public Access ($\mu g/m^3$)	Percent of Regulatory Limit
NO_2	Annual	0.21	0.21
SO_2	Annual	0.015	0.029
	24 hr	13	5.1
	3 hr	89	6.8
	1 hr	200	19
	1 hr[a]	150	23
PM_{10}	Annual	0.33	0.66
	24 hr	43	29

(a) Regulatory limit not to be exceeded more than twice in any 7 consecutive days.

Drying/Passivation with Dry Storage Alternative

During operation, none of the facilities (passivation facility, the staging facility, the dry storage facility, or the existing K Basins storage facilities) would have any significant releases of nonradiological pollutants. However, emissions from construction activities would contribute to the nonradiological consequences in the passivation alternative.

Construction activities would result in emissions of NO_2, SO_2, and PM_{10}. As a byproduct of construction activities, PM_{10} would be emitted in the form of fugitive dust from a total of 3.5 ha (8.6 acres). This includes the 2.8 ha (6.9 acres) required to build the staging and storage facility and an additional 0.7 ha (1.7 acres) to build the passivation facility. Because the passivation facility and the staging and storage facility would be built at the same time (Bergsman et al. 1995), the impacts presented include impacts from construction of both facilities.

If a wet storage pool is used as the staging facility, then additional construction is required to convert the pool into a dry storage vault after passivation. This additional construction would produce additional air quality impacts as a result of emissions from construction equipment but would not produce any significant emission of fugitive dust. As the additional construction would occur after the construction of the wet storage pool and passivation facility, the impacts are presented separately. If a vault is used as the staging facility, then no additional construction is required.

For construction of the staging and storage facility and the passivation facility, Table 5-18 provides estimates of PM_{10} emission rates from fugitive dust. Emissions from construction equipment are reported in Table 5-19 and the resulting air quality impacts are reported in Table 5-20. For the additional construction required with using a wet storage pool, emissions from construction equipment are reported in Table 5-21 and the resulting air quality impacts are reported in Table 5-22.

During the construction phase, the maximum offsite increases in ambient NO_2, SO_2, and PM_{10} from both fugitive dust and construction equipment emission would be below the federal and state regulatory limits. The offsite increases would be temporary and would not adversely affect the regional air quality on a continuing basis.

Table 5-18. Source term for fugitive dust from construction in the passivation alternative

Pollutant	Averaging Time	Mass of Pollutant per Unit Area (kg/m^2)	Area of Source (ha)	Maximum Emission Rate (g/[m^2·s])
PM_{10}	Annual	4.4	3.5	$1.4x10^{-4}$
	24 hr	0.012	3.5	$1.4x10^{-4}$

Table 5-19. Source term for the construction equipment emissions in the passivation alternative

Pollutant	Averaging Time	Mass of Pollutant (kg)	Maximum Emission Rate (g/s)
NO_2	Annual	$1.5x10^5$	4.9
SO_2	Annual	$1.1x10^4$	0.33
	24 hr or less	290	3.3
PM_{10}	Annual	$1.6x10^4$	0.5
	24 hr or less	430	5.0

Table 5-20. Results from construction equipment and fugitive dust emissions for the passivation alternative

Pollutant	Averaging Time	Maximum Concentration at Maximally Impacted Point of Unrestricted Public Access ($\mu g/m^3$)	Percent of Regulatory Limit
NO_2	Annual	0.3	0.3
SO_2	Annual	0.021	0.04
	24 hr	19	7.2
	3 hr	120	10
	1 hr	280	27
	1 hr[a]	210	32
PM_{10}	Annual	0.34	0.68
	24 hr	51	34

(a) Regulatory limit not to be exceeded more than twice in any 7 consecutive days.

Table 5-21. Source term for the construction equipment emissions in the passivation alternative, changing wet storage pool to vault

Pollutant	Averaging Time	Mass of Pollutant (kg)	Maximum Emission Rate (g/s)
NO_2	Annual	$7.2x10^5$	2.2
SO_2	Annual	4500	0.14
	24 hr or less	120	1.4
PM_{10}	Annual	6800	0.22
	24 hr or less	190	2.2

Calcination with Dry Storage Alternative

Nonradiological emissions to the air in the calcination alternative would result from construction activities and from operation of the calcination facility.

Construction. Construction activities would result in emissions of NO_2, SO_2, and PM_{10}. As a byproduct of construction activities, PM_{10} would be emitted in the form of fugitive dust from a total of 5.2 ha (13 acres). This includes the 2.8 ha (6.9 acres) required to build the temporary wet/dry storage facility and an additional 2.4 ha (5.9 acres) to build the calcination facility. As the calcination facility and the temporary wet storage facility

Table 5-22. Results from construction equipment emissions for the passivation alternative, changing wet storage pool to vault

Pollutant	Averaging Time	Maximum Concentration at Maximally Impacted Point of Unrestricted Public Access ($\mu g/m^3$)	Percent of Regulatory Limit
NO_2	Annual	0.14	0.14
SO_2	Annual	9.0×10^{-4}	0.0017
	24 hr	8.0	3.1
	3 hr	54	4.1
	1 hr	120	12
	1 hr[(a)]	91	14
PM_{10}	Annual	0.013	0.027
	24 hr	12	8.0

(a) Regulatory limit not to be exceeded more than twice in any 7 consecutive days.

would not be built at the same time (Bergsman et al. 1995), the air quality impacts from construction of just the calcination facility are presented in this section; air quality impacts from construction of the temporary wet storage facility would be the same as those for the wet storage all facility. Air quality impacts from construction as a result of conversion of the temporary storage facility into the dry storage facility would be the same as presented in the passivation alternative.

Table 5-23 provides estimates of PM_{10} emission rates from fugitive dust. Emissions from construction equipment are reported in Table 5-24, and the resulting air quality impacts are reported in Table 5-25.

During the construction phase, the maximum offsite increases in ambient NO_2, SO_2, and PM_{10} from both fugitive dust and construction equipment emission would be below the federal and state regulatory limits. The offsite increases would be only temporary and would not adversely affect the regional air quality on a continuing basis.

Operation. Routine operation of the calcination facility would release NO_2. The annual amount of NO_2 emitted by the calcination facility is 16,000 kg/year (18 tons/year) through a 61-m (200-ft) stack with a diameter of 1.5 m (4.9 ft) and a flow rate of 47 m^3/s (1.0×10^5 ft^3/min) (Bergsman et al. 1995). The largest initial concentration is 1.87×10^5 $\mu g/m^3$. The gas is assumed to come out at ambient temperature (no buoyant plume rise).

Table 5-23. Source term for fugitive dust from construction in the calcination alternative

Pollutant	Averaging Time	Mass of Pollutant per Unit Area (kg/m^2)	Area of Source (ha)	Maximum Emission Rate ($g/[m^2 \cdot s]$)
PM_{10}	Annual	4.4	2.4	$1.4x10^{-4}$
	24 hr	0.012	2.4	$1.4x10^{-4}$

Table 5-24. Source term for the construction equipment emissions in the calcination alternative

Pollutant	Averaging Time	Mass of Pollutant (kg)	Maximum Emission Rate (g/s)
NO_2	Annual	$1.5x10^5$	4.8
SO_2	Annual	9500	0.3
	24 hr or less	260	3.0
PM_{10}	Annual	$1.4x10^4$	0.45
	24 hr or less	390	4.5

Table 5-25. Results from construction equipment and fugitive dust emissions for the calcination alternative

Pollutant	Averaging Time	Maximum Concentration at Maximally Impacted Point of Unrestricted Public Access ($\mu g/m^3$)	Percent of Regulatory Limit
NO_2	Annual	0.3	0.3
SO_2	Annual	0.019	0.036
	24 hr	17	6.4
	3 hr	110	8.6
	1 hr	250	25
	1 hr[a]	190	29
PM_{10}	Annual	0.028	0.48
	24 hr	42	28

(a) Regulatory limit not to be exceeded more than twice in any 7 consecutive days.

Table 5-26 provides an estimate of the emission, and Table 5-27 presents the air quality impact of operation of the calcination facility.

During the operation phase, the maximum offsite increase in ambient NO_2 would be very small, producing impacts that are well within the most stringent air quality standards.

Onsite Processing Alternative

Nonradiological emissions to the air in the onsite processing alternative would result from construction activities and from operation of the processing facility.

Construction. Construction activities would result in emissions of NO_2, SO_2, and PM_{10}. As a byproduct of construction activities, PM_{10} would be emitted in the form of fugitive dust from a total of 8.1 ha (20 acres). This includes the 2.8 ha (6.9 acres) required to build the temporary storage facility, an additional 4.9 ha (12 acres) to build the processing facility, and an additional 0.4 ha (1 acre) to build the uranium storage facility. Because the processing facility and the temporary storage facility would not be built at the same time (Bergsman et al. 1995), the air quality impacts from construction of just the processing facility and the uranium storage facility are presented in this section; air quality impacts from construction of the temporary storage facility would be the same as those presented for the wet storage facility.

Table 5-26. Source term for operation of the calcination facility in the calcination alternative

Pollutant	Averaging Time	Mass of Pollutant (kg)	Maximum Emission Rate (g/s)
NO_2	Annual	1.6×10^4	0.51

Table 5-27. Results from operation of the calcination facility in the calcination alternative

Pollutant	Averaging Time	Maximum Concentration at Maximally Impacted Point of Unrestricted Public Access[(a)] ($\mu g/m^3$)	Percent of Regulatory Limit
NO_2	Annual	0.0084	0.0084

(a) Maximally impacted point is 17 km (10.6 mi) to the east of the facility.

Table 5-28 provides estimates of PM_{10} emission rates from fugitive dust. Emissions from construction equipment are reported in Table 5-29, and the resulting air quality impacts are reported in Table 5-30.

Table 5-28. Source term for the fugitive dust from construction in the onsite processing alternative

Pollutant	Averaging Time	Mass of Pollutant per Unit Area (kg/m^2)	Area of Source (ha)	Maximum Emission Rate ($g/[m^2 \cdot s]$)
PM_{10}	Annual	4.4	5.3	$1.4x10^{-4}$
	24 hr	0.012	5.3	$1.4x10^{-4}$

Table 5-29. Source term for the construction equipment emissions in the onsite processing alternative

Pollutant	Averaging Time	Mass of Pollutant (kg)	Maximum Emission Rate (g/s)
NO_2	Annual	$5.0x10^4$	1.6
SO_2	Annual	3100	0.099
	24 hr or less	86	0.99
PM_{10}	Annual	4700	0.15
	24 hr or less	130	1.5

Table 5-30. Results from construction equipment and fugitive dust emissions for the onsite processing alternative

Pollutant	Averaging Time	Maximum Concentration at Maximally Impacted Point of Unrestricted Public Access ($\mu g/m^3$)	Percent of Regulatory Limit
NO_2	Annual	0.099	0.099
SO_2	Annual	0.0062	0.012
	24 hr	5.5	2.1
	3 hr	37	2.9
	1 hr	84	8.1
	1 hr[a]	63	9.7
PM_{10}	Annual	0.0093	0.019
	24 hr	8.3	30

(a) Regulatory limit not to be exceeded more than twice in any 7 consecutive days.

During the construction phase, the maximum offsite increases in ambient NO_2, SO_2, and PM_{10} from both fugitive dust and construction equipment emissions would be below the federal and state regulatory limits. The offsite increases would be temporary and would not adversely affect the regional air quality on a continuing basis.

Operation. The operation of the processing facility is assumed to result in the same NO_2 emission levels as the calcination facility (see Tables 5-26 and 5-27), and the ambient air concentrations would not exceed regulatory standards.

Foreign Processing Alternative

The foreign processing alternative could require three new facilities: a transloading facility at the K Basins, a staging facility, and a UO_3 storage facility. During operation, none of these facilities would produce any significant releases of nonradiological pollutants. However, emission from construction activities would contribute to nonradiological consequences in the foreign processing alternative.

Except for those at the staging facility, there would be no significant emission of NO_2, SO_2, or PM_{10} from construction vehicles because the amount of diesel fuel and gasoline required in building the new facilities would be relatively small (Bergsman et al. 1995). However, PM_{10} would be emitted in the form of fugitive dust from a total of 3.6 ha (8.9 acres). This includes 0.4 ha (1 acre) for building the transloading facility, 2.8 ha (6.9 acres) for building the staging facility, and 0.4 ha (1 acre) for building the UO_3 storage facility. Because the various facilities would be located in different areas on the Hanford Site, the air quality impacts for each of the facilities are presented separately. Impacts for the staging facility are given under the wet storage alternative discussion.

Table 5-31 provides estimates of PM_{10} emission rates from fugitive dust for the transloading and UO_3 storage facilities. The resulting air quality impacts are reported in Table 5-32. Emission rates and impacts for the staging facility would be as described for the wet storage alternative.

Table 5-31. Source term of PM_{10} for fugitive dust from construction in the foreign processing alternative

Facility	Averaging Time	Mass of Pollutant per Unit Area (kg/m^2)	Area of Source (ha)	Maximum Emission Rate ($g/[m^2 \cdot s]$)
Transloading	Annual	4.4	1	1.4×10^{-4}
	24 hr	0.012	1	1.4×10^{-4}
UO_3 Storage	Annual	0.49	1	1.5×10^{-5}
	24 hr	1012	1	1.4×10^{-4}

Table 5-32. Results from fugitive dust emissions for the foreign processing alternative

Facility	Averaging Time	Maximum Concentration at Maximally Impacted Point of Unrestricted Public Access ($\mu g/m^3$)	Percent of Regulatory Limit
Transloading	Annual	0.059	0.12
	24 hr	120	81
UO_3 Storage	Annual	0.0039	0.0078
	24 hr	3.0	2.1

5.8 Water Quality and Related Consequences

This section evaluates the potential impacts to groundwater and surface water resources from routine activities associated with the alternatives for management of SNF stored in the K Basins at the Hanford Site. Accidents that may impact water quality are discussed in Section 5.15. Potential impacts to groundwater and surface water, water use, and water quality from the potential release of contaminants into, and migration through, hydrologic water-based environments are evaluated. The significance of these impacts is evaluated with respect to environmental contaminant levels and health effects. Contaminant waste streams include radionuclide and chemical carcinogens and noncarcinogenic chemicals.

The Multimedia Environmental Pollutant Assessment System (MEPAS), a computer model, was used to simulate the release, migration, fate, exposure, and risk to surrounding receptors of wastes that are discharged into the environment from the operation of SNF facilities. The uses of this model include assessing health impacts from releases of both hazardous and radioactive materials. The MEPAS model is designed for site-specific assessments using readily available information. It follows EPA risk-assessment guidance in evaluating the following:

1. the release of contaminants into the environment
2. their movement through and transfer between various environmental media [i.e., subsurface (vadose and saturated zones), surface water, overland (surface soil), and atmospheric]
3. exposure to surrounding receptors via inhalation, ingestion, dermal contact, and external dose
4. risk from carcinogens and hazard from noncarcinogens.

Liquid effluent releases from alternatives for managing SNF in the K Basins result in water either being released directly into the Columbia River or into the soil column with subsequent potential migration into the Columbia River. The scenarios assume that discharge in the Columbia River is under low-flow conditions of 1,000 m^3/s (36,000 ft^3/s) (Whelan et al. 1987), which represents the most conservative case for maximizing surface water concentrations. Also as a conservative assumption, the removal of water from the Columbia River is assumed to be 100 m (328 ft) downstream from the point of entry of the contaminant into the river. In reality, the first withdrawal point is at North Richland, where the water would be relatively well mixed over a significantly larger volume of the river, resulting in substantially lower concentrations. All assessments addressed recreational activities (e.g., boating, swimming, and fishing) in the Columbia River and use of the water as a drinking water supply and for bathing, irrigation, and other uses. Exposures were assumed to a maximum individual in the river and to a population of 75,000 receiving its water from the same location in the river. The maximum effective lifetime radiological dose to an individual represents the effective dose equivalent, which is over a 50-year dose commitment period. For this assessment, the dose commitment period was applied to all radionuclides taken in over a 70-year period, which represents a conservative estimate of the effective dose equivalent. The population risks represent the cancer incidence in the population, exposed at the maximum effective lifetime radiological dose.

5.8.1 No Action Alternative

The only routine release from the K Basins is from directly discharging effluent to the Columbia River. Water that is used by the K Basins flows from and back to the Columbia River by way of the old reactor piping system. A fraction of the water is directly used for the K Basins, while the remainder is returned to the river. The piping system has some radiological contamination associated with it; therefore, the K Basins are combined as one release and represented by a "single liquid release point to the Columbia River" (Bergsman et al. 1995). The annual liquid discharge to the river is approximately 9.1×10^5 m^3/year (2.4×10^8 gal/year), releasing the following (Bergsman et al. 1995): 2.7×10^{-4} Ci cobalt-60, 0.0015 Ci ruthenium-106, 4.7×10^{-5} Ci cesium-134, and 4.0×10^{-4} Ci cesium-137. The annual discharge is assumed to continue at this level over the 18 years from 1997 through 2015, which is consistent with DOE (1995a) and Whelan et al. (1994). For release durations other than 18 years, the dose and risk would be prorated based on the release duration. For example, if the release is half as long (e.g., 9 years), then the dose and risk would be reduced by one-half.

Operational liquid effluents from the K Basins are discharged to the Columbia River via the monitored and regulated National Pollutant Discharge Elimination System (NPDES) permitted 1908-KE outfall. Although the radiological releases occur from the outfall, they are not part of the outfall permit, which specifically addresses nonradiological releases. For nonradiological releases, Bergsman et al. (1995) notes that the analysis performed on the NPDES outfall does not indicate any hazardous constituents. Contaminant migration is from the point-source discharge point to the Columbia River and in the Columbia River to receptors downstream. The maximum effective lifetime radiological dose to an individual, considering all pathways and exposure routes, is 2.2×10^{-6} rem for cesium-137 with a population risk of 7.5×10^{-5} latent cancer fatalities.

Intermittent leakage of water from the K Basins is monitored via onsite groundwater sampling. Although radionuclide concentrations in some of the 100-K Area monitoring wells exceed EPA drinking water standards (DWS), this condition does not constitute a risk to the public because the groundwater is not used directly for human consumption or food production. Analyses of water from the 100-K Area springs, where groundwater enters the Columbia River, indicate that radionuclide levels are below the EPA DWS. Dilution of this seepage in the river flow would further reduce the risk to the downstream population, as indicated by the fact that radionuclide concentrations in the Columbia River at the Richland pump house are orders of magnitude below the DWS (Dirkes et al. 1994).

5.8.2 Enhanced K Basins Storage Alternative

The routine release scenario under the enhanced K Basins storage alternative is the same as the routine release scenario described under the no action alternative (see Section 5.8.1). Bergsman et al. (1995) do not discuss disposal of water in the KE Basin; however, disposal of water from the KE and KW Basins is considered part of the wet storage alternative (see Section 5.8.3). Disposal of water from the KE Basin, as part of the enhanced K Basins storage alternative, would be bounded by disposal of water from the KE and KW Basins, as described for the wet storage alternative.

5.8.3 Wet Storage Alternative

Scenarios and consequences relating to water quality would be the same as for the no action alternative (i.e., Section 5.8.1) with the addition of an operational release scenario to the 200 Area Effluent Treatment Facility (ETF). Bergsman et al. (1995) note that

> "(w)ater would remain in the K Basins following removal of the fuel, sludge, and debris. This water is contaminated with radionuclides including tritium.... Tritium ... cannot be effectively separated from the water. Contaminated basin water would be transported to the 200 Area ETF for final disposal into the 200 Area SALDS."

The State-Approved Land Disposal System (SALDS) is located in the 200 West Area. Concentrations of radiological constituents in water released from all sources from the ETF disposal system are presented in Bergsman et al. (1995) as 7.3 x 10^{7} mCi/L cobalt-60; 1.5 x 10^{-7} mCi/L cesium-134; 3.1 x 10^{-5} mCi/L cesium-137; 0.0034 mCi/L tritium; 3.5 x 10^{-8} mCi/L manganese-54; 3.1 x 10^{-9} mCi/L plutonium-238; 3.5 x 10^{-6} mCi/L plutonium-239,240; 6.0 x 10^{-6} mCi/L antimony-125; and 2.7 x 10^{-5} mCi/L strontium-90. Concentrations of nonradiological constituents in water released from all sources from the ETF disposal system are presented in Bergsman et al. (1995) as 820 μg/L aluminum, 1720 μg/L barium, 335 μg/L calcium, 3430 μg/L iron, 11.5 μg/L magnesium, 3.32 μg/L manganese, 107 μg/L selenium, 11.1 μg/L silver, 176 μg/L sodium, 101 μg/L sulfur, 21.8 μg/L zinc, and 50.1 μg/L zirconium. These chemical constituents are considered noncarcinogens. Over a 2.5-year period from 2000 to 2002, 14,000 m^3/year (3.7 x 10^6 gal/year) would be discharged through buried manifolds occupying an area equaling 2,044 m^2 (22,000 ft^2), resulting in an infiltration rate of 7 m/year (22 ft/year). Holdren et al. (1994) note that the transmission rate of the top soil in the

200 West Area is approximately 3800 m/year (12,500 ft/year). Because the infiltration rate is less than the transmission rate of the soil, no ponding would occur.

Contaminant migration is from the ETF disposal system manifolds, through the vadose zone, through the saturated zone to the Columbia River, and in the Columbia River to receptors downstream. A pore-water velocity in the saturated zone of 0.27 m/day (0.88 ft/day) was used in the modeling (corresponds to the pathway having the shortest travel time to the river reported in Luttrell 1995). The maximum effective lifetime radiological dose to an individual, considering all pathways and exposure routes, is found to be 1.1×10^{-7} rem for plutonium-239 with a population risk of 4.2×10^{-6} latent cancer fatalities. The noncarcinogenic chemical individual doses were found to be below their respective reference doses. EPA (1988b) defines the reference dose as the amount of a chemical that can be taken into the body each day over a lifetime without causing adverse effects.

5.8.4 Drying/Passivation with Dry Storage Alternative

Scenarios and consequences relating to water quality would be the same as for the wet storage alternative (i.e., Section 5.8.3) except the discharge to the ETF disposal system would be 1,000 m^3/year (2.6×10^5 gal/year) released over a 2-year period from 1998 to 2000. This discharge would be from the operation of a new passivation facility. Disposal at the ETF would be through buried manifolds occupying an area equaling 2,044 m^2 (22,000 ft^2), resulting in a Darcy infiltration rate of 0.50 m/year (1.6 ft/year).

The maximum effective lifetime radiological dose to an individual, considering all pathways and exposure routes, is 1.9×10^{-9} rem for plutonium-239 with a population risk of 3.9×10^{-8} latent cancer fatalities. The noncarcinogenic chemical individual doses were found to be well below their respective reference doses.

5.8.5 Calcination with Dry Storage Alternative

Under this alternative, a new calcination facility would be constructed to stabilize the K Basin fuel before storage in a dry vault. Operation of this facility would produce both radiological and nonradiological liquid effluent streams. The radiological stream would be released to the ETF and the nonradiological stream would be released to the 200 Area Treated Effluent Disposal Facility (TEDF), located in the 200 East Area.

Scenarios and consequences relating to the ETF disposal would be the same as for the assessment outlined in the wet storage alternative (i.e., Section 5.8.3), except the discharge to the effluent treatment facility disposal system would be 500 m^3/year (1.3 x 10^5 gal/year) released over a 4-year period from 2002 to 2006 through buried manifolds occupying an area equaling 2,044 m^2 (22,000 ft^2), resulting in an infiltration rate of 0.24 m/year (0.8 ft/year). The maximum effective lifetime radiological dose to an individual, considering all pathways and exposure routes, is 8.6 x 10^{-11} rem for plutonium-239. The noncarcinogenic chemical individual doses were found to be well below their respective reference doses.

The nonradiological liquid effluent stream from the new calcination facility would be added to the TEDF, which receives liquid effluent from many other facilities. The discharge target allowable concentrations in the TEDF for nonradionuclides are presented in Bergsman et al. (1995). In addition, the discharge target allowable concentrations for radionuclides presented in Bergsman (1995) were used in this assessment. Only 380 L/day (100 gal/day) would be discharged to the TEDF basin from this operation, although other facilities unrelated to SNF storage would also discharge to the basin. To address the impact of this additional effluent on water quality resulting from discharges to the TEDF, a ponded situation resulting in maximum outflow from the basin was assumed. This maximum outflow is 3.42 x 10^4 m^3/day (9.04 x 10^6 gal/day), which is the product of the transmission rate (i.e., saturated hydraulic conductivity under a unit hydraulic gradient) of the soil immediately below the basin and the basin area. The ponded assumption maximizes the mass flux of contaminant leaving the basin (i.e., concentration x outflow) and the flow velocity through the vadose zone, resulting in a very conservative assessment. The discharge from the pond is assumed to last for 4 years.

Based on the movement of the second tritium plume from the PUREX cribs in the 200 East Area to Well 699-24-33, a distance of 6 km (4 mi) in a 5-year period (1983 to 1988), the average pore-water velocity (i.e., specific discharge divided by the effective porosity) in the saturated zone is 3.3 m/day (10.8 ft/day) (Schramke 1993; Thorne 1993). Davis et al. (1993) performed a more recent analysis and determined the pore-water velocity as 0.02 m/day (0.08 ft/day) just below the TEDF site, although this is not necessarily indicative of the velocity as the water moves toward the river. The highest pore-water velocity of 3.3 m/day (10.8 ft/day) was used because 1) it is consistent with other assessments at the installation (Whelan et al. 1994), 2) the contaminants reach the river and receptors earlier than if the lower velocity was used, and 3) the resulting exposure analysis provides the more conservative estimate of health impact.

Bergsman et al. (1995) lists the chemical carcinogens and noncarcinogens that could potentially be released from the TEDF. Bergsman (1995) lists the radionuclides that could potentially be released from the TEDF. The concentrations in the TEDF were represented by the discharge target allowable concentrations (Bergsman et al. 1995). Contaminant migration is from the ponded water, through the vadose zone, through the saturated zone to the Columbia River, and in the Columbia River to receptors downstream. The maximum effective lifetime radiological dose to an individual, considering all pathways and exposure routes under the fully ponded condition, is 0.0026 rem for carbon-14 with a population risk of 0.098 latent cancer fatalities. The maximum average daily dose to an individual for chemical carcinogens, considering all pathways and exposure routes, is found to be 1.4×10^{-8} mg/[kg body mass·day] for arsenic with a population risk of 0.023 latent cancer fatalities. The noncarcinogenic chemical individual doses were found to be below their respective reference doses, except nitrate, which had a dose of 2.6 times its reference dose. This value is expected to be an overestimate because of the conservative nature of the assessment. This assessment is overly conservative because 1) the receptor location is extremely close to the contaminant discharge point to the river, thereby minimizing the dilution and maximizing the concentration in the river; 2) the maximum discharge from and the maximum allowable concentration in the TEDF were assumed; and 3) a probability of occurrence of unity was assumed.

5.8.6 Processing Alternative

Scenarios and consequences relating to water quality for this alternative would be the same as for the TEDF scenario outlined in the calcination with dry storage alternative (i.e., Section 5.8.5).

5.8.7 Consequences to Recreation and Fisheries

The doses to offsite members of the public from releases to ground or surface water are sufficiently low that no impacts on recreational use of the Columbia River or on fisheries would be expected for any of the alternatives evaluated.

5.9 Ecological Resources

Two sites are being considered for the alternatives that require the construction of new facilities. The reference site (Figure 5-1) is located outside of 200 East Area (see DOE 1995a for the results of an ecological reconnaissance of this area), and the CSB site is located within the 200 East Area. In the following subsections, potential impacts of construction are

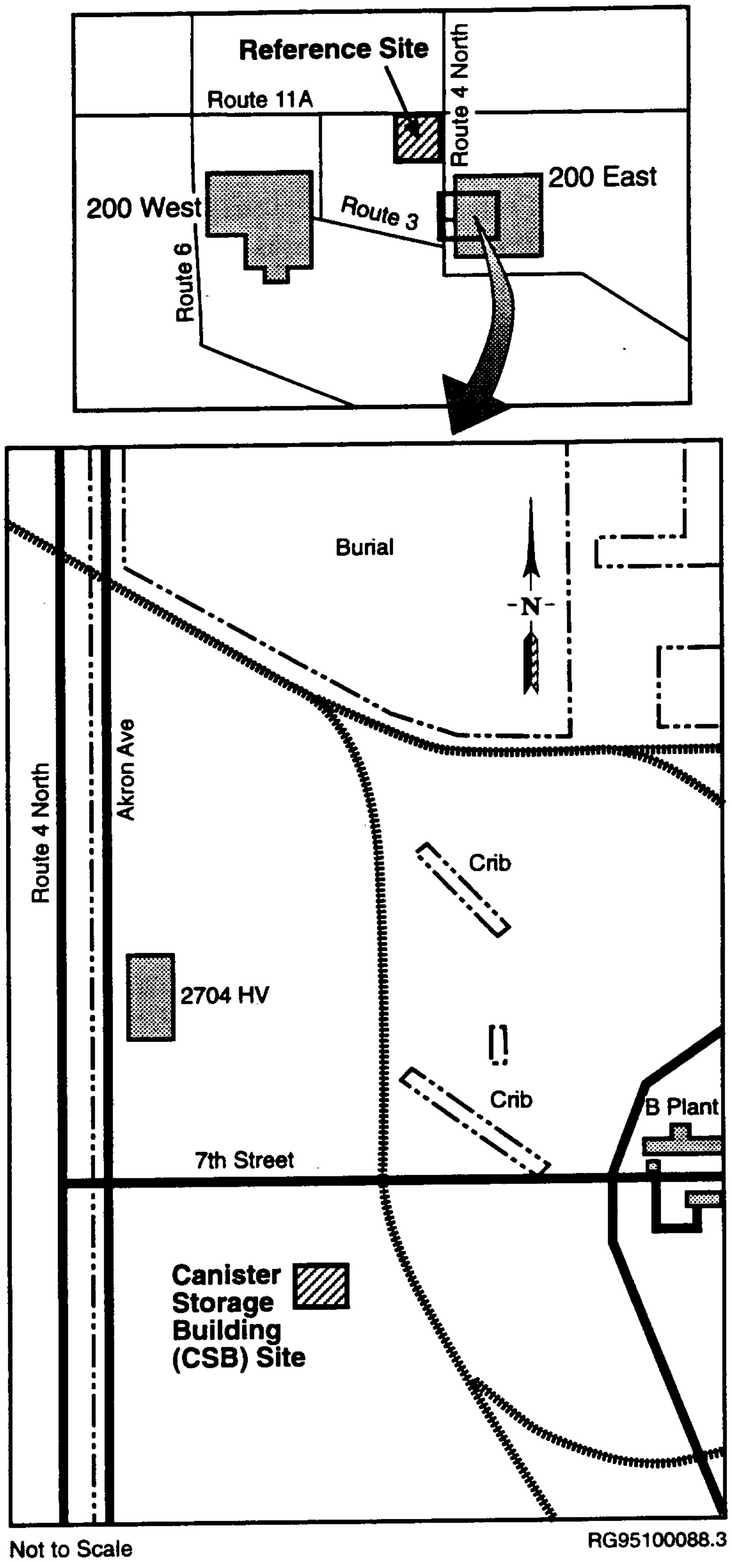


Figure 5-1. The two sites being considered for the construction of new facilities

only discussed for the reference site, outside of the 200 East Area. The CSB site is a construction zone with highly disturbed vegetation cover in isolated places. Thus, impacts to ecological resources would be inconsequential if new facilities are built at the CSB site. Further, no plant or animal species identified as protected under the Endangered Species Act, candidates for such protection, or species listed by the Washington State government were observed near the CSB site.

5.9.1 No Action and Enhanced K Basins Storage Alternatives

No impacts to terrestrial resources, wetlands, aquatic resources, threatened and endangered species, or radioecology would result from implementation of the no action and enhanced K Basin storage alternatives. Accumulation and transfer of radionuclides within the ecosystem associated with the K Reactors would not change from those occurring now, and no measurable impacts would be expected.

5.9.2 Wet Storage Alternative

Terrestrial Resources

Approximately 2.8 ha (6.9 acres) of land and native vegetation would be disturbed during land-clearing activities to provide new pool or vault facilities for this alternative. Plant species most likely to be affected include big sagebrush, cheatgrass, and Sandberg's bluegrass. Although the plant communities to be disturbed are well represented on the Hanford Site, they are relatively uncommon regionally because of the widespread conversion of shrub-steppe habitats to agriculture. Disturbed areas are generally recolonized by cheatgrass, a nonnative species, at the expense of native plants. Mitigation of these impacts would include minimizing the area of disturbance and revegetating with native species, including shrubs, and replacing lost habitat in concert with a habitat enhancement plan currently being developed for the Hanford Site in general. Adverse impacts to vegetation on the Hanford Site are expected to be limited to the project area and vicinity and are not expected to affect the viability of any onsite plant populations.

Construction would have some adverse impact on animal populations. Less mobile animals within the project area, such as invertebrates, reptiles, and small mammals, would be destroyed during land-clearing activities. Larger mammals and birds in construction and adjacent areas would be disturbed by construction activities and would move to adjacent suitable habitat, and these individual animals might not survive and reproduce. Revegetated areas (e.g., construction laydown areas and buried pipeline routes) would be reinvaded by animal species from surrounding, undisturbed habitats. The adverse impacts of construction would be limited to the project area and vicinity and should not affect the viability of any animal populations on the Hanford Site because similar suitable habitat would remain abundant on the Site.

The impacts to the vegetation and animal communities would be mitigated by minimizing the amount of land disturbed during construction, employing soil erosion control measures during construction activities, and revegetating disturbed areas with native species. The mitigation measures would limit the amount of direct and indirect disturbance to the construction area and surrounding habitats and would speed the recovery process for disturbed lands.

Wetlands

No wetlands are located in the area where land disturbance would occur.

Aquatic Resources

No aquatic resources are present in the area where land disturbance would occur.

Threatened and Endangered Species

Construction and operation of the new facilities would remove approximately 2.8 ha (6.9 acres) of relatively pristine shrub-steppe habitat. Construction would also disturb the gravel pit (13.88 ha, 34.29 acres) located in the southwest portion of the proposed site.

The shrub-steppe habitat is considered priority habitat by the state of Washington because of its relative scarcity in the state and its requirement as nesting and breeding habitat by loggerhead shrikes, sage sparrows, sage thrashers, burrowing owls, pygmy rabbits, and sagebrush voles.

Loggerhead shrikes, listed as a federal candidate (Category 2) and state candidate species, forage on the proposed site but are relatively uncommon at Hanford. This species is sagebrush-dependent, as it is known to select primarily tall, big sagebrush as nest sites. Construction of the facility would remove big sagebrush habitat that would preclude loggerhead shrikes from nesting. Site development would also be expected to reduce the value of the site as foraging habitat for shrikes known to nest in adjacent areas.

Sage sparrows and sage thrashers, both state candidate species, are fairly common at Hanford. They were not observed on the reference site, probably because they had begun migration before the site was surveyed. These species are known to nest primarily in sagebrush. Construction of the facility would likely preclude both of these species nesting at the proposed site and reduce the site's suitability as foraging habitat for these species.

Construction is not expected to substantially impact loggerhead shrike, sage sparrow, or sage thrasher populations because similar sagebrush habitat is still relatively common at Hanford. However, the cumulative effects of constructing the facility, in addition to future developments that further reduce shrub-steppe habitat (causing further fragmentation of nesting habitat), would be expected to negatively affect the long-term viability of populations of these species at Hanford.

Burrowing owls, a state candidate species, are relatively common at Hanford and nest in abandoned ground squirrel burrows on the proposed site. Construction would remove sagebrush and disturb soil, displacing ground squirrels and thus reducing the suitability of the area for nesting by burrowing owls. Construction would also displace small mammals, which constitute a portion of the prey base for this species. Construction would, however, not be expected to negatively impact the viability of the population of burrowing owls on Hanford, as their use of ground squirrel burrows as nests is not limited to burrows in shrub-steppe habitat.

Pygmy rabbits, a federal candidate (Category 2) and state threatened species, are known to use tall clumps of big sagebrush throughout most of their range. This species has not been observed on the Hanford Site; however, construction of the facility would reduce the potential for this species' occurrence by removing suitable habitat.

Sagebrush voles, a state monitor species, are common at Hanford and select burrow sites near sagebrush. Construction of the facility would remove sagebrush habitat, precluding sagebrush voles from using the site. However, construction would not affect the overall viability of sagebrush vole populations at Hanford.

The closest known nests of the ferruginous hawk, a federal candidate (Category 2) and state threatened species, and Swainson's hawk, a state candidate, are 8.50 km (5.2 mi) and 6.20 km (3.9 mi), respectively, from the reference site. The site covers a portion of the foraging range of these species. Construction of the facility is not expected to disrupt the nesting activities of these species. However, construction would displace small mammal populations and thus reduce the prey base of these species. The cumulative effects of constructing the facility, in addition to future reductions in shrub-steppe habitat (causing further fragmentation of foraging habitat), could negatively affect the long-term viability of populations of these two species at Hanford.

Radioecology

There would be no routine releases of radioactively contaminated liquid effluents that would reach terrestrial or aquatic resources.

5.9.3 Calcination with Dry Storage Alternative

Terrestrial Resources

Impacts of constructing the dry storage facility would be similar to those described under the wet storage alternative (Section 5.9.2), and an additional 2.4 ha (5.9 acres, see Table 5-1) would be affected by construction of the calcination facility.

Wetlands

No wetlands are located on the area where land disturbance would occur.

Aquatic Resources

No aquatic resources are located on the area where land disturbance would occur.

Threatened and Endangered Species

Impacts to threatened and endangered species would be similar to those described under the wet storage alternative (Section 5.9.2), and an additional 2.4 ha (5.9 acres) would be affected by construction of the calcination facility.

5.9.4 Drying/Passivation with Dry Storage Alternative

Terrestrial Resources

Impacts of constructing the dry storage facility would be similar to those described under the wet storage alternative (Section 5.9.2), except that an additional 0.7 ha (1.7 acres) would be affected by construction of the drying/passivation facility.

Wetlands

No wetlands are located in the area where land disturbance would occur.

Aquatic Resources

No aquatic resources are present in the area where land disturbance would occur.

Threatened and Endangered Species

Impacts to threatened and endangered species would be similar to those described under the wet storage alternative (Section 5.9.2), and an additional 0.7 ha (1.7 acres) would be affected by construction of the drying/passivation facility.

Radioecology

No routine releases of radioactively contaminated liquid effluents would occur that would reach terrestrial or aquatic resources.

5.9.5 Onsite and Foreign Processing Alternatives

Terrestrial Resources

Impacts would be similar to those described under the wet storage alternative (Section 5.9.2), except that an additional 4.9 ha (12 acres) would be required for the processing facility and 0.4 ha (1 acre) for UO_3 storage.

Wetlands

No wetlands are located on the area where land disturbance would occur.

Aquatic Resources

No aquatic resources are located on the area where land disturbance would occur.

Threatened and Endangered Species

Impacts to threatened and endangered species would be similar to those described under the wet storage alternative (Section 5.9.2), except that an additional 4.9 ha (12 acres) would be required for the process facility and 0.4 ha (1 acre) for UO_3 storage.

Radioecology

No routine releases of radioactively contaminated liquid effluents would occur that would reach terrestrial or aquatic resources.

5.10 Noise

Noise impacts resulting from implementation of the alternatives are discussed in the following subsections. The analyses addresses construction and operational noise, and noise resulting from increased traffic from employment.

5.10.1 No Action and Enhanced K Basins Storage Alternatives

The no action alternative establishes the baseline noise levels. Under this option, minor sources of noise associated with ongoing maintenance, monitoring, and safety upgrades would occur. Because of the remote location of the K Basins, impacts to communities would be very low.

Estimated employment under no action establishes the baseline for additional staff labor that was used to estimate potential impacts in communities resulting from traffic. Under the K Basins enhancements, a decrease would occur in traffic noise starting in 2003 and lasting through 2035.

5.10.2 Wet Storage Alternative

The wet storage alternative would require additional construction of a facility, transfer of K Basins SNF, and decommissioning of the K Basins. These actions would result in increased noise from construction; however, noise levels would not exceed other routine noise levels associated with construction, and impacts would be minimal. Operating noise levels would be similar to the no action alternative except that impacts would occur in the 200 Area.

Community traffic noise impacts would show a slight increase in 1996 and then a gradual decrease through 2003. Starting in 2004, a net reduction would occur in traffic noise compared to the no action alternative. Expected increases and decreases in community noise levels associated with changes in traffic would be minor.

5.10.3 Dry Storage Alternative

No distinction has been made between passivation or calcination with dry storage for noise analysis. Construction and operational noise impacts, while greater than the no action alternative, are within state regulations and would not cause an adverse impact to the surrounding environment.

Significantly greater employment would be associated with the dry storage alternative. This employment would result in increased rush-hour traffic in the neighboring communities; however, the increase of traffic noise would be insufficient to cause an adverse impact.

5.10.4 Onsite and Foreign Processing Alternatives

The processing alternative includes construction of the process facility and a facility for staging unprocessed fuel and separated uranium trioxide. Construction and operational noise impacts, while greater than the other alternatives, would be within Washington State regulations and would not cause an adverse impact to the surrounding environment.

Employment associated with the processing alternative would also be greater than for the other alternatives. This would increase rush-hour traffic in the neighboring communities; however, the increase of traffic noise would be of insufficient magnitude to cause an adverse impact.

Noise associated with foreign processing would follow the levels modeled for onsite processing up through the year 2010. Transportation noise associated with moving the stabilized fuel for overseas shipping would be minor relative to baseline traffic noise levels.

5.11 Transportation

This section summarizes the evaluation of the impacts of transporting SNF and basin sludge wastes in support of the alternatives. There are no shipments planned in the no action alternative; therefore, this alternative was not evaluated. Transportation impacts include external radiation exposures received from routine (incident-free) transport and internal and external exposures from vehicular accidents that release radioactive materials from the shipments. Also included are nonradiological impacts from transportation accidents (traumatic fatalities) and nonradiological, routine pollutants emitted by the transport vehicles. Impacts to the public, workers, and truck and rail crew members are calculated.

Several approaches and computer codes were used to perform the transportation impact calculations:

- **RADTRAN 4 Computer Code** (Neuhauser and Kanipe 1992): This computer code is commonly used in EISs. It was used to calculate routine radiological exposures to the public and workers (including truck and rail crews) as well as the population dose (based on a probabalistic determination of the material released) from accidental releases of radioactive materials during transport.

- **GENII Computer Code** (Napier et al. 1988): GENII, also referred to as the Hanford Environmental Dosimetry Software System, is commonly used for analyses of consequences from accidental releases on the Hanford Site. It was used in this analysis to develop estimates of the maximum individual doses to the public and workers from accidental releases during transport.

- **Unit Risk Factor**: The unit risk factor approaches were used to calculate the nonradiological accident and routine impacts. Unit risk factors (health effects per unit distance traveled) were taken from Daling and Harris (1994) and Rao et al. (1982) for nonradiological accidents and routine impacts, respectively, to develop the estimates of these impacts.

Additional information on these approaches and computer codes is provided in Appendix B. Appendix B also contains the detailed assumptions and input data used in the analysis. A summary of the shipping scenario information for the various alternatives is presented in Table 5-33.

5.11.1 Enhanced K Basin Storage Alternative

The enhanced K Basin storage alternative assumes that all SNF canisters within the KE Basin would be transported a short distance and placed in the KW Basin. The SNF in the KE Basin would be placed within MCOs and then loaded into a shipping cask and moved approximately 0.5 km (0.3 mi) to the KW Basin. The basin sludge will be packaged in an overpack, or other high-integrity-container (HIC) and transported to KW Basin or the double-shell tanks or Solid Waste Burial Ground. A DOE-approved shipping cask would be used for this fuel transfer activity. The KE Basin sludge (i.e., sludge external to the canisters) would be packaged, removed from the basin, and transported to a storage or disposal site. Based on the results of waste characterization analyses, the basin sludge would be managed as either SNF, solid waste, or liquid wastes. The basin sludge would be packaged and removed from the basin

Table 5-33. Shipping characteristics

Material	Destination	Number of Shipments	One Way Distance (km)	
			Truck	Rail
Enhanced K Basin Storage				
SNF	KW Basin	410	0.5	0.5
Basin sludge	KW Basin	220	0.5	0.5
	Double-shell tank	100	14	Truck only
	Solid Waste Burial Ground	100	22	Truck only
Basin water	Effluent treatment facility	300	15	Truck only
Debris[a]	Solid Waste Burial Ground	89	22	Truck only
Wet Storage				
SNF	Reference site	750	12	14
	Canister Storage Building	750	14	17
Basin sludge[a]	Reference site	70	12	14
	Canister Storage Building	70	14	17
	Double-shell tank	100	14	Truck only
	Solid Waste Burial Ground	100	22	Truck only
Basin water	Effluent treatment facility	600	15	Truck only
Debris[a]	Solid Waste Burial Ground	89	22	Truck only
Dry Storage				
SNF, no repackage	Same as wet storage			
SNF, repackage	Reference site	390	12	14
	Canister Storage Building	390	14	17
Basin sludge no repackage	Same as wet storage			
Canister sludge	Reference site	60	12	14
	Canister Storage Building	60	14	17
	Double-shell tank	100	14	Truck only
Basin water	Effluent treatment facility	600	15	Truck only
Debris[a]	Solid Waste Burial Ground	89	22	Truck only

(a) Includes KE and KW Basins.

remotely. The basin sludge would be placed in an MCO if the basin sludge is characterized as SNF, a liquid waste high-integrity container (LWHIC) if the basin sludge meets the double-shell tank waste acceptance criteria, or would be grouted and packaged in a solid waste high-integrity container (SWHIC) if the basin sludge meets the Solid Waste Burial Ground waste acceptance criteria. The SNF containers, including the basin sludge if it is designated as SNF, would be transported by truck or rail. The LWHIC and SWHIC containers were assumed to be transported by truck only.

This alternative also includes management of the basin water and debris in the KE Basin. The basin water is assumed to be transported by tanker truck to the ETF in the 200 East Area where it would be processed. The debris would be removed from the basin, packaged, and transported to the Solid Waste Burial Ground for disposal as low-level radioactive waste. The debris was assumed to be packaged in the SWHIC and transported by truck. The number of shipments and shipping distances for these materials are shown in Table 5-33.

Radiological Impacts

The routine radiological doses to the truck crew and the public and public accident risks caused by transportation activities, were calculated using RADTRAN 4 (see Appendix B). The GENII computer code was used to calculate the doses to the maximally exposed individuals (MEIs) using Hanford Site-specific weather data. Because the shipments occur within the Hanford Site (i.e., away from public population zones and public access), impacts to only onsite individuals and transport crew have been evaluated.

The results of the radiological impact analysis are presented in terms of latent cancer fatalities and are shown in Table 5-34. The results are based on a two-person truck crew, three-person rail crew, and a total onsite population along the transportation corridor of approximately 3,200 during accident conditions.

The results in Table 5-34 show that during routine transportation the calculated number of worker and onsite fatalities from radiological impacts increases with the number of shipments or total distance travelled. For all SNF handling options, the expected number of fatalities, for both truck and rail, would be less than 4.8×10^{-7} (onsite) for the entire campaign.

Also shown in Table 5-34 are the radiological impacts from transportation accidents. The onsite impacts for both truck and rail are less than 3.0×10^{-4} latent cancer fatalities for the entire campaign. Although not shown in Table 5-34, impacts or doses to MEIs from an SNF transportation

Table 5-34. Transportation radiological impacts of the enhanced K Basin storage alternative[a]

	Routine Transport			Radiological Accidents	
	Radiological Impacts		Health Effects	Radiological Impacts	Health Effects
Option	Crew (person-rem)	Onsite (person-rem)	Onsite (LCF)	Onsite (person-rem)	Onsite (LCF)
SNF and basin sludge to KW Basin					
Truck	0.004	6.9×10^{-5}	2.8×10^{-8}	4.3×10^{-4}	1.7×10^{-7}
Rail	0.026	6.8×10^{-5}	2.7×10^{-8}	1.3×10^{-4}	5.0×10^{-8}
SNF to KW Basin; basin sludge to double-shell tank					
Truck	0.099	9.2×10^{-5}	3.7×10^{-8}	0.75	3.0×10^{-4}
Rail	0.009	9.1×10^{-5}	3.6×10^{-8}	0.075	3.0×10^{-5}
SNF to KW Basin; basin sludge to Solid Waste Burial Ground					
Truck	0.3	0.0012	4.8×10^{-7}	0.027	1.1×10^{-5}
Rail	0.3	0.0012	4.8×10^{-7}	0.027	1.1×10^{-5}

(a) Potential health effects or latent cancer fatalities (LCFs) to onsite individuals were calculated using the methodology described in the DOE SNF PEIS (DOE 1995a).

accident were also calculated. The calculated dose to the MEI, located 100 m (328 ft) from the accident location, is 2.8 rem and the calculated dose to MEI onsite located 750 m (2,460 ft) from the accident site is 0.9 rem.

Nonradiological Impacts

The results of the nonradiological impact calculations for the enhanced K Basin alternative are presented in Table 5-35.

The results presented in Table 5-35, as with the radiological doses discussed previously, indicate that the calculated number of fatalities from nonradiological impacts increase as the travel distance increases. Overall, the expected number of fatalities from truck shipments are slightly greater than the expected number of fatalities from rail shipments. The potential onsite fatalities are essentially the same for each option and are less than 3.6×10^{-5} for the entire campaign.

Table 5-35. Transportation nonradiological impacts of the enhanced K Basin storage alternative

Option	Traffic Accidents: Crew Fatalities	Traffic Accidents: Onsite Fatalities	Routine Transport: Onsite Fatalities[a]
SNF and basin sludge to KW Basin			
Truck	1.5×10^{-4}	5.1×10^{-4}	2.7×10^{-5}
Rail	1.4×10^{-4}	4.9×10^{-4}	2.8×10^{-5}
SNF to KW Basin; basin sludge to double-shell tank			
Truck	1.9×10^{-4}	6.5×10^{-4}	3.5×10^{-5}
Rail	1.8×10^{-4}	6.5×10^{-4}	3.6×10^{-5}
SNF to KW Basin; basin sludge to Solid Waste Burial Ground			
Truck	2.1×10^{-4}	7.3×10^{-4}	2.7×10^{-5}
Rail	2.1×10^{-4}	7.2×10^{-4}	2.7×10^{-5}

(a) From pollutants emitted during transport.

5.11.2 Wet Storage Alternative

This alternative involves transferring all SNF at the KE and KW Basins to a new wet storage facility located in one of two sites in the 200 East Area. The SNF would be shipped in the same shipping system, including fuel canisters, MCO, and shipping cask, that was used in the enhanced K Basin alternative. The KE Basin sludge waste packages (i.e., LWHICs or SWHICs) were discussed in Section 5.11.1. The KE Basin sludge may also be packaged in a MCO, which was also described in Section 5.11.1.

The KE Basin SNF or basin sludge characterized as SNF would be packaged and loaded into a shipping cask and transported by truck or rail to either the reference site or CSB site. The shipping distances and number of shipment required were presented in Table 5-33. The KE and KW Basins sludge would be recovered from the basin floor, packaged, loaded into shipping casks, and transported to a storage or disposal facility. If designated as SNF, the basin sludge would be loaded into an MCO and transported by truck or rail to either the reference site or the CSB site for continued storage. If designated as liquid waste, the basin sludge would be packaged in a LWHIC, transported by truck to the tank farms, and placed in a double-shell tank. If characterized as solid waste, the basin sludge would be loaded into a SWHIC, grouted, and transported by truck to the Solid Waste Burial Ground for disposal.

This alternative also includes disposition of the water and solid debris in the basins. These materials would be handled the same as that described for the enhanced K Basin alternative (i.e., basin water would be transported by tanker truck to the ETF and debris would be packaged in metal boxes and transported to the Solid Waste Burial Ground for disposal). However, this alternative has a significant difference, because the water and debris from both basins would be removed and dispositioned. In the enhanced K Basin storage alternative, only the water and debris in the KE Basin is removed because the KW Basin would be used for continued storage of SNF (and perhaps packaged KE Basin sludge). This difference is reflected in the shipping information presented in Table 5-35.

Radiological Impacts

A summary of the results of the radiological impact calculations for the new wet storage alternative, including the various suboptions, is presented in Table 5-36.

The results presented in Table 5-36 show that, as expected, the calculated number of worker and public LCFs increases with the distance travelled. Because the shipments occur within the Hanford Site (i.e., away from public population zones and public access), only impacts to onsite individuals and the transport crew have been evaluated. The expected number of LCFs for all SNF handling options, for both truck and rail, is less than 6.3×10^{-7} (onsite) for an entire campaign.

Also shown in Table 5-36 are the radiological impacts from transportation accidents. The impacts to exposed onsite individuals (approximately 3,200 people along the transportation corridor) for both truck and rail are less than 4.0×10^{-5} latent cancer fatalities for the entire campaign. The impacts from those options that transport the basin sludge to the tank farm or Solid Waste Burial Ground are slightly less than the impacts from the options transporting the basin sludge to either of the sites. The impacts to MEIs are the same as the impacts discussed for the enhanced K Basin alternative.

Nonradiological Impacts

The nonradiological impacts of the new wet storage alternative are summarized in Table 5-37. The results presented, as with those for the radiological doses, indicate that the expected number of fatalities from nonradiological impacts increase as the travel distance increases. Overall, the expected number of fatalities from truck shipments are slightly greater

Table 5-36. Transportation radiological impacts of the new wet storage alternative[(a)]

	Routine Transport			Radiological Accidents	
	Radiological Impacts		Health Effects	Radiological Impacts	Health Effects
Option[(b)]	Crew (person-rem)	Onsite (person-rem)	Onsite (LCF)	Onsite (person-rem)	Onsite (LCF)
SNF and basin sludge to reference site					
Truck	0.085	$4.3x10^{-4}$	$1.7x10^{-7}$	0.02	$8.0x10^{-6}$
Rail	0.44	$4.2x10^{-4}$	$1.7x10^{-7}$	0.0064	$2.6x10^{-5}$
SNF to reference site; basin sludge to double-shell tank					
Truck	0.085	$4.3x10^{-4}$	$1.7x10^{-7}$	0.095	$3.8x10^{-5}$
Rail	0.047	$4.2x10^{-4}$	$1.7x10^{-7}$	0.081	$3.3x10^{-5}$
SNF to reference site; basin sludge to Solid Waste Burial Ground					
Truck	0.38	0.0014	$5.8x10^{-7}$	0.047	$1.9x10^{-5}$
Rail	0.34	0.0015	$6.0x10^{-7}$	0.033	$1.3x10^{-5}$
SNF and basin sludge to Canister Storage Building site					
Truck	0.1	$5.1x10^{-4}$	$2.0x10^{-7}$	0.024	$9.7x10^{-6}$
Rail	0.053	$4.9x10^{-4}$	$2.0x10^{-7}$	0.0076	$3.0x10^{-6}$
SNF to Canister Storage Building site; basin sludge to double-shell tank					
Truck	0.1	$5.1x10^{-4}$	$2.0x10^{-7}$	0.099	$4.0x10^{-5}$
Rail	0.056	$4.8x10^{-4}$	$1.9x10^{-7}$	0.083	$3.3x10^{-5}$
SNF to Canister Storage Building site; basin sludge to Solid Waste Burial Ground					
Truck	0.39	0.0016	$6.3x10^{-7}$	0.051	$2.0x10^{-5}$
Rail	0.35	0.0016	$6.2x10^{-7}$	0.035	$1.4x10^{-5}$

(a) Potential health effects or latent cancer fatalities (LCFs) were calculated using the methodology described in the DOE SNF PEIS (DOE 1995a).
(b) Values taken from Daling and Harris (1994). Suburban population characteristics are used to model Hanford Site (onsite) personnel.

Table 5-37. Transportation nonradiological impacts of the wet storage alternative

	Traffic Accidents		Routine Transport
Option	Crew Fatalities	Onsite Fatalities	Onsite Fatalities[(a)]
SNF and basin sludge to the reference site			
Truck	$7.8x10^{-4}$	0.002	$1.1x10^{-4}$
Rail	$3.1x10^{-4}$	0.0015	$1.3x10^{-4}$
SNF to the reference site; basin sludge to double-shell tank			
Truck	$5.8x10^{-4}$	0.0021	$1.1x10^{-4}$
Rail	$3.4x10^{-4}$	0.0016	$1.3x10^{-4}$
SNF to the reference site; basin sludge to Solid Waste Burial Ground			
Truck	$6.1x10^{-4}$	0.0022	$1.2x10^{-4}$
Rail	$3.6x10^{-4}$	0.0017	$1.3x10^{-4}$
SNF and basin sludge to the Canister Storage Building site			
Truck	$6.1x10^{-4}$	0.0022	$1.2x10^{-4}$
Rail	$3.6x10^{-4}$	0.0017	$1.4x10^{-4}$
SNF to the Canister Storage Building site; basin sludge to double-shell tank			
Truck	$6.1x10^{-4}$	0.0022	$1.2x10^{-4}$
Rail	$3.1x10^{-4}$	0.0016	$1.4x10^{-4}$
SNF to the Canister Storage Building site; basin sludge to Solid Waste Burial Ground			
Truck	$6.5x10^{-4}$	0.0023	$1.3x10^{-4}$
Rail	$3.7x10^{-4}$	0.0017	$1.4x10^{-4}$

(a) From pollutants emitted during transport.

than the expected number of fatalities from rail shipments. The potential health effects (fatalities) onsite are essentially the same for each option and are less than 2.3×10^{-3} for the entire campaign.

5.11.3 Dry Storage Alternative

This alternative involves constructing a new dry storage facility in the 200 East Area to accept all KE and KW Basins SNF and basin sludge should it be characterized as SNF. As discussed previously, depending on the results of characterization activities, the basin sludge could be packaged and transported to the new dry storage facility, a double-shell tank, or the Solid Waste Burial Ground. There are four SNF and sludge handling options associated with this alternative, as described below.

The first option, with respect to transportation, is the same as the wet storage alternative (Section B.1.2). That is, the shipping containers, shipping distances, and modes are the same. The differences between this alternative and the wet storage alternative are from SNF conditioning at the dry storage facility and are not related to transportation. The basin sludge, water, and debris would be packaged and shipped as discussed in Section 5.11.1.

The second option is similar to the wet storage option, except that the canisters are perforated to allow for water drainage and gas flow; therefore, the SNF is shipped in a damp or "dry" condition. The basin sludge, water, and debris would be packaged and shipped as discussed previously.

The third option involves mechanically removing the sludge from the existing fuel storage canisters, collecting the canister sludge, and packaging the canister sludge as SNF. That is, the canister sludge would be transferred remotely from an existing canister to an MCO. The SNF and canister sludge would then be transported separately to the dry storage facility for further processing or to a double-shell tank (canister sludge only). The capacity of the MCO is 3.4 metric ton uranium (MTU) of spent fuel or 3.4 metric ton (~7,500 lb) of canister sludge. The canister sludge would be handled as if it were SNF. The basin sludge, water, and debris would be packaged and shipped as discussed previously.

The fourth option involves removing the SNF from the existing canisters and repackaging the SNF into new baskets before loading the MCO. By repackaging the SNF into new baskets, the capacity of the MCO can be increased from 10 canisters or 3.4 MTU/MCO to 19 canisters or 6.5 MTU/MCO. This reduces the number of MCOs required and the number of shipments from 750 to 390. The canister sludge would be transported separately from SNF in MCOs that have a capacity of 3.4 metric tons of canister sludge. Canister sludge shipped to a double-shell tank will be in a LWHIC (2.0 metric tons per LWHIC). The basin sludge, water, and debris would be packaged and shipped as discussed previously.

Radiological Impacts

A summary of the results of the radiological impact calculations for the new dry storage alternative, including the various suboptions, is presented in Table 5-38.

The results presented in Table 5-38 are similar to the results presented in Table 5-36. That is, the expected number of transport crew and onsite fatalities caused by radiological impacts during routine transportation increase with the distance travelled. Because the shipments occur within the Hanford Site (i.e., away from public population zones and public access), only impacts to onsite individuals and the transport crew have been evaluated. For all SNF handling options, the calculated number of LCFs, for both truck and rail, is less than 6.4×10^{-7} (onsite) for an entire campaign.

Also shown in Table 5-38 are the radiological impacts from transportation accidents. The impacts to onsite individuals (approximately 3,200 people along the transportation corridor) for both truck and rail are less than 4.0×10^{-5} latent cancer fatalities for the entire campaign. The impacts associated with the options that transport the basin sludge to the tank farm or Solid Waste Burial Ground are less than the options involving transporting the basin sludge to either of the sites. In addition, the calculated number of worker fatalities increases slightly with the SNF repackaging options.

Although not shown in Table 5-38, impacts or doses to MEIs from an SNF transportation accident were also calculated. The calculated dose to the MEI (for "as-is" and repackaged SNF), located 100 m (328 ft) from the accident location, is 2.8 rem and 5.8 rem, respectively, and the calculated dose to the MEI onsite located 750 m (2,460 ft) from the accident site is 0.9 rem and 1.9 rem, respectively.

Nonradiological Impacts

The nonradiological impacts of dry storage are summarized in Table 5-39.

As expected, the results presented in Table 5-39, as with the radiological doses, indicate that the expected number of fatalities associated with the SNF repackaging options are less than the "as-is" SNF options. This is because of the fewer number of shipments required to transfer the SNF, and the basin and canister sludge. Overall, the expected number of fatalities from truck shipments is slightly greater than the expected number of fatalities

Table 5-38. Transportation radiological impacts of the dry storage alternative[a]

	Routine Transport			Radiological Accidents	
	Radiological Impacts		Health Effects	Radiological Impacts	Health Effects
Option[b]	Crew (person-rem)	Onsite (person-rem)	Onsite (LCF)	Onsite (person-rem)	Onsite (LCF)
SNF, canister sludge, basin sludge packaged separately; all to reference site					
Truck	0.091	4.5×10^{-4}	1.8×10^{-7}	0.021	8.4×10^{-6}
Rail	0.047	4.5×10^{-4}	1.8×10^{-7}	0.0065	2.6×10^{-6}
SNF, canister sludge packaged separately (reference site); basin sludge to double-shell tank					
Truck	0.091	4.5×10^{-4}	1.8×10^{-7}	0.095	3.8×10^{-5}
Rail	0.05	4.5×10^{-4}	1.8×10^{-7}	0.081	3.3×10^{-5}
SNF, canister sludge packaged separately (reference site); basin sludge to Solid Waste Burial Ground					
Truck	0.38	0.0015	6.1×10^{-7}	0.047	1.9×10^{-5}
Rail	0.34	0.0015	6.1×10^{-7}	0.0033	1.3×10^{-5}
SNF, canister sludge, basin sludge packaged separately; all to Canister Storage Building site					
Truck	0.11	5.4×10^{-4}	2.2×10^{-7}	0.024	9.8×10^{-6}
Rail	0.057	5.2×10^{-4}	2.1×10^{-7}	0.0076	3.1×10^{-6}
SNF, canister sludge packaged separately (Canister Storage Building site); basin sludge to double-shell tank					
Truck	0.11	5.3×10^{-4}	2.1×10^{-7}	0.099	4.0×10^{-5}
Rail	0.59	5.1×10^{-4}	2.0×10^{-7}	0.083	3.3×10^{-5}
SNF, canister sludge packaged separately (Canister Storage Building site); basin sludge to Solid Waste Burial Ground					
Truck	0.40	0.0016	6.4×10^{-7}	0.051	2.0×10^{-5}
Rail	0.35	0.0016	6.3×10^{-7}	0.035	1.4×10^{-5}
SNF repackaged; SNF, canister sludge, and basin sludge packaged separately and shipped to reference site					
Truck	0.055	3.2×10^{-4}	1.3×10^{-7}	0.020	8.1×10^{-6}
Rail	0.026	2.9×10^{-4}	1.2×10^{-7}	0.0056	2.2×10^{-6}

Table 5-38. (contd)

	Routine Transport			Radiological Accidents	
	Radiological Impacts		Health Effects	Radiological Impacts	Health Effects
Option[b]	Crew (person-rem)	Onsite (person-rem)	Onsite (LCF)	Onsite (person-rem)	Onsite (LCF)
SNF repackaged; canister sludge packaged separately (reference site); basin sludge packaged separately and shipped to double-shell tank					
Truck	0.055	3.2×10^{-4}	1.3×10^{-7}	0.095	3.8×10^{-5}
Rail	0.03	2.9×10^{-4}	1.2×10^{-7}	0.081	3.2×10^{-5}
SNF repackaged; canister sludge packaged separately (reference site); basin sludge packaged separately and shipped to Solid Waste Burial Ground					
Truck	0.35	0.0014	5.6×10^{-7}	0.047	1.9×10^{-5}
Rail	0.32	0.0014	5.5×10^{-7}	0.033	1.3×10^{-5}
SNF repackaged; SNF, canister sludge, and basin sludge packaged separately and shipped to Canister Storage Building site					
Truck	0.066	3.5×10^{-4}	1.4×10^{-7}	0.024	9.5×10^{-6}
Rail	0.035	3.5×10^{-4}	1.4×10^{-7}	0.0079	3.2×10^{-6}
SNF repackaged; canister sludge packaged separately (Canister Storage Building site); basin sludge packaged separately and shipped to double-shell tank					
Truck	0.064	3.5×10^{-4}	1.4×10^{-7}	0.099	4.0×10^{-5}
Rail	0.037	3.5×10^{-4}	1.4×10^{-7}	0.083	3.3×10^{-5}
SNF repackaged; canister sludge packaged separately (Canister Storage Building site); basin sludge packaged separately and shipped to Solid Waste Burial Ground					
Truck	0.36	0.0014	5.7×10^{-7}	0.051	2.0×10^{-5}
Rail	0.33	0.0014	5.7×10^{-7}	0.035	1.4×10^{-5}

(a) Potential health effects or latent cancer fatalities (LCFs) were calculated using the methodology described in the DOE SNF PEIS (DOE 1995a). For SNF packaged with canister sludge (wet shipments), impacts for the three basin sludge options are the same as those for the enhanced storage alternative (reference site and Canister Storage Building). For SNF packaged with canister sludge (dry shipments), impacts for the basin sludge are the same as those for the enhanced storage alternative (reference site and Canister Storage Building).

(b) Values taken from Daling and Harris (1994). Suburban population characteristics are used to model Hanford Site (onsite) personnel.

Table 5-39. Transportation nonradiological impacts of the dry storage alternative[a]

Option	Traffic Accidents: Worker Fatalities	Traffic Accidents: Onsite Fatalities	Routine Transport: Onsite Fatalities[b]
SNF, canister sludge, basin sludge packaged separately; all to the reference site			
Truck	5.9×10^{-4}	0.0021	1.1×10^{-4}
Rail	3.1×10^{-4}	0.0015	1.3×10^{-4}
SNF, canister sludge packaged separately (reference site); basin sludge to double-shell tank			
Truck	6.0×10^{-4}	0.0022	1.2×10^{-4}
Rail	3.5×10^{-4}	0.0016	1.3×10^{-4}
SNF, canister sludge packaged separately (reference site); basin sludge to Solid Waste Burial Ground			
Truck	6.1×10^{-4}	0.0023	1.2×10^{-4}
Rail	3.7×10^{-4}	0.0017	1.4×10^{-4}
SNF, canister sludge, basin sludge packaged separately; all to the Canister Storage Building site			
Truck	6.4×10^{-4}	0.0023	1.2×10^{-4}
Rail	3.1×10^{-4}	0.0016	1.5×10^{-4}
SNF, canister sludge packaged separately (Canister Storage Building site); basin sludge to double-shell tank			
Truck	6.5×10^{-4}	0.0024	1.3×10^{-4}
Rail	3.5×10^{-4}	0.0017	1.5×10^{-4}
SNF, canister sludge packaged separately (Canister Storage Building site); basin sludge to Solid Waste Burial Ground			
Truck	6.8×10^{-4}	0.0024	1.3×10^{-4}
Rail	3.8×10^{-4}	0.0018	1.5×10^{-4}
SNF repackaged; SNF, canister sludge, and basin sludge packaged separately and shipped to the reference site			
Truck	4.7×10^{-4}	0.0017	8.8×10^{-5}
Rail	3.3×10^{-4}	0.0014	9.9×10^{-5}

Table 5-39. (contd)

Option	Traffic Accidents: Worker Fatalities	Traffic Accidents: Onsite Fatalities	Routine Transport: Onsite Fatalities[b]
SNF repackaged; canister sludge packaged separately (reference site); basin sludge packaged separately and shipped to double-shell tank			
Truck	4.7×10^{-4}	0.0017	9.1×10^{-5}
Rail	3.3×10^{-4}	0.0014	1.0×10^{-4}
SNF repackaged; canister sludge packaged separately (reference site); basin sludge packaged separately and shipped to Solid Waste Burial Ground			
Truck	5.0×10^{-4}	0.0018	9.6×10^{-5}
Rail	3.6×10^{-4}	0.0015	1.1×10^{-4}
SNF repackaged; SNF, canister sludge, and basin sludge packaged separately and shipped to the Canister Storage Building site			
Truck	5.0×10^{-4}	0.0018	9.4×10^{-5}
Rail	3.0×10^{-4}	0.0013	1.1×10^{-4}
SNF repackaged; canister sludge packaged separately (Canister Storage Building site); basin sludge packaged separately and shipped to double-shell tank			
Truck	5.0×10^{-4}	0.0018	9.7×10^{-5}
Rail	3.4×10^{-4}	0.0014	1.1×10^{-4}
SNF repackaged; canister sludge packaged separately (Canister Storage Building site); basin sludge packaged separately and shipped to Solid Waste Burial Ground			
Truck	5.3×10^{-4}	0.0019	1.0×10^{-4}
Rail	3.6×10^{-4}	0.0015	1.1×10^{-4}

(a) For SNF packaged with canister sludge (wet shipments), the impacts for the three basin sludge options are the same as those for the new wet storage alternative (reference site and Canister Storage Building site). For SNF packaged with canister sludge (dry shipments), the impacts for the three basin sludge options are the same as those for the new wet storage (reference site and Canister Storage Building site).
(b) From pollutants emitted during transport.

from rail shipments. The potential onsite fatalities are essentially the same for each option and transportation mode and are less than 1.5×10^{-4} for an entire campaign.

5.11.4 Foreign Processing Alternative

Under this alternative, the SNF currently stored in the K Basins would be packaged for shipment to an overseas facility where it would be processed. The analysis assumes that high-level waste arising from the process would be returned to Hanford for interim storage, although it could potentially be stored overseas until a domestic repository was available in which to permanently dispose of it. Similarly, uranium trioxide and plutonium dioxide resulting from the processing are assumed to be returned to Hanford for interim storage; however, these materials could also be stored overseas until a decision is made on their disposition by DOE.

The analyses performed (see Appendix B) evaluated various shipping scenarios, transportation and packaging systems, radiological characteristics of the shipments, transportation routes, and port facilities. The ports evaluated included two potential West Coast U.S. ports (Seattle/Tacoma, Washington, and Portland, Oregon) and one potential East Coast port (Norfolk, Virginia) for the overland transportation analysis. The overland transportation to Seattle, Washington, would be performed using truck or rail [227 km (172 mi) and 716 km (445 mi), respectively] and to Norfolk, Virginia, also by truck or rail [4,585 km (2,849 mi) and 4,984 km (3,097 mi), respectively]. Transport to Portland, Oregon, would be performed using a barge. At the ports, the shipping casks would be loaded on a transoceanic ship and transported to an oversees port (e.g., U.K.).

Radiological Impacts

The radiological impact calculations for the foreign processing alternative are summarized in Table 5-40. The results shown in this table do not include onsite transportation activities, including the various sludge, and basin water and debris, handling options. However, the results shown in Table 5-40 when compared to those of the Hanford Site alternatives are significantly higher.

As shown in Table 5-40, the radiological impacts associated with routine truck shipments to Norfolk are higher than those for the other alternatives. This is similar to the results of the onsite analyses (i.e., the greater the distance travelled, the greater the impacts). The routine transportation impacts associated with the onsite transportation activities would increase the radiological doses to worker and public from 0.01 to 0.5 person-rem and from 0.0001 to 0.002 person-rem, respectively.

Also shown in Table 5-40 are the radiological impacts associated with transportation accidents. As with the routine analysis, shipments to Norfolk result in higher consequences. With respect to the various onsite transportation activities, the same conclusion drawn from the routine radiological analysis is valid. That is, the impacts associated with the onsite transportation activities would increase the radiological impacts to the public by 0.0002 to 0.5 person-rem.

Nonradiological Impacts

A summary of the nonradiological impact calculations for the foreign processing alternative is presented in Table 5-41. The results shown in this table do not include onsite transportation activities. However, the results shown in Table 5-41 when compared to those of the Hanford Site alternatives are significantly higher.

Table 5-40. Transportation radiological impacts of the foreign processing alternative[a]

	Routine Transport			Radiological Accidents	
	Radiological Impacts		Health Effects	Radiological Impacts	Health Effects
Option[b]	Crew (person-rem)	Public (person-rem)	Public (LCF)	Public (person-rem)	Public (LCF)
Barge to Portland	3.3	0.41	None ($2x10^{-4}$)	0.027	None ($1x10^{-5}$)
Truck to Seattle	6.5	15	None (0.008)	0.0037	None ($2x10^{-6}$)
Rail to Seattle	3.7	1.9	None ($9x10^{-4}$)	0.0037	None ($2x10^{-6}$)
Truck to Norfolk	110	250	None (0.1)	0.085	None ($4x10^{-5}$)
Rail to Norfolk	15	7.3	None (0.004)	0.083	None ($4x10^{-5}$)

(a) Potential health effects or latent cancer fatalities (LCFs) were calculated using the methodology described in the DOE SNF PEIS (DOE 1995a).
(b) Values taken from Daling and Harris (1994). Suburban population characteristics are used to model Hanford Site (onsite) personnel.

Table 5-41. Transportation nonradiological impacts of the foreign processing alternative[a]

Option	Traffic Accidents (total fatalities)[b]	Routine Transport (total fatalities)[b]
Barge to Portland	0.011	0.021
Truck to Seattle	0.0089	0.0012
Rail to Seattle	0.012	0.0034
Truck to Norfolk	0.13	0.016
Rail to Norfolk	0.12	0.015

(a) Includes shipments to and return shipments.
(b) Total fatalities include truck crew and public.

As shown in Table 5-41, the nonradiological impacts associated with routine truck or rail shipments to Norfolk (including the return shipment) are higher than those for the other alternatives. This is similar to the results of the radiological impact analysis. The routine transportation impacts associated with the onsite transportation activities are insignificant [worker and public (onsite) fatalities would increase 0.0002 to 0.0014]. The same conclusion is also valid when evaluating transportation accident impacts.

Also shown in Table 5-41 are the nonradiological impacts associated with transportation accidents. As with the routine analysis, shipments to Norfolk result in higher consequences. With respect to the various sludge handling options, the same conclusion drawn from the routine nonradiological analysis is valid. That is, the impacts associated with the sludge handling operations will not contribute significantly to the accident impacts.

5.12 Occupational and Public Health and Safety

Implications of implementing the alternatives for storage of K Basins SNF on worker and public health and safety at the Hanford Site are discussed in the following subsections. In general, this section consists of summary material extracted from Sections 5.7 "Air Quality and Related Consequences," 5.8 "Water Quality and Related Consequences," 5.11 "Transportation," and 5.15 "Facility Accidents."

5.12.1 Radiological Consequences to the Public

The consequences of radionuclide emissions to air and water from normal operations in all of the alternatives are within regulatory limits established by the EPA and the DOE. Maximum doses to an offsite resident from normal facility operation ranged from 2×10^{-7} to 8×10^{-4} rem/year, and collective doses to the population within 80 km (50 mi) were estimated to be 0.005 to 30 person-rem/year for the no action and calcination (or onsite processing) alternatives, respectively.

Exposures to the public during transportation would not occur except under the foreign processing alternative, where the collective doses were estimated to be 0.4 to 260 person-rem for shipments to representative ports on the west and east coast, respectively. The dose to transportation and port workers directly involved in handling the offsite SNF shipments would be expected to amount to an additional 2 to 37 person-rem over the course of the entire shipping campaign. No health consequences to the public would be expected as a result of activities associated with any alternative (see Sections 5.7, 5.8, and 5.11).

Accidental releases of radionuclides during transportation or facility operation have the potential to result in human health effects if they occur (see Sections 5.11 and 5.15). However, the operations and processes that are ultimately selected for management of K Basins SNF would be evaluated in a detailed safety analysis before they were implemented to ensure that the risks were acceptable, based on the potential consequences and expected frequencies of reasonably foreseeable accidents (see Section 5.20).

5.12.2 Radiological Consequences to Workers

Workers may be subject to routine radiation exposure from many of the operations within the SNF management facilities evaluated in this EIS. The radiation exposure of each operations worker is administratively controlled to no more than 2 rem/year with a worker monitoring program that provides hold points starting at a cumulative exposure to any worker of 0.5 rem. Such controls assure that under normal operating conditions individual workers will not be exposed to levels approaching the DOE limit of 5 rem/year as prescribed in 10 CFR 835. Radiological exposures to workers during facility operations are summarized in Table 5-42 for all of the alternatives considered in this EIS. Operation of a new process facility results in the highest exposures; however, cumulative exposures for all of the alternatives are similar and range from about 900 to 1,500 person-rem over the entire storage period. Exposure at this level might result in at most one latent cancer fatality within the exposed worker population. Dose reduction measures (see Section 5.20) could decrease these exposures to workers under all of the alternatives if they are implemented.

Table 5-42. Radiological exposures to workers during facility operations (Bergsman et al. 1995, Appendix D)

Alternative	Occupational Exposure (person-rem)[a] 40-yr Cumulative
No action	910
Enhanced K Basins storage	950
New wet storage	1000
Drying/passivation	960 - 1200
Calcination	1100
Onsite processing	1500
Foreign processing	1000

(a) For most alternatives, most of the cumulative exposures would occur during operations at the K Basins, involving about 115 radiation workers. Onsite processing operations include about 1,100 workers (of whom an unspecified number are radiation workers).

The estimates in Table 5-42 include only direct radiation exposure to facility workers. If operations conducted under any alternatives had the potential for generation of significant airborne contamination that might result in radionuclide intake by workers, appropriate protective measures (such as anticontamination clothing and respiratory protection) would be required. Therefore, internal deposition of radionuclides would not be expected to contribute substantially to the total worker doses estimated on the basis of external exposure rates.

Radiological doses to transportation workers are discussed in Section 5.11 and are small compared with the exposures to facility workers. The transportation worker doses would not be expected to result in health effects.

5.12.3 Nonradiological Consequences to the Public

The consequences of routine emissions to air and water of nonradiological compounds that could result in potential health effects are discussed in Sections 5.7, 5.8, and 5.11. Emissions of criteria pollutants (particulates, NO_x, and SO_x) from facilities or vehicles during transportation and normal operation of facilities are within state and federal regulatory limits, and would not be expected to result in adverse health effects at these levels. However, short-term (24-hour) standards for particulate concentrations might be approached on a temporary basis during construction of facilities associated with the foreign processing alternative, where construction would occur near the Site boundary or other onsite locations to which the public has access. Fugitive dust emissions during construction could be controlled by standard dust suppression methods and would not be expected to affect the regional air quality on a continuing basis. Emissions of other potentially hazardous materials to air are not expected as a result of any alternatives in this EIS, and routine discharges of regulated compounds in liquid wastes to land disposal facilities would be limited to permitted concentrations.

Accidents involving releases of hazardous or toxic material from facilities are evaluated in Section 5.15 and could result in adverse health effects if such accidents were to occur. Because the accident assessment uses hypothetical, nonspecific release scenarios based on facility inventory, the estimated frequency and the resulting risk from these accidents cannot be assessed directly. However, the frequencies of the types of accidents that could result in substantial releases to the environment are typically low enough that they would not be expected to occur during the operations considered in this EIS.

5.12.4 Nonradiological Consequences to Workers

Health effects and fatalities from traffic or industrial accidents are discussed in Sections 5.11 and 5.15, respectively. Facility operation and construction would be expected to contribute up to several hundred injuries and illnesses over the 40-year period evaluated for this EIS. Traffic accidents, and accidents during facility construction and operation, might result in at most one fatality over the same period of time.

5.13 Site Services

This section discusses the utilities and energy usage resulting from implementation of the various alternatives. The existing consumption rates for electricity, coal, natural gas, propane, and other utilities are shown in Table 4-5.

Implementation of the alternatives would have incremental impacts on existing utilities and energy resources. Most of the alternatives would require an extension or upgrade of utilities to the project site. However, adequate power exists on the Hanford Site. Energy consumption rates are taken from Bergsman et al. (1995) and are discussed in the following subsections for each alternative.

5.13.1 No Action Alternative

The no action alternative would not require additional energy, other than that necessary to maintain the safe and secure operation of the K Basins facilities. Excluding energy expended during minimal upgrades for safety and security purposes, electrical consumption is estimated to be 14,400 MWh annually (Table 5-43).

5.13.2 Enhanced K Basins Storage Alternative

In the enhanced K Basin storage alternative, upgrades of existing facilities and new storage systems would need to be constructed. These upgrades would include an additional increment of energy. However, this alternative is ultimately estimated to save approximately 35% of the total amount of energy currently expended annually at the K Basins because of improved operations and consolidation of the SNF into one facility (Table 5-44).

Table 5-43. Estimated resource consumption for the no action alternative (continued storage at K Basins)

Resource	Consumption	
Electricity	14,400 MWh/yr	
Chlorine	1,320 kg/yr	(2,910 lb/yr)
Alum	8,800 kg/yr	(19,400 lb/yr)
Water		
Basin makeup replacement	332 m^3/yr	(87,710 gal/yr)
Potable	5,448 m^3/yr	(1,440,000 gal/yr)

Table 5-44. Resource consumption for enhanced storage at the K Basins

Resource	Consumption	
Electricity	9,300 MWh/yr	
Chlorine	853 kg/yr	(1,880 lb/yr)
Alum	5,683 kg/yr	(12,528 lb/yr)
Stainless steel for Mark II canisters	70 MT	(77.2 ton)
Water		
Basin makeup replacement	170 m^3/yr	(44,900 gal/yr)
Potable	3,600 m^3/yr	(951,000 gal/yr)
For sludge removal	600 m^3/yr	(158,000 gal/yr)

5.13.3 Wet Storage Alternative

This alternative requires material for casks and canisters, and water for sludge and tritium treatment during SNF removal from the K Basins. It represents an approximately 42% increase in yearly electrical consumption (Table 5-45) compared to current K Basin operations. The resource requirements for two approaches to wet storage are discussed in the following text.

Wet Storage in a Dry Vault

This alternative requires material for storage tubes and concrete for building materials. Operation of the storage facility represents no change in yearly electrical consumption (Table 5-46) compared to current K Basin operations, although there is some additional electrical consumption allotted for construction purposes.

Wet Storage Pool

This alternative requires material for storage tubes and concrete for building materials. Operation of the facility represents no change in yearly electrical consumption compared with current K Basin operations (Table 5-47), although there is some additional electrical consumption allotted for construction purposes.

Table 5-45. Resource consumption for sludge management, water removal, and transport

Resource	Consumption			
Electricity for operations	14,400	MWh/yr		
Fuel (diesel)	1,057	m^3	(4,000)	gal)[(a)]
Stainless steel				
For Mark II canisters	110	MT	(106	tons)
For placing sludge in MCOs	70	MT	(77	tons)
Carbon and alloy steel for shipping casks	65,000	kg	(143,000	lb)
Inert gas	100	m^3/yr	(26,417	gal/yr)
Water for sludge removal	120	m^3/yr	(31,600	gal/yr)

(a) Assuming 64,400 km (40,000 mi) at 4 km/L (10 mpg).

Table 5-46. Resource consumption for wet storage in a dry vault

Resource	Consumption	
Electricity (for construction, 2-3 yr)		
At partially constructed CSB site	1,700 MWh/yr	
At reference site	2,800 MWh/yr	
Electricity (for operations) at either site	14,900 MWh/yr	
Diesel fuel (for construction)		
At partially constructed CSB site	700 m^3	(185,540 gal)
At reference site	1,100 m^3	(290,000 gal)
Stainless steel at either site for storage tubes	1,500 MT	(1,800 ton)
Carbon and alloy steel (for construction)		
At partially constructed CSB site	3,600 MT	(4,000 ton)
At reference site	4,600 MT	(5,100 ton)
Concrete (for construction)		
At partially constructed CSB site	8,400 m^3	(11,100 yd^3)
At reference site	13,500 m^3	(17,700 yd^3)
Water for potable uses	2,000 m^3/yr	(500,000 gal/yr)

Table 5-47. Resource consumption for a wet storage pool

Resource	Consumption	
Electricity (for construction)		
At partially constructed CSB site	1,200 MWh/yr	
At reference site	2,300 MWh/yr	
Electricity (for operations) at either site	14,400 MWh/yr	
Diesel fuel (for construction)		
At partially constructed CSB site	500 m^3	(130,000 gal)
At reference site	900 m^3	(240,000 gal)
Stainless steel (for liner)		
At partially constructed CSB site	100 MT	(110 ton)
At reference site	1,500 MT	(1,800 ton)
Carbon and alloy steel (for construction)		
At partially constructed CSB site	3,100 MT	(3,400 ton)
At reference site	4,100 MT	(4,500 ton)
Concrete (for construction)		
At partially constructed CSB site	5,900 m^3	(7,700 yd^3)
At reference site	11,000 m^3	(14,400 yd^3)
Water for potable uses	2,000 m^3/yr	(500,000 gal/yr)

5.13.4 Passivation or Calcination with Dry Storage Alternatives

Dry storage of K Basins SNF uses resources for removal of SNF from K Basins, treatment (conditioning or calcination) in a new facility, and interim storage in a new dry storage facility. Resources required for these activities are discussed in the following text.

Removal of Sludge for Dry Storage

This alternative requires a minimal expenditure of resources to implement and an increase in materials required (Table 5-48).

Passivation Facility

This alternative offers an approximately 53% decrease in operational use of electricity, and while it requires a significant outlay of electricity (1,800 MWh) during construction (Table 5-49), it is still trivial compared to operations.

Calcination Facility

This alternative requires the most significant increase in electrical consumption, approximately 60%, and also the highest construction costs (Table 5-50).

Dry Storage Facility

This alternative requires no change in electrical consumption compared to the no action alternative but requires a fairly high construction usage of electricity (Table 5-51).

Table 5-48. Resources needed for removal of sludge for dry storage

Resource	Consumption	
Water		
Basin replacement	300 m^3/yr	(100,000 gal/yr)
Potable	3,600 m^3/yr	(951,000 gal/yr)
For sludge removal	120 m^3/yr	(31,700 gal/yr)
Inert gas (for vacuum drying)	4,000 m^3/yr	(141,240 ft^3/yr)
Stainless steel for placing sludge in MCOs	200 MT	(221 ton)

MCOs = multicanister overpacks.

Table 5-49. Resource consumption for a passivation facility

Resource	Consumption		
Electricity			
For construction	1,800	MWh	
For operations	6,800	MWh/yr	
Diesel fuel (for construction)	190	m^3	(50,190 gal)
Copper	11,000	kg	(4,950 lb)
Lumber	144	m^3	(61,000 bd ft)
Gases			
For construction			
Helium	2,800	m^3	(739,680 gal)
Oxygen	200	m^3	(52,834 gal)
Acetylene	200	m^3	(52,834 gal)
For operations			
Helium	160	kg/yr	(355 lb/yr)
Oxygen	1,000	kg/yr	(2,220 lb/yr)
Argon	40,000	kg/yr	(88,800 lb/yr)
Miscellaneous chemicals			
For construction			
Concrete admixtures	2,700	L	(713 gal)
Paint and coatings	3,800	L	(1,004 gal)
For operations			
Commercial cleaners for decontamination, paint, lubricants	<1	m^3	(264 gal)
Stainless steel for construction	540	MT	(488 ton)
Carbon and alloy steel	3,900	MT	(3,526 ton)
Concrete (for construction)	3,300	m^3	(4,320 yd^3)
Water			
For construction	8,000	m^3	(211,340 gal)
For operation	4,000	m^3/yr	(105,670 gal/yr)

Table 5-50. Resource consumption for a calcination facility

Resource	Consumption	
Electricity		
For construction	4,370 MWh	
For operations	23,000 MWh/yr	
Diesel fuel (for construction)	830 m^3	(219,290 gal)
Gasoline (for construction)	830 m^3	(219,290 gal)
Copper	59 kg	(27 lb)
Lumber	2,000 m^3	(850,000 bd ft)
Asphalt, sand, and crushed rock	1,100 m^3	(1,438 yd^3)
Stainless steel for construction	540 MT	(623 ton)
Carbon and alloy steel (for construction)	3,900 MT	(4,500 ton)
Concrete (for construction)	22,000 m^3	(28,775 yd^3)
Water		
For construction	530,000 m^3	(14,001,275 gal)
For operation	80 m^3/yr	(20,000 gal/yr)

Dry Storage in Casks

The dry storage of fuel in casks option is expected to consume minimal amounts of electricity during construction and operation. Some materials would be needed to construct the concrete pad that the casks would be set upon.

5.13.5 Onsite and Foreign Processing Alternatives

Processing at the Hanford Site appears to have the highest resource consumption rate of the alternatives (Table 5-52). Resources required to construct and operate the process facility are listed in Table 5-52, and those needed to construct and operate the uranium trioxide storage facility are listed in Table 5-53. Resources consumed during removal of SNF from K Basins would be comparable to those previously described in Table 5-45.

Table 5-51. Resource consumption for the dry storage facility

Resource	Consumption	
If staging operations conducted in a vault:		
Electricity (for construction)		
At partially constructed CSB site	1,700 MWh/yr	
At reference site	2,800 MWh/yr	
Electricity (for operations) at either site	14,400 MWh/yr	
Diesel Fuel (for construction)		
At partially constructed CSB site	700 m^3	(185,540 gal)
At reference site	1,100 m^3	(290,000 gal)
Stainless steel at either site for storage tubes	1,500 MT	(1,800 ton)
Carbon and alloy steel (for construction)		
At partially constructed CSB site	3,600 MT	(4,000 ton)
At reference site	4,600 MT	(5,100 ton)
Concrete (for construction)		
At partially constructed CSB site	8,400 m^3	(11,100 yd^3)
At reference site	13,500 m^3	(17,700 yd^3)
If staging operations conducted in a pool:		
Electricity		
For construction	500 MWh	
For operations	100 MWh/yr	
Diesel fuel	200 m^3	(52,834 gal)
Carbon and alloy steel (for construction)		
For rebar	500 MT	(600 ton)
For storage tubes	1,500 MT	(1,700 ton)
Concrete (for construction)	2,500 m^3	(3,300 yd^3)
Water for operation	400 m^3/yr	(100,000 gal/yr)
If dry storage conducted in casks:		
Electricity	minimal	
Concrete	12,000 m^3	(16,000 $yd^{3)}$
Steel (rebar)	2,300,000 kg	(5,000,000 lbs)
Lumber (forms)		500,000 bd ft

As can be seen in Table 5-54, the onsite processing alternative is the greatest energy user, requiring 368% more energy than is consumed at present. However, this facility would only operate 4 years. The calcination alternative at the Hanford Site would be the next greatest user of energy resources but also only for 4 years.

Table 5-52. Resource consumption for onsite processing

Resource	Consumption	
Electricity		
For construction	5,700 MWh	
For operations	53,000 MWh/yr	
Diesel fuel (for construction)	1,097,730 L	(290,000 gal)
Gasoline (for construction)	1,097,730 L	(290,000 gal)
Copper	77 MT	(85 ton)
Lumber	1,087 MT	(1,100,000 bd ft)
Asphalt, sand, and crushed rock	1,376 m^3	(1,800 yd^3)
Stainless steel (for construction)	667 MT	(800 ton)
Carbon and alloy steel (for construction)	4,667 MT	(5,600 ton)
Concrete (for construction)	29,050 m^3	(38,000 yd^3)
Water		
For operation	30,000 L/yr	(7,925 gal/yr)

Table 5-53. Resource consumption for a uranium trioxide storage facility

Resource	Consumption	
For transloading facilities		
Carbon steel (for reinforcement)	16 MT	(17.5 ton)
Structural steel (pallets)	24 MT	(26 ton)
Structural steel (building)	16 MT	(17.5 ton)
For construction		
Structural steel and siding	15 MT	(16.5 ton)
Concrete	400 m^3	(500 yd^3)

Table 5-54. Comparison of electrical consumption values for each alternative and percent change over existing consumption

Alternative	Construction (MWh)	Operations (MWh/yr)	% Change
No action (Baseline)	NA	14,400	NA
Enhanced K Basins storage	Negligible	9,300	-35
Wet storage			
SNF removal; sludge, debris, and water disposal at K Basins	Negligible	14,400	NA
Wet storage in a dry vault	1,400-2,800	14,400	NA
Wet storage pool change	1,200-2,300	14,400	NA
Dry storage			
Drying and passivation	1,800	6,800	-53
Calcination	4,370	23,000	+60
Dry storage facility	500	100	NA
Onsite processing	5,700	53,000	+368

NA = not applicable.

5.14 Waste Management

This section describes impacts to waste management for all alternatives.

5.14.1 No Action Alternative

The no action alternative involves only fuel storage at existing K Basin facilities. The quantity of waste generated in the no action alternative is relatively small because the only planned modifications to existing facilities are safety and security upgrades. However, sludge inside the fuel canisters and on the basin floor continues to accumulate in the KE Basin from various sources (e.g., fuel corrosion, facility corrosion, dust, and sand) along with the continued contamination of basin water.

Impacts associated with the no action alternative are based on current conditions. The following is a summary of routine K Basin operation waste volume production rates.[a] These include liquid and solid waste. Liquid wastes are generated from the heating, ventilation, and air conditioning systems. Liquid wastes are released at permitted discharge points. Solid waste is generated from failed equipment, normal radiation zone entry, and water treatment processes. Spent filters and ion exchange resins are the only potential sources of transuranic (TRU) waste. In addition there is currently 20 m^3 (26 yd^3) of TRU waste associated with existing spent ion exchange columns and resins from prior operations that must be disposed of. Because the volume is preexisting it has not been incorporated into the summary total:

- Low-level waste 95 m^3/yr (124 yd^3/yr)
- TRU waste 2 m^3/yr (2.6 yd^3/yr)
- High-level waste 0 m^3/yr (0 yd^3/yr)
- Mixed waste 1 m^3/yr (1.3 yd^3/yr)
- Hazardous waste 2.3 m^3/yr (3.0 yd^3/yr)

5.14.2 Enhanced K Basin Storage Alternative

The enhanced K Basin storage alternative also leaves the fuel at the existing facilities. However, the fuel at the KE Basin would be containerized, some facility upgrades would be performed, and the fuel would be consolidated at the KW Basin. Fragments and oxides that may be generated during containerization would be placed in new containers. Pieces too small to be retrieved would be allowed to fall and mix in with a limited sludge accumulation on the floor (Bergsman et al. 1995). Preparation activities are anticipated to generate approximately 3 m^3 (4 yd^3) of nonradioactive, nonhazardous waste, which will be shipped to the existing Hanford Site Solid Waste Operations Complex for disposal. About 516 m^3 (670 yd^3) of low-level waste would result from containerization of SNF in the KE Basin. In addition, 15 m^3 (20 yd^3) of TRU waste would be generated from spent filters.

Excess KW Basin water, displaced by the addition of the new storage racks, will be handled by evaporative loss. After the removal of the fuel, sludge, debris, and water would still remain in the KE Basin. This water would be contaminated with radionuclides, including tritium. In addition to filtering the water for the removal of isotopes, the water would be trucked from the KE Basin to the 200 Area ETF for final treatment and disposal into

(a) For a more detailed analysis and explanation of the waste volumes presented for each alternative, refer to the *K Basins Environmental Impact Statement Technical Input* (Bergsman et al. 1995).

the 200 Area SALDS. The water removed from the KE Basin would then be replaced with clean water, maintaining the KE Basin water level. Eventually, all of the basin water would be removed. If this is done, an estimated 7,000 m^3 (9,450 yd^3) of water per year for 2.5 years may be used at the basin for makeup. The KE Basin contains approximately 33,600 m^3 (1.2 million gal) of water.

Both K Basins contain sludge that has accumulated within storage canisters or on the floor of the basins. For this alternative, sludge within the canisters would be left in the canisters and managed as SNF. Sludge on the floor of KW Basin has an estimated volume of 4 m^3 (5.4 yd^3) (or 8 m^3 or 10.8 yd^3 after grouting) and is expected to be low-level waste. It may be grouted at the K Basins and moved to the 200 Area solid waste disposal facility at the Solid Waste Operations Complex or transported for disposal at the tank farms. The estimated volume of floor sludge in the KE Basin is 50 m^3 (67.5 yd^3) of TRU and/or mixed TRU waste. Options for managing KE Basin floor sludge include transferring the sludge to Hanford double-shell tanks, disposal as solid waste, or continued management of the sludge as SNF and transferring the sludge to the KW Basin.

There is an estimated noncompacted volume of 20 m^3 (26 yd^3) of low-level waste associated with the replaced racks in the KW Basin.

After fuel consolidation activities into KW Basin are complete, operational wastes are estimated to be the same as those from the current operation of the KW Basin, which are as follows:

• TRU waste	1.0 m^3/yr	(1.30 yd^3/yr)
• Low-level waste	40 m^3/yr	(50 yd^3/yr)
• High-level waste	0 m^3/yr	(0 yr^3/yr)
• Mixed waste	0.23 m^3/yr	(0.30 yd^3/yr)
• Hazardous waste	1.0 m^3/yr	(1.30 yd^3/yr)

5.14.3 New Wet Storage Alternative

For the wet storage alternative, all fuel canisters in both basins will be moved and loaded into MCOs. However, waste generation for fuel removal and encapsulation activities is based on containerization activities for all of the fuel and sludge in the KE Basin and repackaging the fuel from approximately one-half of the KW Basin canisters (aluminum canisters from which SNF will be repacked into sealed Mark II stainless steel fuel canisters). Preparation activities for the fuel removal action are anticipated to generate approximately 3 m^3 (4 yd^3) of nonradioactive, nonhazardous waste to be disposed of in the Hanford Central Landfill; and 7 m^3 (9 yd^3) of low-level solid radioactive waste consisting of installation scrap and radiation zone personnel waste to be disposed of in the Hanford 200 Area low-level burial grounds. No hazardous or mixed waste would be generated from preparation activities.

Approximately 210 m^3 (270 yd^3) of low-level solid radioactive waste and 15 m^3 (120 yd^3) of TRU waste would be generated by the fuel removal work. The waste would be packaged and shipped to the Hanford 200 Area low-level burial grounds.

Both K Basins contain sludge that has accumulated within storage canisters or on the floor of the basins (for more detailed information, refer to Bergsman et al. 1995). For the wet storage alternative, as with enhanced K Basin storage, sludge within the canisters would be left in the canisters and managed as SNF at the new wet storage facility. KW Basin floor sludge is expected to be low-level waste, and, thus, it may be grouted and trucked to solid waste disposal [4 m^3 (5.4 yd^3) or 8 m^3 (10.8 yd^3) after grouting] or transported to the tank farms for disposal. Management options for KE Basin floor sludge being considered include transferring sludges to Hanford double-shell tanks or solid waste disposal; and/or transferring the sludges to the new wet storage facility. Approximately 50 m^3 (67.5 yd^3) of TRU or mixed TRU waste combined with 550 m^3 (742.5 yd^3) of water are expected to be generated if all the sludge from the KE Basin floor is disposed of at the tank farms.

Debris removal would also generate low-level radioactive waste (clothing, tools, scrap materials) that would be managed in existing Hanford waste management units. Estimated noncompacted volumes include the following:

- Storage racks 40 m^3 (52 yd^3)
- Empty canisters 220 m^3 (290 yd^3)
- Miscellaneous debris 34 m^3 (44 yd^3)

Treatment activities for water remaining in the K Basins following removal of the fuel, sludge, and debris would result in an average 30 m^3/yr (40.5 yd^3/yr) for 3 years for a total of 90 m^3 (121.5 yd^3) of low-level waste and 40 m^3 (54 yd^3) of TRU waste in the year 2000 and 10 m^3/yr or 13.5 yd^3/yr (of TRU waste) in 2001 and 2002 for a total of 60 m^3 (81 yd^3) for spent filters. Small volumes of low-level waste generated from human entry (tape, clothing) would also be produced. These numbers will also apply to the dry storage alternative.

Operating waste estimates for wet storage in a vault facility are estimated to be the same as those at the current KW Basin, and are as follows:

• Low-level waste	40 m^3/yr	(50 yd^3)
• TRU waste	1 m^3/yr	(1 yd^3/yr)
• High-level waste	0 m^3/yr	(0 yd^3/yr)
• Mixed waste	0.23 m^3/yr	(0.30 yd^3/yr)
• Hazardous waste	1 m^3/yr	(1 yd^3/yr)
• Construction waste	800 m^3	(1,100 yd^3) (total for the CSB site)
	1,400 m^3	(1,800 yd^3) (total for the reference site)

Operating waste estimates for wet storage in a new pool are the same as those for a vault facility. Anticipated construction waste volumes are as follows:

• Construction waste	590 m^3	(770 yd^3) (total for the CSB site)
	1,100 m^3	(1,400 yd^3) (total for the reference site)

When calculating total annual waste generation for any alternative, which facilities will be in operation during the specific time period must be considered. For the wet storage alternative, the minimum annual waste generation is during operation of both K Basins (before any new facilities are operating), and the maximum annual waste generation is during the period of fuel transfer when both the basins and the storage facility are operating.

5.14.4 Dry Storage Alternative

As with the wet storage alternative, waste generation is based on encapsulation activities for the fuel and sludge in the KE Basin and repackaging the fuel from approximately one-half of the KW Basin canisters. Preparation activities for the fuel removal action are anticipated to generate approximately 4 m^3 (5 yd^3) of nonradioactive, nonhazardous waste; and 9 m^3 (12 yd^3) of low-level solid radioactive waste. No hazardous or mixed waste will be generated from preparation activities.

Approximately 650 m^3 (850 yd^3) of low-level solid radioactive waste and 20 m^3 (26 yd^3) of TRU waste from cartridge filters would be generated by fuel removal work. Additionally, 30 m^3 (40.5 yd^3) of TRU or mixed-TRU waste combined with 570 m^3 (770 yd^3) of water are expected to be generated from canister sludge if all of the canister sludge is disposed of at the tank farms. Waste generation from floor sludge retrieval, noncompacted waste, and water treatment are expected to be the same as the volumes estimated for the wet storage alternative.

Material requirements for dry storage of fuel are minimal and consist of decontamination chemicals in small quantities. Construction waste generated for each of the suboptions depends on the size and number of facilities required. Operating and construction wastes for vault or pool storage facilities are the same as those given in the new wet storage alternative.

Operating estimates for solid waste generated by a drying/passivation facility are as follows:

• TRU waste	14 m^3/yr	(18 yd^3/yr)
• Low-level waste	85 m^3/yr	(111 yd^3/yr)

Liquid nonradioactive waste would include sewage and service waste. Radioactive solid waste would include filters, contaminated rags, paper, trash, and clothing.

Anticipated construction waste for a drying/passivation facility are as follows:

• Metal/wood/paper	230 m^3	(300 yd^3)
• Excavated dirt	1,500 m^3	(1,962 yd^3)

Operating estimates for solid waste generated by a calcination process are as follows:

• Hazardous waste	3 m^3/yr	(4 yd^3/yr)
• Radioactive hazardous waste	2 m^3/yr	(2.6 yd^3/yr)
• Remote-handled TRU waste	28 m^3/yr	(37 yd^3/yr)
• Low-level waste	280 m^3/yr	(370 yd^3/yr)
• TRU waste	1 m^3/yr	(1.3 yd^3/yr)

Liquid nonradioactive waste would include sewage and service waste. Radioactive solid waste would include filters, contaminated rags, paper, trash, and clothing. An additional 1 m^3 (1.3 yd^3) of TRU-generated waste would result from the use of cartridge filters. Anticipated construction waste for a calcination facility would include 2600 m^3 (3400 yd^3) of nonradioactive, nonhazardous waste.

Minimal waste would be produced once the fuel was in the dry storage facility. No low-level, high-level, TRU, mixed, or hazardous waste is expected to be generated during dry storage operations.

When calculating minimum and maximum total annual waste generation rates, which facilities will be in operation must be considered. For dry storage with passivation, the minimum waste generation rate occurs during the long-term operation of the dry storage facility (after fuel transfers, completion of storage and drying/passivation activities), and the maximum waste generation rate occurs during the operation of both K Basins, the vault storage facility at the new site, and the drying/passivation facility (during the period of fuel transfer to the basins). For the dry storage alternative with calcination, the minimum waste generation rate occurs during the long-term operation of the dry storage facility and the maximum waste generation rate occurs during the operation of both the vault storage facility at the new site and the calcination facility.

5.14.5 Processing Alternatives

The processing approaches consist of two alternatives: a separation process in a facility onsite or an existing overseas facility. The onsite processing facility would be scheduled for operation in a way to use the existing high-level waste tank system rather than constructing a new system. Many of the initial activities for retrieval and packaging would be handled in a very similar manner to those in the wet storage or dry storage alternatives. Processing overseas may require the construction of a temporary SNF storage facility, depending on scheduling and transport agreements. SNF would be packaged in approved casks and shipped overseas. Once vitrified, the high-level waste would be returned to Hanford.

The following table summaries estimates of solid waste generation from an onsite processing facility (Bergsman et al. 1995):

• Hazardous waste	3 m^3/yr	(4 yd^3/yr)
• Radioactive hazardous waste	2 m^3/yr	(2.6 yd^3/yr)
• Remote-handled TRU (high-level canyon waste)	57 m^3/yr	(75 yd^3/yr)
• Remote-handled TRU cladding waste	42 m^3/yr	(55 yd^3/yr)
• Contact-handled TRU waste	4 m^3/yr	(5 yd^3/yr)
• Contact-handled mixed-TRU waste	4 m^3/yr	(5 yd^3/yr)
• Low-level waste	425 m^3/yr	(550 yd^3/yr)

Approximately 3,400 m^3 (4,500 yd^3) of nonradioactive, nonhazardous waste would be generated during construction of any onsite processing facility or about 900 m^3 (1,200 yd^3) per year of construction. Additionally approximately 4 m^3/yr (5 yd^3/yr) of hazardous waste would be generated during construction.

For onsite processing, the minimum waste generation rate occurs during the long-term operation of the separated product storage facility and the K Basins surveillance. The K Basins will be deactivated before the processing facility begins operation. The maximum waste generation rate occurs during the operation of the vault storage facility at the new site and the processing facility. For foreign processing, the minimum waste generation rate occurs during the long-term operation of the separated product storage facilities and the K Basin surveillance. The maximum waste generation rate occurs during the operation of the K Basins during fuel transfers. If the alternative includes a stabilization facility to prepare the fuel before shipment overseas, the maximum waste generation rate occurs during the operation of the vault storage facility and the stabilization facility.

5.14.6 Comparison to Current Waste Generation Rates

Waste types and corresponding disposal methods are discussed in Section 4.14. The volumes of high-level, low-level and TRU waste generated for each proposed alternative are summarized in Table 5-55. Waste generation quantities from the proposed operating facilities are presented in comparison with current production volumes.

Table 5-55. Radioactive waste generated for each proposed alternative compared to current onsite production rates[a]

	Radioactive Waste Generated During Containerization and Deactivation (m^3)		
	High Level	Low Level	Transuranic
No action	NA	NA	NA
Enhanced K Basin storage	0	540	65
New wet storage	0	610	130
Dry storage/passivation	0	1060	160
Dry storage/calcination	0	1060	160
Onsite processing	0	610	130
Offsite processing	0	610	130

Table 5-55. (contd)

	Radioactive Waste Generated During Facility Operations[a]		
	High-Level	Low-Level	Transuranic
No action			
Maximum annual volume (m^3/yr)	0	95	2
1995 forecasted annual (m^3/yr)[b]	0	12,890	230
% of 1995 volume	0	0.74	0.86
Enhanced K Basin storage			
Maximum annual volume (m^3/yr)	0	40	1
1995 forecasted annual (m^3/yr)[b]	0	12,890	230
% of 1995 volume	0	0.31	0.43
New wet storage			
Maximum annual volume (m^3/yr)	0	40	1
1995 forecasted annual (m^3/yr)[b]	0	12,890	230
% of 1995 volume	0	0.31	0.43
Dry storage/passivation			
Maximum annual volume (m^3/yr)[c]	0	125	15
1995 forecasted annual (m^3/yr)[b]	0	12,890	230
% of 1995 volume	0	0.97	6.4
Dry storage/calcination			
Maximum annual volume (m^3/yr)[c]	0	320	30
1995 forecasted annual (m^3/yr)[b]	0	12,890	230
% of 1995 volume	0	2.5	12.5
Onsite processing			
Maximum annual volume (m^3/yr)	57	425	50
1995 forecasted annual (m^3/yr)[b]	0	12,890	230
% of 1995 volume	NA	3.3	20
Foreign processing			
Maximum annual volume (m^3/yr)	0	0	0
1995 forecasted annual (m^3/yr)[b]	0	12,890	230
% of 1995 volume	0	NA	NA

(a) Forecasted volume data are from the Solid Waste Forecasting Database, which is maintained by the Pacific Northwest Laboratory for the Hanford Site.
(b) 1995 forecasted annual waste generation rates for ongoing Hanford operations.
(c) Total maximum annual volumes includes waste generated at both the storage and dry processing or calcination facilities.

No alternative is expected to generate high-level waste except for the onsite processing alternative. High-level waste treatment at Hanford is included within the Tank Waste Remediation System program. As of May 1995 there was approximately 17.8 million L (4.7 million gal; 17,800 m^3) of available space in the double-shell tanks. This space will be used for waste storage from a variety of sources including a contingency volume for emergency management of wastes from other tank storage facilities (DOE and Ecology 1995). Low-level waste would be forwarded to the low-level waste burial grounds in the 200 Area with the highest production volumes resulting from onsite processing, creating an estimated yearly increase of about 3% over 1995 forecasted volumes. Transuranic wastes would be handled by facilities in the Hanford Central Waste Complex, and the Transuranic Waste Storage and Assay Facility. Onsite processing would result in a volume increase of about 21%. Other waste types discussed in this section include mixed waste (which would also be handled by the Tank Waste Remediation System program), hazardous waste (which would continue to be shipped offsite), and nonhazardous waste (which would be forwarded to the Hanford Site Solid Waste Operations Complex in the 200 Area).

5.15 Facility Accidents

Consequences of facility accidents associated with implementing the alternatives for SNF storage at Hanford are discussed in the following subsections. The method used to select accidents for analysis is described, as are the procedures for evaluating the consequences of selected accidents, and the results of the analysis.

5.15.1 Historical Accidents Involving SNF at Hanford

At Hanford, no known instances of routine storage, handling, or processing of SNF have resulted in an accident that involved a significant release of radioactive or other hazardous materials to the environment or that resulted in detrimental exposure of workers or members of the public to hazardous materials.

5.15.2 Emergency Preparedness Planning at Hanford

Although the safety record for operations at Hanford and other DOE facilities is generally good, the Richland Operations Office and all Hanford Site contractors have established emergency response plans to prepare for and mitigate the consequences of potential emergencies on the Hanford Site (DOE 1992a). These plans were prepared in accordance with DOE Orders and other federal, state, and local regulations.

5.15.3 Accident Selection for the EIS Analysis

The alternatives for SNF storage considered in this EIS necessitate evaluation of accidents at a variety of different types of facilities. In the no action and enhanced K Basins storage alternatives, the facilities consist of the K Basins where most SNF is currently stored on the Hanford Site. For the other alternatives (wet storage, dry storage following either passivation or calcination, and processing), construction of new SNF management facilities is assumed.

Accidents evaluated for SNF management facilities at Hanford consist of maximum reasonably foreseeable accidents described in such previously published analysis as safety or National Environmental Policy Act documentation, or are adaptations of accident scenarios developed for similar types of facilities. The source documents for specific accidents evaluated in this section are referenced in the detailed accident descriptions, where applicable. In the case of new facilities, hypothetical accidents were based on analysis developed for similar facilities at Hanford or other sites. Transportation accidents are considered in Section 5.11 of this document.

Accident frequencies as reported in safety analysis reports and related analysis typically represents the overall probability of the accident, including the probability of the initiating event combined with the frequency of any contributing events required for an environmental release to occur. The contributing events may include equipment or barrier failures, or failures of other mitigating systems designed to prevent accidental releases. In general, the safety documents do not evaluate the consequences of events with expected frequencies of $<10^{-6}$ per year (one chance in a million) because such accidents are not considered reasonably foreseeable. Evaluation of aircraft traffic at the Richland and Pasco, Washington, airports determined that frequency of accidents involving commercial or military aircraft were less than 1×10^{-7}/year for a facility in the Hanford 300 Area, which is at highest risk because of its location (PNL 1992). Therefore, aircraft accidents are not considered further in this analysis as initiators for accidents at Hanford SNF management facilities.

5.15.4 Method for Accident Consequence Analysis

Accident consequence analysis used release estimates as presented in the source document for a given existing facility or as adapted for this analysis (Bergsman et al. 1995). For new facilities, release estimates were based on existing safety analysis for similar DOE facilities, or on assessments developed specifically for the facilities considered in the alternatives.

Because most source documents (other than the more recent safety analysis reports) do not evaluate hazardous materials other than radionuclides, a different approach was used for accidents involving nonradioactive materials. The hazardous material inventories for each facility were used to estimate releases based on the physical state of each compound. Specific initiators and accident scenarios were generally not postulated for nonradioactive materials; therefore, frequencies were not estimated for accidents involving hazardous chemicals.

The downwind concentrations for materials released in accidents were then calculated at receptor locations as defined for the EIS. The receptors included a nearby worker who is onsite but outside the facility where the accident takes place, a member of the public who is temporarily at the nearest access location (such as a road that crosses the Site, the Columbia River, or at the Site boundary), and the maximally exposed offsite resident. Collective dose to the offsite population within 80 km (50 mi) was calculated for radionuclide releases. Collective dose to workers within the Hanford Site boundary was also estimated. Consequences in terms of the involved workers for representative accident scenarios in each type of facility are discussed in Attachment A to Appendix A, Volume 1 of the DOE SNF PEIS (DOE 1995a), and are not re-evaluated for this analysis.

The accident evaluation is a conservative scoping analysis intended to identify events that would potentially impact onsite or offsite receptors at levels that could result in health effects, and the exposure pathways that would contribute to those consequences. The scenarios for release of radionuclides or hazardous materials to air assume mitigation by facility effluent controls, at least a reduction by 99% for particulate materials released through normal building exhaust systems. No credit is taken for systems designed to prevent or mitigate the emissions from specific types of accidents, such as fire suppression systems or secondary containment for leaks or spills. Atmospheric dispersion following the accident also was estimated using a range of conditions from "typical" conditions (those that might be exceeded 50% of the time) to "bounding" conditions resulting in downwind concentrations that would not be exceeded more than 5% of the time.

Individual doses were based on exposure of the receptor during the entire release, except where the release time was sufficiently long that such an assumption is unrealistic. For releases that were expected to last more than a few hours, the exposure duration for onsite workers and members of the public at accessible onsite locations was limited to 2 hour, corresponding to the assumed time required to evacuate the Hanford Site in the event of an accident. Offsite residents were assumed to be exposed during the entire release, regardless of the accident duration. Exposure via inhalation and external pathways (groundshine and submersion in the plume) were considered for workers and the nearest public access receptors; in addition to those pathways, ingestion of contaminated food was evaluated for offsite residents. Because EPA protective action guidelines specify mitigative actions to prevent consumption of contaminated food, the dose to offsite individuals and populations from inhalation and external pathways is reported separately from the dose including all pathways. Reduced exposure to the plume or to contaminated ground surface as a result of early evacuation of offsite populations was not assumed for the purposes of this analysis, although such actions would also be mandated if the projected dose from an accident exceeded the protective action guidelines.

5.15.5 Radiological Accident Analysis

Radiological accidents resulting in the release of radionuclides into the environment were evaluated for the various types of facilities needed for management of SNF currently stored at the K Basins, under each of the alternatives. In general, the accidents evaluated represent the maximum reasonably foreseeable accidents for a given type of facility and are intended to bound the potential consequences of SNF management activities.

No Action and Enhanced K Basins Storage Alternatives

The no action and enhanced K Basins storage alternatives consist of continued fuel storage at the 100-K Area SNF storage basins, either with or without facility upgrades. Both airborne and liquid release scenarios were evaluated for these facilities.

Cask Drop Scenario. The following describes the bounding K Basin accident that would result in airborne releases. In this scenario, a loaded transfer cask from the N Reactor Basin is dropped accidentally to the floor of the transfer area from a height of 4.6 m (15 ft) because of a postulated crane failure. The scenario assumes that the cask overturns, the cask lid comes off, and the irradiated fuel spills out. The cask is assumed to be loaded with three canisters containing the maximum 14 fuel assemblies in each canister (total of 42 fuel assemblies, 84 elements), all of which are exposed to the ambient air.

The K Basins are enclosed in buildings that do not serve as containment but would at least partially confine or mitigate any releases occurring inside the structure. The buildings have no forced ventilation. Although the scenario assumes that the cask would open if it falls, the probability of such an event is small because the cask has an internal locking mechanism. The locking mechanism is operated by a detachable power tool and is not subject to activation by contact with items or protrusions on the floor or walls. The frequency of this accident is estimated to be 5×10^{-3} to 7×10^{-2} per year over a period of 2 years. The cumulative probability of the accident during removal of KE Basin SNF and sludge is therefore 9×10^{-3} to 0.14. The cumulative probability for no action is assumed to be the same as for enhanced storage because of the potential need to move fuel within the basins during safety upgrades.

The estimated airborne radionuclide release to the environment is based on assumptions and information described in Bergsman et al. (1995). The total amount of fuel released from the building was estimated to be 5.9 g (Table 5-56), consisting of 1.1 g of fuel and 4.8 g of sludge, including 1.5 g during the first 2 hours. (The release rate is taken to be 0.2 g sludge per hour over 24 hours).

The impacts of this accident in terms of dose and latent cancer fatalities in the exposed population are presented in Table 5-57. The maximum dose to an individual member of the public (at an onsite public access point) for this scenario is 0.19 mrem. The collective dose to the offsite population would result no latent cancer fatalities (0.01 to 0.4), if the accident occurred.

Spray Leak Scenario. An airborne release with lower consequences than the cask drop would result from a spray leak in the basin water recirculation system. This accident was evaluated to account for increased water concentrations in the K Basins during dose reduction activities or SNF removal and deactivation. The leak was assumed to develop as a result of blockage and pressure buildup in a line supplying basin water to the filtration and purification systems. The leak of unfiltered water was evaluated for a 24-hour release period for offsite receptors; exposures to onsite workers were assumed to be limited to a single shift (8 hours) of the total release (Table 5-58). The frequency of this accident was estimated as greater than 0.01/year. The cumulative probability over the 40-year period for the no action alternative

Table 5-56. Estimated radionuclide releases for a postulated cask drop accident at the K Basins (Bergsman et al. 1995, Table 3-4)

Radionuclide	Release (Ci) 2-hr	Release (Ci) Total	Radionuclide	Release (Ci) 2-hr	Release (Ci) Total
^{3}H	$5.5x10^{-5}$	$2.1x10^{-4}$	^{135}Cs	$8.8x10^{-8}$	$3.4x10^{-7}$
^{14}C	$8.5x10^{-7}$	$3.3x10^{-6}$	^{137}Cs	0.017	0.064
^{55}Fe	$4.4x10^{-6}$	$1.7x10^{-5}$			
			^{144}Ce	$3.0x10^{-7}$	$1.2x10^{-6}$
^{60}Co	$1.8x10^{-4}$	$7.1x10^{-4}$	^{144}Pr	$3.0x10^{-7}$	$1.2x10^{-6}$
^{59}Ni	$4.9x10^{-8}$	$1.9x10^{-7}$	^{144m}Pr	$3.6x10^{-9}$	$1.4x10^{-8}$
^{63}Ni	$5.6x10^{-6}$	$2.2x10^{-5}$			
			^{147}Pm	$8.4x10^{-4}$	0.0032
^{79}Se	$9.7x10^{-8}$	$3.8x10^{-7}$	^{151}Sm	$1.6x10^{-4}$	$6.0x10^{-4}$
^{85}Kr	$8.3x10^{-4}$	0.0032	^{152}Eu	$1.6x10^{-6}$	$6.4x10^{-6}$
^{90}Sr	0.012	0.047			
			^{154}Eu	$2.8x10^{-4}$	0.0011
^{90}Y	0.012	0.047	^{155}Eu	$3.7x10^{-5}$	$1.4x10^{-4}$
^{93}Zr	$4.4x10^{-7}$	$1.7x10^{-6}$	^{234}U	$5.9x10^{-7}$	$2.3x10^{-6}$
^{93m}Nb	$2.4x10^{-7}$	$9.3x10^{-7}$			
			^{235}U	$1.9x10^{-8}$	$7.4x10^{-8}$
^{99}Tc	$3.3x10^{-6}$	$1.3x10^{-5}$	^{236}U	$1.1x10^{-7}$	$4.3x10^{-7}$
^{106}Ru	$2.7x10^{-6}$	$1.1x10^{-5}$	^{238}U	$5.1x10^{-7}$	$2.0x10^{-6}$
^{107}Pd	$2.3x10^{-8}$	$8.8x10^{-8}$	^{237}Np	$8.7x10^{-8}$	$3.4x10^{-7}$
^{110m}Ag	$4.4x10^{-11}$	$1.7x10^{-10}$	^{238}Pu	$2.6x10^{-4}$	0.0010
^{113m}Cd	$5.4x10^{-6}$	$2.1x10^{-5}$	^{239}Pu	$2.4x10^{-4}$	$9.4x10^{-4}$
^{119m}Sn	$5.9x10^{-11}$	$2.3x10^{-10}$	^{240}Pu	$2.0x10^{-4}$	$7.6x10^{-4}$
^{121m}Sn	$1.0x10^{-7}$	$4.0x10^{-7}$	^{241}Pu	0.014	0.055
^{126}Sn	$1.9x10^{-7}$	$7.3x10^{-7}$	^{242}Pu	$1.6x10^{-7}$	$6.2x10^{-7}$
^{125}Sb	$8.2x10^{-5}$	$3.2x10^{-4}$	^{241}Am	$5.5x10^{-4}$	0.0021
^{126}Sb	$2.6x10^{-8}$	$1.0x10^{-7}$	^{242}Am	$1.3x10^{-6}$	$4.9x10^{-6}$
^{126m}Sb	$1.9x10^{-7}$	$7.3x10^{-7}$	^{242m}Am	$1.3x10^{-6}$	$5.0x10^{-6}$
^{125m}Te	$2.0x10^{-5}$	$7.7x10^{-5}$	^{243}Am	$1.8x10^{-7}$	$7.1x10^{-7}$
^{129}I	$7.6x10^{-9}$	$2.9x10^{-8}$	^{242}Cm	$1.1x10^{-6}$	$4.1x10^{-6}$
^{134}Cs	$8.0x10^{-5}$	$3.1x10^{-4}$	^{244}Cm	$8.3x10^{-5}$	$3.2x10^{-4}$

is therefore taken to be 0.4 to 1, although more than one occurrence might be expected over the life of the proposed storage period. Over the 10-year period before deactivation of KE Basin in the enhanced K Basin storage alternative, the cumulative probability is 0.1 to 1.

The dose and consequences of the accident are presented in Table 5-59, and would not be expected to result in latent fatal cancers.

Liquid Release Scenario for the K Basins. Accidental liquid releases from the K Basins could result from seismic events or other mechanical disruption of the basin or its water supply system (DOE 1994b). The most probable scenario is a break in a 20-cm (8-in.) water supply line that drains into one of the K Basin SNF storage pools, causing it to overfill and overflow onto the

Table 5-57. Dose and consequence for a postulated cask drop accident at the K Basins

	Individual Impacts - Onsite and Offsite			
	Onsite Worker	Onsite Public Access Location	Individual Resident: All Pathways	Individual Resident: Without Ingestion
Dose (rem)	0.23	0.19	0.073	0.033
	Collective Impacts to Onsite Workers			
	50% E/Q[a][b]		95% E/Q	
Dose (person-rem)	6.3		54	
Fatal cancers	None (0.003)		None (0.02)	
	Collective Impacts to Offsite Population within 80 km[c]			
	50% E/Q: All Pathways	50% E/Q: Without Ingestion	95% E/Q: All Pathways	95% E/Q: Without Ingestion
Dose (person-rem)	42	24	720	410
Fatal cancers (if accident occurs)	None (0.02)	None (0.01)	None (0.4)	None (0.2)
Point-risk estimate for latent cancer fatality[d]	$2x10^{-4}$ to $3x10^{-3}$	$1x10^{-4}$ to $2x10^{-3}$	$3x10^{-3}$ to $5x10^{-2}$	$2x10^{-3}$ to $3x10^{-2}$

(a) The term E/Q refers to the time-integrated air concentration at the receptor location for an acute release. It is analogous to the X/Q dispersion parameter used for a chronic release scenario.
(b) The maximum consequence is for the SSW Sector, with 8,000 workers.
(c) The maximum consequence is for the W Sector, with 98,000 residents, (50% E/Q), or the SSE Sector with 78,000 residents (95% E/Q).
(d) The point risk estimate for latent cancer fatality equals the product of the number of latent fatal cancers (if the accident occurs) and the cumulative probability of the accident over the duration of the operation.

surrounding soil. The flow is assumed to continue for 8 hours before the supply is shut off, resulting in release of 2,300 m^3 (600,000 gal) of water over an area of 2.6 ha (6.4 acres) and 60% of the radionuclide inventory in the pool water.

Table 5-58. Estimated radionuclide releases for a postulated spray leak accident at the K Basins (Bergsman et al. 1995, Table 3-6)

	8-hr Release (Ci)	24-hr Release (Ci)
^{3}H	$4.3x10^{-4}$	$1.3x10^{-3}$
^{90}Sr	$3.2x10^{-4}$	$9.5x10^{-4}$
^{137}Cs	$7.7x10^{-4}$	$2.3x10^{-3}$
^{238}Pu	$8.7x10^{-6}$	$2.6x10^{-5}$
$^{239,240}Pu$	$4.2x10^{-5}$	$1.2x10^{-4}$
^{241}Am	$8.8x10^{-7}$	$2.6x10^{-6}$

Table 5-59. Dose and consequences for a postulated spray leak accident at the K Basins

	Individual Impacts - Onsite and Offsite			
	Onsite Worker	Onsite Public Access Location	Individual All Pathways	Resident Without Ingestion
Dose (rem)	0.0067	0.0053	0.0016	$7.2x10^{-4}$
	Collective Impacts to Onsite Workers[(a)]			
	50% E/Q		95% E/Q	
Dose (person-rem)	0.18		1.6	
Fatal Cancers	None ($7x10^{-5}$)		None ($6x10^{-4}$)	
	Collective Impacts to Offsite Population within 80 km[(b)]			
	50% E/Q		95% E/Q	
	All Pathways	Without Ingestion	All Pathways	Without Ingestion
Dose (person-rem	0.94	0.49	16	8.7
Fatal Cancers	None ($5x10^{-4}$)	None ($2x10^{-4}$)	None (0.008)	None (0.004)
Point-risk estimate of latent cancer fatality	$2x10^{-4}$ to $5x10^{-4}$	$1x10^{-4}$ to $2x10^{-4}$	$3x10^{-3}$ to 0.008	$2x10^{-3}$ to 0.004

(a) The maximum consequence is for the SSW Sector, with 8,000 workers.
(b) The maximum consequence is for the W Sector, with 98,000 residents (50% E/Q), or the SSE Sector with 78,000 residents (95% E/Q).

The assumed radionuclide release from this event is tabulated in Table 5-60 for the K Basins. The frequency of this event is estimated to be less than 0.01 per year.

The overflow is assumed to leach through the subsurface environment to the Columbia River. Because the transmission rate of the soil is estimated as 570 cm/day (19 ft/day) (Holdren et al. 1994; Schramke et al. 1994), a leaching rate of 26 cm/day (10 in./day) (i.e., 600,000 gal/8-hours over an acre of 6.4 acres) would not result in the water forming a pond. Therefore, the entire 2,300 m^3 (600,000 gal) of overflow would leach into the soil over an 8-hour period (Bergsman 1995; Whelan et al. 1994). Contaminants are assumed to travel through the vadose zone and the saturated zone to the Columbia River and in the Columbia River to receptors downstream.

The flow rate in the Columbia River assumes low-flow conditions of 1,000 m^3/s (36,000 ft^3/s) (Whelan et al. 1987), which represents the most conservative case for maximizing surface water concentrations. Also as a conservative assumption, the removal of water from the Columbia River is assumed to be 100 m (328 ft) downstream from the point of entry of the contaminant into the river. The assessment addresses recreational activities (e.g., boating, swimming, fishing) in the Columbia River and use of the water as a drinking water supply and for bathing, irrigation, and other uses. For the KE Basin overflow scenario, the maximum dose, considering all pathways and exposure routes, was estimated to be 8.6×10^{-6} rem to an individual with a population risk of 0.0038 latent cancer fatalities. The corresponding individual dose for the KW Basin overflow scenario is 1.9×10^{-8} rem for tritium with a population risk of 7.5×10^{-9} latent cancer fatalities.

Table 5-60. Radionuclides released from K Basins during a postulated liquid overflow accident (Bergsman et al. 1995, Table 3-5)

Radionuclide	Curies Released	
	KE Basin	KW Basin
^{3}H	13	0.48
^{60}Co	0.029	0.0013
^{90}Sr	9.2	1.1
^{134}Cs	0.042	0.0031
$^{137}Cs/^{137m}Ba$	12	0.22
^{238}Pu	0.0098	5.9×10^{-6}
^{239}Pu	0.056	3.1×10^{-5}

Although this incident may represent a most probable scenario, an earthquake or other mechanical failure might involve 100% release of the radionuclide inventory, which would result in dose and risk estimates being a factor of 1.7 higher (i.e., 1/0.6). The overflow scenarios described in the previous paragraphs have been extrapolated to include larger releases because of recent concerns about the effects of a seismic event severe enough to breach joints in the basin or having a cask drop through the pool bottom. A crack in the basin would potentially release all of the basin water and perhaps some of the sludge to the subsurface environment, where it would be available for leaching to groundwater and transport to the Columbia River.

Because the liquid overflow scenario assumes release of over half of the basin water, the dose to a downstream individual from release of all the basin water would be less than twice that estimated for the overflow scenario. Radionuclides in the sludge would be much less mobile and would leach into groundwater slowly, providing time for remediation and mitigation measures as necessary. Even if significant quantities of sludge remained in the subsurface soil for a period before clean up, the dose to downstream individuals and population would not likely be substantially higher than that estimated for the overflow scenario.

This accident would not likely present a hazard to workers at the basin because the scenario involves a relatively fast release of liquid to ground, to groundwater, and on to the Columbia River. Therefore, the potential for direct exposure to basin workers is small.

Wet Storage Alternative

Wet storage of the K Basins SNF in either a pool or a vault containing water-filled MCOs entails removing the fuel from the K Basins and transporting it to the storage facility in the 200 Area. The consequences of accidents during these activities would depend on the quantity of material released to the environment and the location of the receptors relative to the accident site. Accidents associated with the removal and storage activities are discussed in the following subsections.

Removal of Fuel from the K Basins. Bounding plausible accidents for fuel removal from the K Basins are similar to those discussed in the no action alternative, except that larger quantities of fuel may be handled in a single operation when transferring the fuel in MCOs. For this alternative, a crane failure accident with a loaded MCO is evaluated. In this accident at the K Basins, an MCO in the process of placement or retrieval is dropped by lifting equipment or human failure. The MCO falls to the floor of the storage area. The drop causes a release of MCO contents (fuel, sludge, and water) to the staging area floor, resulting in an airborne release. The estimated frequency is 0.002 to 0.03 per year, and the cumulative probability over 2 years of fuel removal is 0.004 to 0.06.

The estimated airborne radionuclide release to the environment is based on assumptions and information described in Bergsman et al. (1995). The radionuclide release is tabulated in Table 5-61 based on the worst-case canister, which contains Mark IV fuel from the KE Basin. The source terms shown

Table 5-61. Source term associated with an airborne release of fuel following a postulated MCO-handling accident at K Basins (Bergsman et al. 1995, Table 3-9)

Radionuclide	Release, Ci 2-hr	Release, Ci Total	Radionuclide	Release, Ci 2-hr	Release, Ci Total
^{3}H	1.8×10^{-4}	7.1×10^{-4}	^{135}Cs	2.9×10^{-7}	1.1×10^{-6}
^{14}C	2.8×10^{-6}	1.1×10^{-5}	^{137}Cs	0.055	0.21
^{55}Fe	1.5×10^{-5}	5.7×10^{-5}			
			^{144}Ce	1.0×10^{-6}	3.9×10^{-6}
^{60}Co	6.1×10^{-4}	0.0024	^{144}Pr	1.0×10^{-6}	3.9×10^{-6}
^{59}Ni	1.6×10^{-7}	6.3×10^{-7}	^{144m}Pr	1.2×10^{-8}	4.7×10^{-8}
^{63}Ni	1.9×10^{-5}	7.2×10^{-5}			
			^{147}Pm	0.0028	0.011
^{79}Se	3.2×10^{-7}	1.3×10^{-6}	^{151}Sm	5.2×10^{-4}	0.002
^{85}Kr	0.0028	0.011	^{152}Eu	5.5×10^{-6}	2.1×10^{-5}
^{90}Sr	0.040	0.16			
			^{154}Eu	9.3×10^{-4}	0.0036
^{90}Y	0.040	0.16	^{155}Eu	1.2×10^{-4}	4.8×10^{-4}
^{93}Zr	1.5×10^{-6}	5.7×10^{-6}	^{234}U	2.0×10^{-6}	7.6×10^{-6}
^{93m}Nb	8.0×10^{-7}	3.1×10^{-6}			
			^{235}U	6.4×10^{-8}	2.5×10^{-7}
^{99}Tc	1.1×10^{-5}	4.2×10^{-5}	^{236}U	3.7×10^{-7}	1.4×10^{-6}
^{106}Ru	9.1×10^{-6}	3.5×10^{-5}	^{238}U	1.7×10^{-6}	6.5×10^{-6}
^{107}Pd	7.6×10^{-8}	2.9×10^{-7}	^{237}Np	2.9×10^{-7}	1.1×10^{-6}
^{110m}Ag	1.5×10^{-10}	5.7×10^{-10}	^{238}Pu	8.8×10^{-4}	0.0034
^{113m}Cd	1.8×10^{-5}	7.0×10^{-5}	^{239}Pu	8.1×10^{-4}	0.0031
^{119m}Sn	2.0×10^{-10}	7.6×10^{-10}	^{240}Pu	6.6×10^{-4}	0.0025
^{121m}Sn	3.5×10^{-7}	1.3×10^{-6}	^{241}Pu	0.048	0.18
^{126}Sn	6.3×10^{-7}	2.4×10^{-6}	^{242}Pu	5.4×10^{-7}	2.1×10^{-6}
^{125}Sb	2.7×10^{-4}	0.0011	^{241}Am	0.0018	0.0071
^{126}Sb	8.8×10^{-8}	3.4×10^{-7}	^{242}Am	4.3×10^{-6}	1.6×10^{-5}
^{126m}Sb	6.3×10^{-7}	2.4×10^{-6}	^{242m}Am	4.3×10^{-6}	1.7×10^{-5}
^{125m}Te	6.7×10^{-5}	2.6×10^{-4}	^{243}Am	6.2×10^{-7}	2.4×10^{-6}
^{129}I	2.5×10^{-8}	9.8×10^{-8}	^{242}Cm	3.5×10^{-6}	1.4×10^{-5}
^{134}Cs	2.7×10^{-4}	0.0010	^{244}Cm	2.8×10^{-4}	0.0011

are for current isotopic content of 10 Mark IV canisters, based on release of 19.8 g of fuel and sludge in 24 hours, including 5.1 g in the first 2 hours.

The consequences of this accident in terms of dose and risk of latent cancer fatality in the exposed population are presented in Table 5-62. The maximum individual dose in this scenario is 0.78 rem for the onsite worker. The collective dose to the population would result in at most two latent cancer fatalities if the accident occurred.

Table 5-62. Dose and consequences from a postulated MCO-handling accident at the K Basins

	Individual Impacts - Onsite and Offsite			
			Individual Resident	
	Onsite Worker	Onsite Public Access Location	All Pathways	Without Ingestion
Dose (rem)	0.78	0.61	0.24	0.11
	Collective Impacts to Onsite Workers			
	50% E/Q[(a)(b)]		95% E/Q	
Dose (person-rem)	21		180	
Fatal Cancers	None (0.009)		None (0.07)	
	Collective Impacts to Offsite Population within 80 km			
	50% E/Q[(c)]		95% E/Q	
	All Pathways	Without Ingestion	All Pathways	Without Ingestion
Dose (person-rem)	140	78	2400	1400
Fatal Cancers	None (0.07)	None (0.04)	1	1
Point-risk estimate of latent cancer fatality	$3x10^{-4}$ to $4x10^{-3}$	$2x10^{-4}$ to $2x10^{-3}$	$5x10^{-3}$ to $7x10^{-2}$	$3x10^{-3}$ to $4x10^{-2}$

(a) The term E/Q refers to the time-integrated air concentration at the receptor location for an acute release. It is analogous to the X/Q dispersion parameter used for a chronic release scenario.
(b) The maximum consequence is for the SSW Sector, with 8,000 workers.
(c) The maximum consequence is for the W Sector, with 98,000 residents, (50% E/Q), or the SSE Sector with 78,000 residents (95% E/Q).

Fuel Storage at 200 Areas Facility. The following information describes bounding plausible accidents for the either a pool or vault wet storage facility. The accident at a vault storage facility results from overpressurization of an MCO. A second accident that could apply to either type of wet storage is a crane failure that causes an MCO to drop. Both accidents are described in the following sections.

MCO Overpressurization. During transport from the K Basins to the wet storage vault, enhanced corrosion of fuel may cause excessive pressure in a sealed MCO. The MCO would be in the receiving area of the vault; the pressure ruptures the rupture disk with potential releases of aerosols outside of the building or a release of hydrogen with a potential hydrogen deflagration and release of the MCO contents. The air exhaust stack is assumed to be 50 m (165 ft) high. The estimated frequency of this accident is 1×10^{-4} to 1×10^{-2} per year over 2 years of SNF shipment from the K Basins to the new storage facility. The cumulative probability of the accident is therefore 2×10^{-4} to 2×10^{-2}.

Information and assumptions used to estimate the amount of material released are described in Bergsman et al. (1995), and the releases by radionuclide are shown in Table 5-63. The release quantity is assumed to be 333.6 g of material.

The consequences of this accident are listed in Table 5-64, with a maximum individual dose of 2.7 rem to the onsite worker. The collective dose to the population would result in at most 8 latent fatal cancers if the accident occurred.

Crane Failure and MCO Drop. In the crane failure accident with an MCO at a wet storage facility, an MCO in the process of placement or retrieval is dropped as a result of lifting equipment or human failure. It falls into a storage tube containing one MCO that had previously been placed there, rupturing both MCOs. The drop causes a release of MCO contents (fuel, sludge, and water), resulting in an airborne release. The estimated frequency is 0.002 to 0.03 per year over 2 years of transferring SNF to the storage facility. The cumulative probability is 0.004 to 0.07 over the course of the transport. Assumptions used to model the accident scenario and releases are described in Bergsman et al. (1995).

The source term is tabulated in Table 5-65 based on the worst-case fuel, which is Mark IV fuel from the KE Basin. The source terms shown are for

Table 5-63. Estimated release associated with a postulated 10-canister MCO overpressurization accident (Bergsman et al. 1995, Table 3-15)

Radionuclide	Total Release (Ci)	Radionuclide	Total Release (Ci)
^{3}H	0.012	^{135}Cs	1.9×10^{-5}
^{14}C	1.8×10^{-4}	^{137}Cs	3.6
^{55}Fe	9.5×10^{-4}		
		^{144}Ce	6.6×10^{-5}
^{60}Co	0.040	^{144}Pr	6.5×10^{-5}
^{59}Ni	1.1×10^{-5}	^{144m}Pr	7.9×10^{-7}
^{63}Ni	0.0012		
		^{147}Pm	0.18
^{79}Se	2.1×10^{-5}	^{151}Sm	0.034
^{85}Kr	0.18	^{152}Eu	3.6×10^{-4}
^{90}Sr	2.6		
		^{154}Eu	0.060
^{90}Y	2.6	^{155}Eu	0.0081
^{93}Zr	9.6×10^{-5}	^{234}U	1.3×10^{-4}
^{93m}Nb	5.2×10^{-4}		
		^{235}U	4.2×10^{-6}
^{99}Tc	7.1×10^{-4}	^{236}U	2.4×10^{-25}
^{106}Ru	5.9×10^{-4}	^{238}U	1.1×10^{-4}
^{107}Pd	4.9×10^{-6}	^{237}Np	1.9×10^{-5}
^{110m}Ag	9.5×10^{-9}	^{238}Pu	0.057
^{113m}Cd	0.0012	^{239}Pu	0.053
^{119m}Sn	1.3×10^{-8}	^{240}Pu	0.043
^{121m}Sn	2.2×10^{-5}	^{241}Pu	3.1
^{126}Sn	4.1×10^{-5}	^{242}Pu	3.5×10^{-5}
^{125}Sb	0.018	^{241}Am	0.12
^{126}Sb	5.7×10^{-6}	^{242}Am	2.8×10^{-4}
^{126m}Sb	4.1×10^{-5}	^{242m}Am	2.8×10^{-4}
^{125m}Te	0.0043	^{243}Am	4.0×10^{-5}
^{129}I	1.6×10^{-6}	^{242}Cm	2.3×10^{-4}
^{134}Cs	0.0010	^{244}Cm	0.018

current isotopic content of 10 Mark IV canisters. The release of 408.6 g of material is assumed to occur over 24 hours, including 115 g in the initial 2 hours.

Table 5-64. Dose and consequences from a postulated MCO overpressurization accident at the 200 Areas fuel storage facility

	Individual Impacts - Onsite and Offsite			
		Onsite Public	Individual Resident	
	Onsite Worker	Access Location	All Pathways	Without Ingestion
Dose (rem)	2.7	0.55	0.87[a]	0.40
	Collective Impacts to Onsite Workers[b]			
	50% E/Q		95% E/Q	
Dose (person-rem)	270		2500	
Fatal cancers	None (0.1)		1	
	Collective Impacts to Offsite Population within 80 km[c]			
	50% E/Q		95% E/Q	
	All Pathways	Without Ingestion	All Pathways	Without Ingestion
Dose (person-rem)	990	570	1.6×10^{4}	9,000
Fatal cancers	1	None (0.3)	8	5
Point-risk estimate of latent cancer fatality	1×10^{-4} to 2×10^{-1}	6×10^{-5} to 6×10^{-3}	2×10^{-3} to 2×10^{-1}	9.0×10^{-4} to 9.0×10^{-2}

(a) The estimated potential dose to an offsite resident from the ingestion pathway is 0.5 rem. In practice, the dose would be limited by protective action guidelines that specify remedial measures if the potential dose is greater than 0.5 rem.
(b) Maximum consequence is for the SE Sector, with 9,500 workers.
(c) Maximum consequence is for the SE Sector, with 115,000 residents (50% E/Q), or the W Sector, with 103,000 residents (95% E/Q).

The consequences of this accident are listed in Table 5-66 with a maximum individual dose of 1.1 rem to the offsite resident. The collective dose to the population would result in less than 10 latent cancer fatalities, if the accident occurs.

Drying/Passivation with Dry Storage Alternative

For the drying/passivation alternative, the fuel would be removed from the K Basins, placed in the same MCOs as described within the wet storage alternative, and sent to a drying or passivation facility in the 200 Areas for

Table 5-65. Release associated with a postulated MCO drop accident at the 200 Area wet storage facility (Bergsman et al. 1995, Table 3-16)

	Release, Ci			Release, Ci	
Radionuclide	2-hr	Total	Radionuclide	2-hr	Total
^{3}H	0.0041	0.015	^{135}Cs	6.6×10^{-6}	2.3×10^{-5}
^{14}C	6.3×10^{-5}	2.3×10^{-4}	^{137}Cs	1.2	4.4
^{55}Fe	3.3×10^{-4}	0.0012			
			^{144}Ce	2.3×10^{-5}	8.0×10^{-5}
^{60}Co	0.014	0.049	^{144}Pr	2.3×10^{-5}	8.0×10^{-5}
^{59}Ni	3.6×10^{-6}	1.3×10^{-5}	^{144m}Pr	2.7×10^{-7}	9.6×10^{-7}
^{63}Ni	4.2×10^{-4}	0.0015			
			^{147}Pm	0.063	0.22
^{79}Se	7.3×10^{-6}	2.6×10^{-5}	^{151}Sm	0.012	0.041
^{85}Kr	0.062	0.22	^{152}Eu	1.2×10^{-4}	4.4×10^{-4}
^{90}Sr	9.0×10^{-1}	3.2			
			^{154}Eu	0.021	0.074
^{90}Y	0.90	3.2	^{155}Eu	0.0028	0.0099
^{93}Zr	3.3×10^{-5}	1.2×10^{-4}	^{234}U	4.4×10^{-5}	1.6×10^{-4}
^{93m}Nb	1.8×10^{-5}	6.4×10^{-5}			
			^{235}U	1.4×10^{-6}	5.1×10^{-6}
^{99}Tc	2.4×10^{-4}	8.7×10^{-4}	^{236}U	8.3×10^{-6}	2.9×10^{-5}
^{106}Ru	2.0×10^{-4}	7.2×10^{-4}	^{238}U	3.8×10^{-5}	1.3×10^{-4}
^{107}Pd	1.7×10^{-6}	6.0×10^{-6}	^{237}Np	6.5×10^{-6}	2.3×10^{-5}
^{110m}Ag	3.3×10^{-9}	1.2×10^{-8}	^{238}Pu	0.020	0.070
^{113m}Cd	4.0×10^{-4}	0.0014	^{239}Pu	0.018	0.065
^{119m}Sn	4.4×10^{-9}	1.6×10^{-8}	^{240}Pu	0.015	0.052
^{121m}Sn	7.7×10^{-6}	2.7×10^{-5}	^{241}Pu	1.1	3.8
^{126}Sn	1.4×10^{-5}	5.0×10^{-5}	^{242}Pu	1.2×10^{-5}	4.3×10^{-5}
^{125}Sb	0.0061	0.022	^{241}Am	0.041	0.15
^{126}Sb	2.0×10^{-6}	7.0×10^{-6}	^{242}Am	9.5×10^{-5}	3.4×10^{-4}
^{126m}Sb	1.4×10^{-5}	5.0×10^{-5}	^{242m}Am	9.6×10^{-5}	3.4×10^{-4}
^{125m}Te	0.0015	0.0053	^{243}Am	4.1×10^{-5}	4.9×10^{-5}
^{129}I	5.7×10^{-7}	2.0×10^{-6}	^{242}Cm	7.9×10^{-5}	2.8×10^{-4}
^{134}Cs	0.0059	0.021	^{244}Cm	0.0062	0.022

treatment before storage. Accidents associated with these activities would be the same as those described previously for the K Basins and the wet storage facility, with the exception that fuel may be repackaged for shipment from the K Basins to the new storage facilities. If fuel is repackaged to include 19 full canisters rather than 10, the releases and impacts of those accidents would be about 1.9 times greater. Two additional accident scenarios specific to this alternative are described in the following sections: 1) MCO fire at the K Basins and 2) MCO fire at the new passivation facility.

Table 5-66. Dose and consequences from a postulated MCO drop accident at the 200 Areas wet storage facility

	Individual Impacts - Onsite and Offsite			
		Onsite Public Access Location	Individual Resident	
	Onsite Worker		All Pathways	Without Ingestion
Dose (rem)	0.94	0.19	1.1[a]	0.49
	Collective Impacts to Onsite Workers[b]			
	50% E/Q		95% E/Q	
Dose (person-rem)	92		880	
Fatal Cancers	None (0.04)		None (0.4)	
	Collective Impacts to Offsite Population within 80 km[c]			
	50% E/Q		95% E/Q	
	All Pathways	Without Ingestion	All Pathways	Without Ingestion
Dose (person-rem)	1200	700	1.9×10^{4}	1.1×10^{4}
Fatal Cancers	1	None (0.4)	10	6
Point-risk estimate of latent cancer fatality	2×10^{-3} to 4×10^{-2}	1×10^{-3} to 2×10^{-2}	4×10^{-2} to 6×10^{-1}	2×10^{-2} to 4×10^{-1}

(a) The estimated potential dose to an offsite resident from the ingestion pathway is 0.59 rem. In practice, the dose would be limited by protective action guidelines that specify remedial measures if the potential dose is greater than 0.5 rem.
(b) Maximum consequence is for the SE Sector, with 9,500 workers.
(c) Maximum consequence is for the SE Sector, with 115,000 residents (50% E/Q) or the W Sector, with 103,000 residents (95% E/Q).

Fuel Removal from the K Basins. A number of different methods are currently being considered for loading SNF into MCOs and preparing the MCOs for transport, as described in Bergsman et al. (1995). Some of these methods could result in the SNF being placed within water-flooded MCOs. In the water-flooded condition, the fuel would continue to corrode and generate gaseous corrosion products. Shipments would have to be timely and closely supervised to prevent excess gas pressure inside the MCO from corrosion. The MCO design would provide for emergency pressure relief, which could take the form of a rupture disk.

Each of the fuel loading methods could also be modified to drain the water and vacuum dry the SNF at the K Basins to greatly reduce the uranium corrosion and gas generation during transport and staging before stabilization.

Conservative plausible accidents for fuel removal are the same as those discussed in the no action and wet storage alternatives for handling and removal of SNF from the K Basins, with the addition a fuel fire in an MCO, which is discussed in the following section.

Stabilization and Storage of K Basins SNF. After removal of SNF from the K Basins, accidents associated with drying or passivation include a fuel fire in an MCO. Accidents at the dry storage facility could result in failure of an MCO; however, this accident was not evaluated in detail. The estimated release (less than 1 μg/day), and the projected frequency of the event (1×10^{-6} to 1×10^{-4} per year) are so low that the consequences would be very small.

Fuel Stabilization at a Drying/Passivation Facility. An MCO containing 10 canisters of irradiated fuel and sludge is in the process of being dried and passivated at a temperature of 300°C (572°F). As a result of a loss of system pressure boundary integrity or other failure, control of the process is lost and the fuel rapidly oxidizes. The heat of oxidation combines with the heat being externally supplied by the passivation process. The fuel in the MCO oxidizes with the potential for release of radioactive materials through pressure boundary failure and complete oxidation. The frequency of such an event was estimated to be 1×10^{-6} to 1×10^{-4} per year, during 2 years required to passivate the fuel, resulting in a cumulative probability of 2×10^{-6} to 2×10^{-4}.

Table 5-67 contains the estimated airborne release from this accident based on 10 canisters of the "worst case" fuel (Mark IV fuel irradiated to 16.72% ^{240}Pu/total Pu and cooled 16 years) (Bergsman et al. 1995). Repackaging fuel to load the MCOs more efficiently would increase the estimated release by a factor of 1.9.

The consequences of this accident are listed in Table 5-68 with a maximum individual dose of 2 rem to the offsite resident. The collective dose to the population would result in less than one (0.03) to 17 latent fatal

Table 5-67. Release estimates for a postulated MCO fire accident (Bergsman et al. 1995, Table 3-22 Mitigated Release[a])

Radionuclide	Release (Ci)	Radionuclide	Release (Ci)
^{3}H	118	^{135}Cs	1.70×10^{-4}
^{14}C	1.82	^{137}Cs	32.2
^{55}Fe	9.42×10^{-5}	^{137m}Ba	0.338
^{59}Ni	1.05×10^{-6}	^{144}Ce	6.50×10^{-6}
^{60}Co	0.00391	^{144}Pr	6.46×10^{-6}
^{63}Ni	1.20×10^{-4}	^{144m}Pr	7.80×10^{-8}
^{79}Se	2.09×10^{-6}	^{147}Pm	0.0180
^{85}Kr	1780	^{151}Sm	0.00334
^{90}Sr	0.259	^{152}Eu	3.54×10^{-5}
^{90}Y	0.259	^{153}Gd	1.10×10^{-11}
^{93}Zr	9.51×10^{-6}	^{154}Eu	0.00598
^{93m}Nb	5.15×10^{-6}	^{155}Eu	7.99×10^{-4}
^{99}Tc	6.98×10^{-5}	^{234}U	1.26×10^{-5}
^{106}Rh	5.83×10^{-5}	^{235}U	4.13×10^{-7}
^{106}Ru	5.83×10^{-5}	^{236}U	2.38×10^{-6}
^{107}Pd	4.88×10^{-7}	^{237}Np	1.87×10^{-6}
^{110}Ag	1.25×10^{-11}	^{238}Pu	0.00564
^{110m}Ag	9.42×10^{-10}	^{238}U	1.09×10^{-5}
^{113m}Cd	1.16×10^{-4}	^{239}Pu	0.00521
^{119m}Sn	1.26×10^{-9}	^{240}Pu	0.00422
^{121m}Sn	2.22×10^{-6}	^{241}Am	0.0118
^{125}Sb	0.00175	^{241}Pu	0.305
^{126}Sb	5.64×10^{-7}	^{242}Am	2.74×10^{-5}
^{126}Sn	4.05×10^{-6}	^{242}Cm	2.28×10^{-5}
^{126m}Sb	4.05×10^{-6}	^{242}Pu	3.46×10^{-6}
^{125m}Te	4.27×10^{-4}	^{242m}Am	2.75×10^{-5}
^{129}I	0.0163	^{243}Am	3.97×10^{-6}
^{134}Cs	0.153	^{244}Cm	0.00177

(a) This accident involves 3.3 MTU (approximately 10 canisters) of the "worst case" Mark IV fuel. Releases to the building air from the MCO were assumed to consist of 9% of the semivolatile cesium inventory, and 0.1% of all other nonvolatile radionuclides (unmitigated release in Bergsman et al., 1995, Table 3-22). The facility emission controls were assumed to remove an additional 99% of cesium and nonvolatile radionuclides before effluents exit the building stack (mitigated release in Bergsman et al., 1995, Table 3-22). Release of volatile radionuclides (hydrogen, carbon, krypton, and iodine) from the facility was assumed to equal 100% of the MCO inventory.

cancers if the accident occurs and no protective action is taken. Repackaging in the MCO would increase the consequences by a factor of about 1.9 (0.06 to 32 latent fatal cancers if the accident occurs).

Table 5-68. Dose and consequences from a postulated MCO fire accident at the 200 Areas drying/passivation facility

	Individual Impacts - Onsite and Offsite			
			Individual Resident	
	Onsite Worker	Onsite Public Access Location	All Pathways	Without Ingestion
Dose (rem)				
10 Canisters/MCO	0.29	0.059	2.0[(a)]	0.045
19 Canisters/MCO	0.55	0.11	3.8	0.086

	Collective Impacts to Onsite Workers[(b)]	
	50% E/Q	95% E/Q
10 Canisters/MCO		
Dose (person-rem)	29	270
Fatal Cancers	None (0.01)	None (0.1)
19 Canisters/MCO		
Dose (person-rem)	55	510
Fatal Cancers	None (0.02)	None (0.2)

	Collective Impacts to Offsite Population within 80 km[(c)]			
	50% E/Q		95% E/Q	
	All Pathways	Without Ingestion	All Pathways	Without Ingestion
10 Canisters/MCO				
Dose (person-rem)	2100	63	3.4×10^{4}	990
Fatal Cancers	1	None (0.03)	17	1
Point-risk estimate of latent cancer fatality	2×10^{-6} to 2×10^{-4}	6×10^{-8} to 6×10^{-6}	3×10^{-5} to 3×10^{-3}	1×10^{-6} to 1×10^{-4}
19 Canisters/MCO				
Dose (person-rem)	4000	120	6.5×10^{4}	1900
Fatal Cancers	2	None (0.06)	32	1
Point-risk estimate of latent cancer fatality	4×10^{-6} to 4×10^{-4}	1×10^{-7} to 1×10^{-5}	6×10^{-5} to 6×10^{-3}	2×10^{-6} to 2×10^{-4}

a) The estimated potential dose to an offsite resident from the ingestion pathway is 1.9 rem. In practice, the dose would be limited by protective action guidelines that specify remedial measures if the potential dose is greater than 0.5 rem.
(b) Maximum consequence is for the SE Sector, with 9,500 workers.
(c) Maximum consequence is for the SE Sector, with 115,000 residents (50% E/Q), or the W Sector, with 103,000 residents (95% E/Q).

If the MCO fire were to occur at the 100 Area during handling or cold vacuum drying of the fuel, the consequences would be more severe than at the 200 Areas because the radionuclides released would exit the K Basins via a shorter stack and the distance to potentially exposed members of the public is smaller. An accident of this type is assumed to require an external heat source in addition to the decay heat generated by the fuel to initiate the fire, based on current information available about the nature of the stored SNF. A fire would be much less likely to occur at the K Basins during handling or during cold vacuum drying of the fuel because much less heat is applied; however, an analysis of the consequences is included in this section to provide a bounding accident for the cold vacuum drying process and a perspective on the maximum impact if hot drying were also performed at the K Basins.

The estimated emissions from an MCO fire at the K Basins are shown in Table 5-67. The consequences of the accident (Table 5-69) indicate that less than one (0.08) to 44 latent cancer fatalities could occur if the accident happens and no protective action is taken. Repackaging of SNF in the MCO could increase the consequences of this accident by a factor pf 1.9 (0.1 to 84 latent cancer fatalities if the accident occurs). In addition, should the MCO fail without adequate fire protection or should the facility emission controls fail, the consequences of the accident at either the 100 or 200 Areas could be higher.

Calcination with Dry Storage Alternative

If calcination were chosen as the stabilization method for K Basins SNF, the accidents associated with removal of fuel from the basins and staging and storage of fuel at the 200 Area facilities would be the same as for the drying/passivation alternative. The only exception would be that fuel removed from the K Basins would likely not be dried before transporting it to the 200 Area. Therefore, the accidents described for vacuum drying and the MCO fire at either the 100 or 200 Areas would not apply. The only additional accident that would apply to this alternative is a fire in a fuel dissolver cell, which would also constitute the bounding accident for the onsite processing alternative.

The design basis accident for the shear leach calcine facility is the complete burn of 7 MTU of fuel in the fuel dissolver. There are no other potential accidents associated with the calcine process that would involve a greater quantity of fuel or greater release fraction. The estimated amount of fuel released from a uranium burn during the fuel dissolution process is based on assumptions and information described in Bergsman et al. (1995). The

Table 5-69. Dose and consequences for a postulated MCO fire accident at the K Basins

	Individual Impacts - Onsite and Offsite			
			Individual Resident	
	Onsite Worker	Onsite Public Access Location	All Pathways	Without Ingestion
Dose (rem)				
10 Canisters/MCO	5.5	4.3	9.2 [a]	0.21
19 Canisters/MCO	10.	8.2	17.	0.38

	Collective Impacts to Onsite Workers[b]	
	50% E/Q	95% E/Q
10 Canisters/MCO		
Dose (person-rem)	150	1300
Fatal Cancers	None (0.06)	1
19 Canisters/MCO		
Dose (person-rem)	290	2500
Fatal Cancers	None (0.1)	1

	Collective Impacts to Offsite Population within 80 km[c]			
	50% E/Q		95% E/Q	
	All Pathways	Without Ingestion	All Pathways	Without Ingestion
10 Canisters/MCO				
Dose (person-rem)	5100	150	8.8×10^{4}	2600
Fatal Cancers	3	None (0.08)	44	1
Point-risk estimate of latent cancer fatality	5×10^{-6} to 5×10^{-4}	2×10^{-7} to 2×10^{-5}	9×10^{-5} to 9×10^{-3}	3×10^{-6} to 3×10^{-4}
19 Canisters/MCO				
Dose (person-rem)	9700	290	1.7×10^{5}	4900
Fatal Cancers	5	None (0.1)	84	2
Point-risk estimate of latent cancer fatality	1×10^{-5} to 1×10^{-3}	3×10^{-7} to 3×10^{-5}	2×10^{-4} to 2×10^{-2}	5×10^{-6} to 5×10^{-4}

(a) The estimated potential dose to an offsite resident from the ingestion pathway is 9 rem. In practice, the dose would be limited by protective action guidelines that specify remedial measures if the potential dose is greater than 0.5 rem.
(b) Maximum consequence is for the SSW Sector, with 8,000 workers.
(c) Maximum consequence is for the W Sector, with 98,000 residents (50% E/Q), or the SSE Sector, with 78,000 residents (95% E/Q).

frequency of this accident was estimated as 10^{-6} to 10^{-4} per year. The cumulative probability of this accident over 4 years of operating the calcine or process facility is 4 x 10^{-6} to 4 x 10^{-4}. Releases of specific radionuclides to the environment are listed in Table 5-70.

The consequences of this accident are presented in Table 5-71, with a maximum individual dose of 4.1 rem to the offsite resident from all exposure pathways. The collective risk to the population would be less than one (0.07) to 37 latent fatal cancers if the accident occurs and no protective action is taken.

Table 5-70. Release estimate for a postulated dissolver fire at a calcination or process facility in the 200 Area (Bergsman et al. 1995, Table 3-27)

Radionuclide	Release (Ci)	Radionuclide	Release (Ci)
^{3}H	250	^{129}I	0.0346
^{14}C	3.87	^{134}Cs	0.325
^{55}Fe	$2.00x10^{-4}$	^{135}Cs	$3.61x10^{-4}$
^{59}Ni	$2.22x10^{-6}$	^{137}Cs	68.2
^{60}Co	0.008	^{137m}Ba	0.717
^{63}Ni	$2.55x10^{-4}$	^{144}Ce	$1.38x10^{-5}$
^{79}Se	$4.42x10^{-6}$	^{144}Pr	$1.37x10^{-5}$
^{85}Kr	3770	^{144m}Pr	$1.65x10^{-7}$
^{90}Sr	0.549	^{147}Pm	0.0381
^{90}Y	0.549	^{151}Sm	0.00708
^{93}Zr	$2.02x10^{-5}$	^{152}Eu	$7.52x10^{-5}$
^{93m}Nb	$1.09x10^{-5}$	^{153}Gd	$2.33x10^{-11}$
^{99}Tc	$1.48x10^{-4}$	^{154}Eu	0.0127
^{106}Rh	$1.24x10^{-4}$	^{155}Eu	0.00169
^{106}Ru	$1.24x10^{-4}$	^{234}U	$2.68x10^{-5}$
^{107}Pd	$1.03x10^{-6}$	^{235}U	$8.77x10^{-7}$
^{110}Ag	$2.66x10^{-11}$	^{236}U	$5.04x10^{-6}$
^{110m}Ag	$2.00x10^{-9}$	^{237}Np	$3.97x10^{-6}$
^{113m}Cd	$2.46x10^{-4}$	^{238}Pu	0.012
^{119m}Sn	$2.67x10^{-9}$	^{238}U	$2.30x10^{-5}$
^{121m}Sn	$4.71x10^{-6}$	^{239}Pu	0.0111
^{125m}Te	$9.07x10^{-4}$	^{240}Pu	0.00896
^{125}Sb	0.00372	^{241}Am	0.0251
^{126}Sb	$1.20x10^{-6}$	^{241}Pu	0.647
^{126}Sn	$8.58x10^{-6}$	^{242}Am	$5.81x10^{-5}$
^{126m}Sb	$8.58x10^{-6}$	^{242}Cm	$4.83x10^{-5}$
^{243}Am	$8.43x10^{-6}$	^{242}Pu	$7.34x10^{-6}$
^{244}Cm	0.00375	^{242m}Am	$5.84x10^{-6}$

Table 5-71. Dose and consequences from a postulated dissolver fire at the 200 Area calcine or process facilities

	Individual Impacts - Onsite and Offsite			
			Individual Resident	
	Onsite Worker	Onsite Public Access Location	All Pathways	Without Ingestion
Dose (rem)	0.62	0.13	4.1[a]	0.095

	Collective Impacts to Onsite Workers[b]	
	50% E/Q	95% E/Q
Dose (person-rem)	60	580
Fatal Cancers	None (0.02)	None (0.2)

	Collective Impacts to Offsite Population within 80 km[c]			
	50% E/Q		95% E/Q	
	All Pathways	Without Ingestion	All Pathways	Without Ingestion
Dose (person-rem)	4600	130	7.3×10^4	2100
Fatal Cancers	2	None (0.07)	37	1
Point-risk estimate of latent cancer fatality	9×10^{-6} to 9×10^{-4}	3×10^{-7} to 3×10^{-5}	1×10^{-4} to 1×10^{-2}	4×10^{-6} to 4×10^{-4}

(a) The estimated potential dose to an offsite resident from the ingestion pathway is 4 rem. In practice, the dose would be limited by protective action guidelines that specify remedial measures if the potential dose is greater than 0.5 rem.
(b) Maximum consequence is for the SE Sector, with 9,500 workers.
(c) Maximum consequence is for the SE Sector with 115,000 residents (50% E/Q), or the W Sector, with 103,000 residents (95% E/Q).

Onsite Processing Alternative

Processing K Basins SNF via a solvent extraction process would involve activities similar to those of the calcination with dry storage alternative, except that the extracted uranium and plutonium oxides rather than calcined SNF would be stored. The high-level waste resulting from the separation process would be treated with other similar wastes at the Hanford Site. Accidents associated with fuel removal from the K Basins and staging in the

200 Areas would be similar to those described in the wet storage alternative. Accidents at the process facility would be bounded by the uranium fire described in the previous section for the calcine facility (see Tables 5-70 and 5-71). Accidents during storage of uranium and plutonium are described in safety documentation for existing facilities and have not been reevaluated for this analysis. The bounding accident associated with uranium storage is addressed in the *UO_3 Plant Safety Analysis Report* (WHC 1993b). Actual impacts are likely to be lower than those estimated in the safety analysis because the uranium will be stored inside a building rather than outside as they are in the UO_3 Plant. The bounding accident associated with plutonium storage is addressed in the *PFP Safety Analysis Report* (WHC 1995).

Foreign Processing Alternative

Accidents associated with preparation of K Basins SNF for overseas shipment would generally be the same as those described previously for the no action alternative. A dropped transfer cask represents the maximum reasonably foreseeable accident associated with loading the fuel for shipment (Tables 5-56 and 5-57). The cumulative frequency and point risk estimates of latent fatal cancer are assumed to be twice those for the enhanced K Basin storage alternative, however, because the fuel in both the KE and KW Basins would be removed for shipment. Other accidents related to continued operation of the K Basins--the liquid release and spray leak scenarios (Tables 5-58, 5-59, and 5-60)--would result in lower consequences than the cask drop, and they would be less likely because of the limited time during which the K Basins would operate under this alternative.

5.15.6 Secondary Impacts of Radiological Accidents

Secondary impacts of radiological accidents have been evaluated qualitatively for this analysis. Although the levels of environmental contamination were not assessed directly, the dose to the offsite MEI provides a measure of the air concentration and radionuclide deposition at the Site boundary. Therefore, the dose can be used as a semi-quantitative estimate of the level of environmental contamination from a given accident.

Accidents that result in estimated doses of less than 0.5 rem to the MEI would likely have little or no secondary impacts because the levels of offsite environmental contamination in these cases would be relatively small.

Accidents that exceed estimated doses of 0.5 rem to the MEI would have some secondary impacts, with their extent and severity depending on the expected levels of environmental contamination. Protective action guidelines would require mitigating actions such as evacuation of residents surrounding the Site or interdiction of food crops depending on the nature and location of the accident as described in Section 5.20. Other secondary impacts might include:

- local (onsite) effects on ecosystems or individual members of some sensitive species
- temporary closure of the Columbia River, shorelines, and affected islands (including restrictions on traditional fishing rights and recreational use of the river for boating or fishing)
- temporary local restrictions on use of river water for agricultural or domestic purposes
- possible loss of agricultural crops
- temporary restrictions on land use for agricultural purposes
- costs associated with cleanup of environmental contamination.

Accidents evaluated for this EIS that could result in secondary impacts of this magnitude include MCO handling or overpressure accidents at the wet storage facility, an MCO fire at K Basins or the passivation facility, and a uranium fire at the calcination or processing facility. Others would result in only local, onsite impacts.

5.15.7 Nonradiological Accident Analysis

For purposes of this EIS, a bounding accident scenario was developed for each existing and planned facility. The methods for assessment of the nonradiological accident scenario are summarized in this section. The accident assumes that a chemical spill occurs within a building and is followed by an environmental release from the normal exhaust system. It is assumed that the building remains intact but containment measures fail, allowing releases to occur through the ventilation system. The assumption is made that all, or a portion of, the entire inventory of toxic chemicals stored in each building is spilled. The environmental releases are modeled, and the hypothetical concentrations at three key receptor locations are compared to toxicological limits.

Several chemical inventory and chemical emissions lists are provided by alternative and facility in Bergsman et al. (1995) and the DOE SNF PEIS (DOE 1995a, Table A-18). Effects to collocated workers, the public at nearest point of public access, and the public at the nearest offsite residence were estimated using the computer model EPIcode (Homann Associates Incorporated 1988). Results from the EPIcode model were compared to available Emergency

Response Planning Guideline values, Immediately Dangerous to Life and Health values, and Threshold Limit Values/Time Weighted Averages. In the absence of these values, acute toxicity data from the Registry of Toxic Effects for Chemical Substances were utilized to generate exposure limits to approximate Emergency Response Planning Guideline endpoints--irritation/odor, irreversible health effects, and death.

Table 5-72 presents for all alternatives the bounding nonradiological impacts to collocated workers, the public at the nearest point of public access, and the public at the nearest offsite residence for the postulated accident scenarios. The potential consequences of these accidents are discussed in the following subsections

No Action Alternative

A baseline of chemicals kept in the K Basins was developed from chemical inventories for these facilities compiled in 1992 to comply with the Emergency Planning and Community Right-To-Know Act.

Under the no action alternative, there would be a potential for fatalities to collocated workers and the public at the nearest point of public access from an accident in which sulfuric acid is released from the KE or KW Basin or PCBs are released from the KE Basin facility. The public at the nearest offsite residence could suffer health effects from the accident involving the release of PCBs in the KE Basin facility. Health effects to collocated workers and the public at the nearest point of public access could also occur from an accident in which sodium hydroxide is released from either the KE or KW Basins. Irritation and odor would be problem for nearby workers and public at nearest point of public access from accidents involving the release of chlorine stored in either basin or by polyacrylamide released from the KW Basin.

Enhanced K Basins Storage Alternative

The enhanced K Basins storage alternative would have the same accident scenarios and impacts as the no action alternative.

Wet Storage Alternative

Because the K Basins would be in operation during the removal and transport of the SNF to the wet storage facility, accident scenarios under the wet storage alternative would include accident scenarios described in the no action alternative. The new wet storage facility can be either a storage pool

Table 5-72. Nonradiological exposure to public and workers during a postulated accident

Alternative/Facility/Chemical	Worker Exposure (mg/m³)	Exposure at Nearest Public Access (mg/m³)	Exposure at Nearest Public Resident (mg/m³)	ERPG 1[a] or TLV/TWA (mg/m³)	ERPG 2[b] or 0.1 IDLH (mg/m³)	ERPG 3[c] or IDLH (mg/m³)
No action alternative						
KE Basin						
Chlorine	4.30	4.30	0.13	**2.9**[d]	8.7	58
PCB	23.00	23.00	0.66	**0.5**	**0.5**	**5**
Sodium hydroxide	140.00	140.00	0.40	2	20	200
Sulfuric acid	220.00	220.00	6.40	**2**	**10**	**30**
KW Basin						
Chlorine	4.30	4.30	0.13	**2.9**	8.7	58
Ethylene glycol	2.40	2.40	0.07	127	300	3000
Kerosene	15.00	0.86	0.43	100	500	5000
Polyacrylamide	4.20	0.24	0.12	**0.03**	400	4000
Sodium hydroxide	140.00	140.00	0.40	**2**	**20**	200
Sulfuric acid	220.00	220.00	6.40	**2**	**10**	**30**
Wet storage alternative						
Wet storage pool						
Chlorine	0.75	0.10	0.04	**2.9**	**8.7**	**58**
Sodium hydroxide	36.00	1.10	0.06	**2**	**20**	200
Sulfuric acid	39.00	5.30	2.00	**2**	**10**	**30**
Vault storage facility						
No chemicals of concern						
Passivation alternative						
Passivation facility						
Diesel fuel	0.42	0.40	0.26	7	170	1700
Sodium hydroxide	0.09	0.07	0.02	2	20	200
Sodium nitrite	0.11	0.10	0.06	96	960	9600
Sulfuric acid	0.53	0.51	0.32	2	10	30
Calcination alternative						
Calcination facility						
Diesel fuel	0.42	0.40	0.26	7	170	1700
Nitric acid	21.00	20.00	13.00	**5.2**	25.8	258
Sodium hydroxide	0.86	0.73	0.20	2	20	200
Sodium nitrite	0.11	0.10	0.06	96	960	9600
Sulfuric acid	0.53	0.51	0.32	2	10	30
Uranyl nitrate hexahydrate	0.84	0.80	0.51	**0.2**	2	20
Onsite processing alternative						
Onsite processing facility						
Cadmium nitrate tetrahydrate	0.03	0.03	0.02	0.05	10.5	105
Diesel fuel	0.42	0.40	0.26	7	170	1700
Hydrazine	0.02	0.02	0.01	0.13	10.5	104.8
Kerosene	0.84	0.81	0.51	100	500	5000
Nitric acid	21.00	20.00	13.00	**5.2**	25.8	258
Potassium permanganate	0.00	0.00	0.00	2	10	30
Sodium hydroxide	0.86	0.73	0.20	2	20	200
Sodium nitrite	0.11	0.10	0.06	96	960	9600
Sulfuric acid	0.53	0.51	0.32	2	10	30
Uranyl nitrate hexahydrate	0.84	0.80	0.51	**0.2**	2	20

(a) Emergency Response Planning Guideline (ERPG) value 1 (irritation or odor), or Threshold Limit Values/Time Weighted Averages (TLV/TWA), or value for a similar toxicological end point from toxicological data in the Registry of Toxic Effects for Chemical Substances (RTEC).
(b) ERPG 2 (irreversible health effects), or 0.1 of Immediately Dangerous to Life and Health (IDLH), or value for a similar toxicological end point from toxicological data in RTEC.
(c) ERPG 3 (death), IDLH, or value for a similar toxicological end point from toxicological data in RTEC.
(d) Bold, underline type indicates that the toxicological limit was exceeded at one or more exposure points.

or a storage vault. The wet storage pool uses the KE Basin as a surrogate for a baseline chemical inventory. The vault storage facility does not have any significant amounts of chemicals (Bergsman et al. 1995).

Under the wet storage alternative, impacts from the accident scenarios involving the K Basins would present the major health impacts to workers and the public. After the K Basins are shut down, the impacts from accident scenarios involving the new storage pool (Table 5-72) would be possible fatalities to collocated workers from a release of sulfuric acid. No significant impacts would occur from accident scenarios involving the new storage vault.

Drying/Passivation With Dry Storage Alternative

Accidents under conditions of this alternative would include scenarios for the drying/passivation facility as well as those described in the no action alternative because the K Basins would still be in operation during the removal and transport of the SNF, and those described in the wet storage alternative in this section because the fuel would need to be temporarily stored before passivation.

Consequences of accidents at the drying/passivation facilities are based on previously evaluated accidents for similar installations, adapted for the conditions and location of these facility as assumed in this EIS. Baseline chemical inventories for the proposed facility are primarily derived from the facility engineering design data (DOE 1995a).

Under the passivation alternative, the major health impacts to workers and the public would be from accidents involving the chemicals stored in the K Basins. Impact on workers and the public from accidents involving the chemicals stored in the passivation plant would be small and would pose no major health risks (Table 5-72).

Calcination Followed by Dry Storage Alternative

Accidents under conditions of the calcination alternative would include accident scenarios for the calcination facility and those described in the no action alternative in this section because the K Basins would still be in operation during the removal of the fuel from the basins, and those described in the wet storage alternative in this section because the fuel would need to be temporarily stored before being processed by the calcination facility.

Consequences of accidents at the calcination facility are based on previously evaluated accidents for similar installations, adapted for the conditions and location of this facility as assumed in this EIS. Baseline chemical inventories for the proposed facility are primarily derived from the facility engineering design data (DOE 1995a).

Under the calcination alternative, the major health impacts to workers and the public would be from accidents involving the chemicals stored in the K Basins. The major health impacts from the calcination facility would be potential irritation and odor problem for collocated workers and the public from accidental releases of nitric acid or uranyl nitrate hexahydrate stored in the calcination facility (Table 5-72).

Onsite Processing Followed by Storage Alternative

Accidents in the onsite processing alternative would include accident scenarios for the processing facility as well as those described in the no action alternative in this section because the K Basins would still be in operation during the removal of the fuel, and those described in the wet storage alternative in this section because the fuel would need to be temporarily stored before processing.

Consequences of the processing facility accidents are based on previously evaluated accidents for similar installations, adapted for the conditions and location of these facilities as assumed in this EIS. Baseline chemical inventory for the proposed facilities is primarily derived from the facility engineering design data (DOE 1995a).

Under the onsite processing alternative, the major health impacts to the workers and the public would be from accidents involving chemicals stored in the K Basins. The major health impacts from the processing facility (see Table 5-72) would be potential irritation or odor problems from the releases of nitric acid or uranyl nitrate hexahydrate stored in the processing facility.

Foreign Processing Alternative

Because the K Basins would be in operation during the removal and transport of the SNF, accident scenarios under the foreign processing alternative would include accident scenarios described in the no action alternative. Of the three new facilities (the transloading facility, the staging facility, and the UO_3 storage facility) associated with the foreign processing alternative the transloading and UO_3 facilities would not have any significant amounts of chemicals (Bergsman et al. 1995). The staging facility would be the same as the facility in the wet storage alternative.

Under the foreign processing alternative, impacts from accident scenarios involving the K Basins would present the major health impacts to workers and the public. After the K Basins are shut down, significant impacts would be from accident scenarios involving the staging facility as described in the wet storage alternative.

5.15.8 Construction and Occupational Accidents

Table 5-73 shows the estimated number of injuries, illnesses, and fatalities among workers from construction activities and facility operations for each alternative. Injury, illness, and fatality rates for construction workers are presented separately from those for facility operation because of the relatively more hazardous nature of construction work.

The alternatives that require processing or calcination of the K Basin SNF before storage represent the highest predicted construction and occupational accident rates of the alternatives. The higher number of injuries is attributable to the increased scope of construction and labor requirements for fuel stabilization in these alternatives. The lowest accident rates for the onsite alternatives are associated with the passivation/dry storage alternative because of the relatively simpler nature of the construction and the longer-term labor savings from dry storage of the stabilized SNF. The foreign processing alternative results in the lowest onsite consequences because a substantial amount of activity (construction and operation of the process facility) would occur at an overseas location.

5.16 Cumulative Impacts Including Past and Reasonably Foreseeable Actions

Cumulative impacts associated with implementing the alternatives for storage of K Basins SNF at the Hanford Site together with impacts from past and reasonably foreseeable future actions are described in the following subsections.

5.16.1 Land Use, Geological Resources, and Ecological Resources

The Hanford Site covers about 1450 km^2 (570 mi^2), of which about 87 km^2 (34 mi^2) have been disturbed. Implementation of the no action and enhanced K Basins alternatives would not affect land use at Hanford because all facilities utilized in these alternatives currently exist. Construction of new facilities in the other alternatives for storage of K Basins SNF would disturb varying areas of previously undisturbed land if construction occurred at the reference site, up to a maximum of 20 acres for the onsite processing alternative. Construction at the CSB site would occur on land that has previously

Table 5-73. Estimated occupational injuries, illnesses, and fatalities for facility construction and operation

Alternative	Labor (worker-years)		Injury/Illness[a]			Fatality[a]		
	Construction	Operations	Construction	Operations	Total	Construction	Operations	Total
No action	0	11,200	0	358	358	0.0	0.4	None (0.4)
Enhanced K Basin storage	0	8,440	0	270	270	0.0	0.3	None (0.3)
New wet storage:								
Vault--CSB site	320	5,747	20	184	204	0.0	0.2	None (0.2)
Vault--reference site	370	5,747	23	184	207	0.0	0.2	None (0.2)
Pool--CSB site	270	5,747	17	184	201	0.0	0.2	None (0.2)
Pool--reference site	330	5,747	20	184	204	0.0	0.2	None (0.2)
Drying/passivation/dry storage								
Minimum	549	3,507	34	112	146	0.1	0.1	None (0.2)
Maximum	704	3,507	44	112	156	0.1	0.1	None (0.2)
Calcination/dry storage:								
Minimum	3,265	6,437	202	206	408	0.4	0.2	1
Maximum	3,420	6,437	212	206	418	0.4	0.2	1
Onsite processing:								
Minimum	3,867	7,509	240	240	480	0.4	0.2	1
Maximum	3,967	7,509	246	240	486	0.4	0.2	1
Foreign processing	17	4,555	1	146	147	0.0	0.1	None (0.1)

(a) The following rates were assumed to apply to construction and operation of DOE facilities (DOE 1995a, Vol. 2, Table F-4-7):

Consequence Rates per Worker-year	Operations	Construction
Injury/illness	0.032	0.062
Accidental fatality	0.000032	0.00011

been excavated and would require little if any new land disturbance. The represents less than 0.1% of the existing disturbed area on the Site, and less than 0.01% of the total Site. The impact of any of the alternatives would therefore be negligible in terms of land use or geological resources.

The cumulative effects of constructing new SNF management facilities in relatively undisturbed areas such as the reference site, in addition to other ongoing or future developments, may reduce the availability of shrub-steppe habitat at Hanford. For example, construction of the Environmental Restoration Disposal Facility would disturb approximately 4.1 km^2 (1,000 acres) of land. Shrub-steppe habitat is used by several listed or candidate bird and mammal species for forage or nesting, although nesting of these species was not directly observed at the sites surveyed for the facilities evaluated in this EIS. Fragmentation or removal of potential nesting and foraging habitat could negatively affect the long-term viability of populations of these species at Hanford.

5.16.2 Air Quality

Air quality limits (WAC 173-470-030,-100) at the Hanford Site boundary are not expected to be approached as a result of reasonably foreseeable additions to the Hanford Site, e.g., construction and operation of a Laser Interferometer Gravitational-Wave Observatory or from decommissioning of unused facilities or site restoration activities. Air quality analysis for the EIS alternatives indicates that implementation of any of the alternatives (other than foreign processing) would result in little likelihood of these limits being exceeded, even in conjunction with other site activities and other nuclear facilities in the region (e.g., the WNP-2 power reactor or the nearby Siemens commercial reactor fuel fabrication facility).

Under the foreign processing alternative, construction of a transloading facility at the 100-K Area could result in fugitive dust concentrations that approach 24-hour air quality standards at locations accessible by the public. Although dust suppression measures could be employed, the proximity of these facilities to the Columbia River would make it difficult to ensure that the air quality standards could be met if construction of SNF management facilities were to coincide with some other construction or Site restoration activities.

5.16.3 Waste Management

Low-level radioactive wastes generated as a result of facility operations would amount to less than 5% of the total quantity that is expected to be produced at Hanford during 1995 for all alternatives, and deactivation of the K Basins would contribute an additional quantity equivalent to 5 to 10% of the annual production rate (see Section 5.14).

Annual production of transuranic waste from routine operations would contribute from less than 1 to about 20% of the current Site annual production for the wet storage and onsite processing alternatives, respectively. Deactivation of one or both of the K Basins could produce transuranic waste equivalent to 30 to 70% of the annual production at Hanford if KE Basin floor sludge and sludge from the SNF canisters were disposed as radioactive waste at the 200 Area tank farms.

High-level wastes would only be produced during operation of a processing facility in the onsite processing alternative, and the total quantity generated over the 4-year period during which the facility would operate is relatively small compared to the current Site inventory. Vitrified high-level waste generated during foreign processing would ultimately be stored at Hanford with other treated tank wastes and also would not substantially increase the quantity of such wastes that would be generated by remediation of existing tank waste.

5.16.4 Socioeconomics

The Hanford Site work force has dropped from above 18,000 in 1994 to less than 14,000 in late 1995 and is expected to remain approximately at that level through 2004. The regional work force is expected to range from 81,000 to 86,000 in that same period.

Under the no action and enhanced K Basins storage alternatives, the SNF work force would remain substantially the same, about 190 to 280 workers. Construction and operation of new facilities in the other alternatives would add up to about 1,100 workers on a temporary basis and would result in a net decrease of 200 to 300 workers compared to the no action alternative on a longer-term basis. The temporary increases in the onsite work force would not likely necessitate a substantial increase in the need for community services, and may help to offset projected work force reductions over the short term. However, if peak construction activities coincide with the schedule for other major projects planned for the Hanford Site (for example, construction of facilities for the tank waste remediation project), there may be short-term impacts on community services and infrastructure.

5.16.5 Occupational and Public Health

The cumulative population dose since plant startup was estimated to be about 100,000 person-rem (estimated to one significant figure; Section 4.12.2). The number of inferred fatal cancers since plant startup would amount to about 50 (essentially all of which would be attributed to dose received in the 1945-to-1952 timeframe). In the 50 years since plant startup, the population of interest (assuming a constant population of 380,000 and an individual dose of about 0.3 rem/year) would have received about 5,000,000 person-rem from naturally occurring radiation sources (natural background), which might result in about 2,500 latent cancer fatalities. In the same 50 years, about 27,000 cancer fatalities from all causes would have been expected in that population.

Over the next 40 years, if the Hanford Sitewide contribution to public dose from all exposure pathways is considered (about 0.5 person-rem/year from DOE facilities and 0.7 person-rem/year from Washington Public Power Supply System reactor operation), it is estimated that the cumulative collective dose would be approximately 50 person-rem. No latent cancer fatalities would be expected from such a dose. Over 40 years of interim storage of SNF, the population (380,000 people) would have received 4,000,000 person-rem from natural background radiation. That dose might result in 2,000 latent cancer fatalities. In the same 40 years, about 21,000 cancer fatalities from all causes would be expected among the population in the region of interest (within 80 km or 50 miles).

Air and water quality limits for radionuclides and other potentially hazardous pollutants are not expected to be approached as a result of implementing any of the EIS alternatives or from reasonably foreseeable activities at the Hanford Site. Therefore, health consequences to workers or the public would not be expected as a result of discharges from SNF management operations.

The cumulative dose from all SNF storage activities since facility startup was estimated at about 2,000 person-rem (DOE 1995a, Section 4.12.1.2), from which one fatal cancer might be inferred. In the near term, the annual increments to cumulative worker dose would be expected to be about 21 person-rem from operation of the K Basins. No latent fatal cancers would be expected from 40 years of SNF storage in the no action alternative (about 910 person-rem). Cumulative worker dose from storage and stabilization as needed for K Basins SNF in the other alternatives would be somewhat higher than in the no action alternative, and might result in at most one latent cancer fatality.

The worker dose from future site restoration activities is difficult to quantify; however, if Hanford Site workers continue to accumulate dose at the 1994 rate of 210 person-rem/year, the cumulative dose over the next 40 years would be about 8400 person-rem. The cumulative dose from the start up of plant operations through the end of the 40-year SNF management period would therefore amount to about 110,000 person-rem, from which 50 latent cancer fatalities would be inferred (3 of which are attributable to the SNF management period from 1996 to 2035). Over 90 years, about 110 latent cancer fatalities would be inferred from natural background radiation, and 1300 cancer fatalities from all causes would be expected, in a population of 10,000 workers.

5.17 Adverse Environmental Impacts that Cannot be Avoided

Unavoidable adverse impacts that might arise as a result of implementing the alternatives for interim storage of SNF at the Hanford Site are discussed in the following subsections.

5.17.1 No Action and Enhanced K Basins Storage Alternatives

Adverse impacts associated with the no action and enhanced K Basins storage alternatives would derive from the expense and radiation exposure associated with maintaining facilities that are near or at the end of their design life and the possible future degradation of fuel and facilities, thus increasing the potential for release of pollutants to the environment.

5.17.2 Other EIS Alternatives

Adverse impacts associated with the EIS alternatives where fuel is relocated to the 200 Areas would derive principally from construction activities needed for new facilities. There would be loss or fragmentation of wildlife habitat, displacement of some animals from the construction site, and the destruction of plant life within the site up to 8 ha (20 acres) if an undisturbed site is chosen for construction of new facilities. Criteria pollutants, radionuclides, and hazardous chemicals would also be released during some types of SNF management activities. Traffic congestion and noise are expected to increase by a few percent during the construction of major facilities.

5.18 Relationship Between Short-Term Uses of the Environment and the Maintenance and Enhancement of Long-Term Productivity

Storage of K Basins SNF is considered for up to 40 years pending decisions on ultimate disposition. SNF is essentially uranium-238 with varying amounts of uranium-235 and small amounts of plutonium contaminated by small masses of high-activity fission products. Because of this composition, a decision could be made at the end of the planned storage period to either continue storage until the energy resource value of the SNF warrants processing or to determine that the fuel will never have any resource value and will be disposed of. If the decision is to continue to store the SNF, that option could be seen as the best use of land at the Hanford Site in terms of long-term productivity.

If the decision is made to dispose of the SNF, land occupied by SNF management facilities at the Hanford Site could become available for other uses. Because of the potential for, or perception of, contamination by radionuclides or hazardous chemicals, use of the land for agriculture might not be appropriate. Moreover, the land that is currently occupied, or which would be occupied, by SNF facilities was of marginal utility for farming before it was obtained for the Hanford Site. However, other uses, such as for wildlife refuges, might be appropriate long-term uses of land vacated by SNF facilities after decommissioning is completed.

5.19 Irreversible and Irretrievable Commitment of Resources

This section addresses the irretrievable commitment of resources that would likely be used to implement the proposed EIS alternatives. An irretrievable resource is a resource that is irreplaceably consumed and cannot be replenished.

If DOE decides to locate SNF management facilities at the reference site, or at another previously undisturbed site, construction of the facilities could destroy shrub-steppe habitat, which has been designated as priority habitat by the State of Washington. This loss would continue until the SNF facilities were decommissioned, and the site returned to its natural state. If the CSB site were utilized for SNF management, additional loss of habitat would not occur because the site was previously developed for another project. In either case, land utilized by the facilities would not be available for other use until after final decommissioning.

With respect to the discharge of water to the soil column through the ETF and SALDS, no hazardous substances other than tritium would be released. Tritium will decay in time, making the soil column available for other uses.

Implementation of EIS alternatives requiring construction of new facilities would result in the irretrievable use of labor, fossil fuels and other raw materials in construction activities and in the transport of raw materials to the project site. In addition, there would be an irretrievable use of electricity and fossil fuel in the SNF removal and transport operations. The relative degree of irretrievable and irreversible use of resources in SNF management alternatives is summarized in Table 5-74.

5.20 Potential Mitigation Measures

This section contains a description of possible mitigation measures that might be considered to avoid or reduce impacts to the environment as a result of Hanford Site operations in support of K Basins SNF management. These measures would be reviewed and revised as appropriate, depending on the specific actions to be taken at a facility, the level of impact, and other pertinent factors. Following publication of the record of decision, a mitigation plan would be prepared to address actions specific to the selected alternative. That plan would be implemented, as necessary, to mitigate significant adverse impacts of SNF management activities. Possible mitigation measures are generally the same for all alternatives and are summarized by resource category below. No impacts on land use, geologic resources, or aesthetic and scenic resources were identified; therefore, mitigation measures would not be necessary.

5.20.1 Pollution Prevention/Waste Minimization

The DOE is responding to Executive Order 12856 (58 FR 41981) and associated DOE Orders and guidelines by reducing the use of toxic chemicals; improving emergency planning, response, and accident notification; and encouraging the development and use of clean technologies and the testing of innovative pollution prevention technologies. Program components include waste minimization, source reduction and recycling, and procurement practices that preferentially procure products made from recycled materials. The pollution prevention program at the Hanford Site is formalized in a Hanford Site Waste Minimization and Pollution Prevention Awareness Program Plan (DOE 1994a).

Table 5-74. Irreversible and irretrievable commitment of resources

Consequence Category	Unit of Measure	Alternatives						
		No Action	Enhanced K Basin Storage	New Wet Storage	Passivation Dry Storage	Calcination Dry Storage	Onsite Processing	Foreign Processing
Land use (new facilities):								
Total disturbed	ha	0	0	2.8	3.5	5.2	8.1	1.6
	acres	0	0	6.9	8.6	15.	20.	4.0
Ecological resources:								
New habitat destruction	ha	0	0	0-2.8	0-3.5	0-5.2	0-8.1	0
	acres	0	0	0-6.9	0-8.6	0-13	0-20.	0
Socioeconomics:								
Primary employment								
Maximum annual	workers	280	280	480	850	1300	1300	310
Storage annual		280	210	80	10	10	10	10
Total labor (40-year storage)	100 worker-years	110	84	56	43	100	120	46
Resource use: SNF consolidation, removal, construction								
Electricity	MWh	-	-	1200-2800	3500-4600	6100-7200	6900-8500	-
Diesel fuel	m^3	-	-	500-1100	890-1300	1500-1900	1600-2200	-
	1000 gal	-	-	130-290	240-350	400-500	420-580	-
Gasoline	m^3	-	-	-	190	830	1100	-
	1000 gal	-	-	-	50	220	290	-
Lumber	m^3	-	-	-	61	850	1100	-
	1000 bd ft	-	-	-	26	360	470	-
Gases	m^3	-	100	100	7200	4000	100	100
	100 ft^3	-	35	35	250	140	35	35
Stainless steel	100 Tonnes	-	-	15-30	16-31	19-34	23-37	1.3-2.0
	100 Tons	-	-	17-33	18-34	21-37	25-41	1.4-2.2
Construction steel	100 Tonnes	-	1.0	32-62	39-67	76-100	84-110	2.6
	100 Tons	-	1.1	35-68	43-74	84-110	92-120	2.9
Concrete	100 m^3	-	-	59-140	120-170	300-360	350-430	18
	100 yd^3	-	-	77-180	160-220	390-470	460-560	24
Water	100 m^3	-	3-6	350	80	530	7400	3-6
	1000 gal	-	80-160	9300	2100	1.4×10^5	20×10^5	80-160

Table 5-74. (contd)

Consequence Category	Unit of Measure	Alternatives: No Action	Enhanced K Basin Storage	New Wet Storage	Passivation Dry Storage	Calcination Dry Storage	Onsite Processing	Foreign Processing
Operations								
Electricity, maximum storage	100 MWh/yr	140 140	140 93	150 140	150 1	230 1	530 1	140 -
Gases	1000 kg/yr 1000 lb/yr	- -	- -	- -	41 90	- -	- -	- -
Chlorine	kg/yr lb/yr	1300 2900	1300 2900	1300 2900	1300 2900	1300 2900	1300 2900	1300 2900
Alum	100 kg/yr 100 lb/yr	88 190	88 190	88 190	88 190	88 190	88 190	88 190
Nitric acid	1000 L/yr 1000 gal/yr	- -	- -	- -		100 27	1100 290	- -
Water	100 m^3 1000 gal/yr	58 1500	38 1000	23-39 610-1000	40 1100	200 5300	300 8000	38 1000
Cost:								
40-year storage	Billion Dollars	1.7	1.2	0.96	0.99	2.0	2.7	2.1-3.8
Life cycle		2.1-3.7	1.6-3.2	1.3-2.9	1.1-2.7	2.1	2.7	2.2-3.9

The SNF program activities would be conducted in accordance with this plan, and implementation of the pollution prevention and waste minimization plans would minimize the generation of waste during SNF management activities.

5.20.2 Socioeconomics

The level of predicted employment for any of the proposed SNF management activities at the Hanford Site is not large enough in comparison with present Hanford, local, or regional employment to produce a boom-bust impact on the economy. Therefore mitigation measures would not likely be necessary.

5.20.3 Cultural (Including Archaeological and Cultural) Resources

To avoid loss of cultural resources during construction of SNF facilities on the Hanford Site, a cultural resources survey of the area of interest has been conducted. The survey did not identify cultural resources that might preclude construction at the either of the proposed new facility sites. If, however, during construction (earth moving) any cultural resource is discovered, construction activities would be halted and the find would be evaluated to determine its appropriate disposition.

5.20.4 Air Resources

To avoid impacts associated with emissions of fugitive dust during construction activities, exposed soils would be treated using standard dust suppression techniques, or by stockpiling soil under a cover where necessary. Following construction, soil loss would be controlled by revegetation and relandscaping of disturbed areas. Any soil that might become contaminated as a result of SNF management activities could be remediated using methods appropriate to the type and extent of contamination.

Construction activities would not be expected to generate fugitive dust at levels that exceed air quality standards, except possibly construction of facilities near the Site boundary in conjunction with the foreign processing alternative. In that case, standard dust suppression techniques could be used to reduce the particulate loading levels to an acceptable level (EPA 1993). New facility sources of pollutant emissions to the atmosphere would be designed using best available technology to reduce emissions to as low as reasonably achievable.

5.20.5 Water Resources

The impacts to surface and groundwater sources could be minimized through recycling of water, where feasible, and with clean-up of excess process water before release to ground or surface water. Levels of contaminants that might affect surface or groundwater quality are controlled by permit where process effluents are released to the environment.

5.20.6 Ecology

To avoid impacts to threatened, endangered, candidate, or state-identified sensitive species, preconstruction surveys have been completed to determine the presence of these species or their habitat. During these surveys, the proposed construction sites at Hanford were not found to contain currently listed species. The shrub-steppe habitat identified at the reference site provides potential nesting or foraging habitat for listed species. Shrub-steppe habitat has been identified as priority habitat by the state of Washington because of its relative scarcity in the region outside of Hanford.

If the reference site, or another undisturbed site, were selected for construction of new SNF management facilities, a habitat replacement program could be implemented to mitigate the loss. This could be accomplished by restoration of natural habitat in other disturbed areas of the Site as old facilities are decommissioned, or by purchase and protection of lands containing such habitat in another location. The preferred mechanism by which the loss would be mitigated is to avoid loss of the habitat by selecting a previously developed site, such as the CSB site, for SNF management activities.

5.20.7 Noise, Traffic, and Transportation

Generation of construction and operations noise would be reduced, as practicable, by using equipment that complies with EPA noise guidelines (40 CFR 201-211). Construction workers and other personnel working in environments exceeding EPA-recommended guidelines during SNF storage construction or operation would be provided with hearing protection devices approved by the Occupational Safety and Health Administration (29 CFR 1910). Because of the remote location of the Hanford SNF activities, there would be no construction noise impacts with respect to the public for which mitigation would be necessary.

At sites with increasing traffic concerns, DOE could encourage use of high-occupancy vehicles (such as vans or buses), implementing carpooling and ride-sharing programs, and staggering work hours to reduce peak traffic and associated traffic noise.

5.20.8 Occupational and Public Health and Safety

Members of the general public would not be expected to experience any adverse consequences as a result of routine SNF management activities considered in this document. Design and construction of facilities would incorporate the best available technology to control discharge of potentially hazardous materials to the environment.

Exposure of workers to radioactive or other potentially hazardous materials would be controlled using the ALARA ("as low as reasonably achievable") principle. As part of the SNF management program, operations would be reviewed before implementing them to identify measures that could be used to minimize worker exposures. Examples of such activities that might be implemented at the K Basins include cleaning or removing contaminated equipment from the work areas, providing extra shielding at work locations, using remote handling techniques for high-exposure operations where possible, and providing training to minimize the time required to perform tasks in high-exposure areas. Worker safety programs and operating procedures could also be developed to reduce the potential for industrial accidents.

5.20.9 Site Utilities and Support Services

No mitigation measures beyond those identified in Section 5.20.4 for ground disturbance activities associated with bringing power and water to the SNF site would appear necessary. In those cases use of standard dust suppression techniques and revegetation of disturbed areas would mitigate ground disturbance impacts.

5.20.10 Accidents

Although the safety record for operations at Hanford and other DOE facilities is good, DOE Richland Operations Office and all Hanford Site contractors have established emergency response plans to prepare for and mitigate the consequences of potential emergencies on the Hanford Site (DOE 1992a). These plans were prepared in accordance with DOE Orders and other federal, state, and local regulations. The plans describe actions that will be taken to evaluate the severity of a potential emergency and the steps necessary to notify and coordinate the activities of other agencies having emergency response functions in the surrounding communities. They also specify levels at which the hazard to workers and the public are of sufficient concern that protective action should be taken. The Site holds regularly scheduled exercises to ensure that individuals with responsibilities in emergency planning are properly trained in the procedures that have been implemented to mitigate the consequences of potential accidents and other events. The Hanford Site emergency response plans would be updated to include consideration of new SNF facilities and activities as necessary.

The consequences of potential accidents at facilities can be mitigated in several ways, including facility design to prevent or reduce emissions and provision for protective action for workers and members of the public. Facility design may incorporate features to maintain the building's integrity and prevent release of hazardous materials when subjected to mechanical or thermal stress (such as earthquakes, external impacts, or internal fires or explosions). Emission controls in the form of secondary containment barriers, filtration of exhaust air and other features to be installed to minimize release of hazardous substances under normal operation as well as accident conditions. Other safety systems may be incorporated into facilities if needed to mitigate the potential consequences of accidents involving specific processes unique to that facility. Examples include fire detection and suppression equipment, auxiliary exhaust filters such as high-efficiency particulate air (HEPA) filters that are activated if a hazardous material is released within the building, and detectors and alarms that provide workers and emergency response personnel with early warning of an abnormal event so that preventive or protective action could be taken.

Safety evaluations would be performed in conjunction with the design of SNF management facilities to ensure that the risks associated with their operation fall within acceptable guidelines. Specifications for seismic protection and emission controls would be in accordance with DOE and EPA standards to reduce the potential consequences of accidents. Facility emission controls (containment, pre-filters, HEPA filters and other specialized systems) would be designed to maintain facility emissions at acceptable levels both during normal operation, and in the event of an accident. In the event of an accident, protective action guidelines have been established to specify the types of measures that might be necessary to protect the public. Examples of such actions include sheltering or evacuating nearby members of the public, restricting public access to onsite public roads or to the Columbia River adjacent to the Site, or restrictions on the use of potentially contaminated food or water.

5.21 Environmental Justice

As a result of Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations* (59 FR 7629), federal agencies are responsible for identifying and addressing the possibility of disproportionately high and adverse environmental impacts of their programs and activities on minority and low-income populations. This section considers the location of minority and low-income populations surrounding the Hanford Site and considers their susceptibility to disproportionately adverse environmental consequences of operations to retrieve, prepare, and store SNF currently stored in the KE and KW Basins for all alternatives considered in this EIS. In addition, for the foreign processing alternative, the analysis also considers these population groups at example ports where the fuel might be loaded and unloaded for shipment to/from a foreign processor. Impacts along transportation routes for either routine operations or accidents to even the MEI located at 100 m (30 ft) from the release site are estimated to be insignificant (Section 5.11 and Appendix B). Because the consequences for any individual of any group from transportation are insignificant, minority and low-income individuals are not considered to be adversely and disproportionately affected along those routes.

For purposes of this analysis, minority populations are defined as all non-white individuals, plus Hispanic whites, as reported in the 1990 census. Low-income persons are defined as living in households in the 1990 Census that reported an annual income less than the United States official poverty level. The poverty level varies by size and relationship of the members of the household. It was $12,674 for a family of 4 at the 1990 Census. Nationally, in 1990, 24.2% of all persons were minorities and 13.1% of all households had incomes less than the poverty level.

5.21.1 Hanford Vicinity (All Alternatives)

Figures 5-2 and 5-3 and Table 5-75 show the geographic distribution of minority and low-income population within census block groups (areas defined for monitoring census data of approximately 250 to 550 housing units) that are within 80 km (50 mi) of the KE and KW Basins. The two figures also show the location of these populations within 80 km (50 mi) of the CSB site, indicated as 200 East on the maps.

There is not yet an agreed-upon standard within the emerging federal guidance on environmental justice for what constitutes an area that has a minority or low-income population large enough to act as a test for disproportionate impact. For example, it has not been decided in the case of

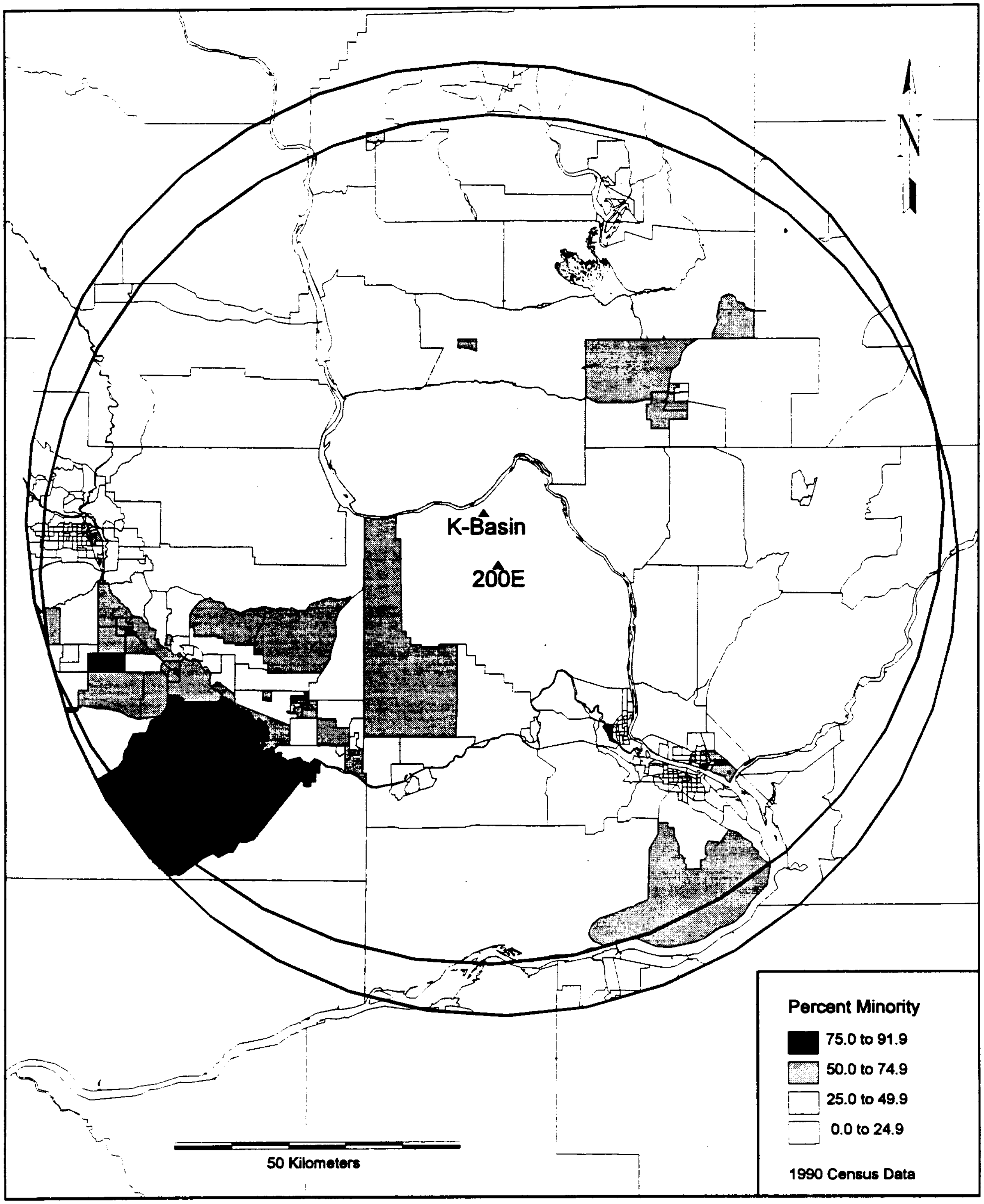


Figure 5-2. Location of minority populations surrounding the K Basins and 200 East Area (CSB site)

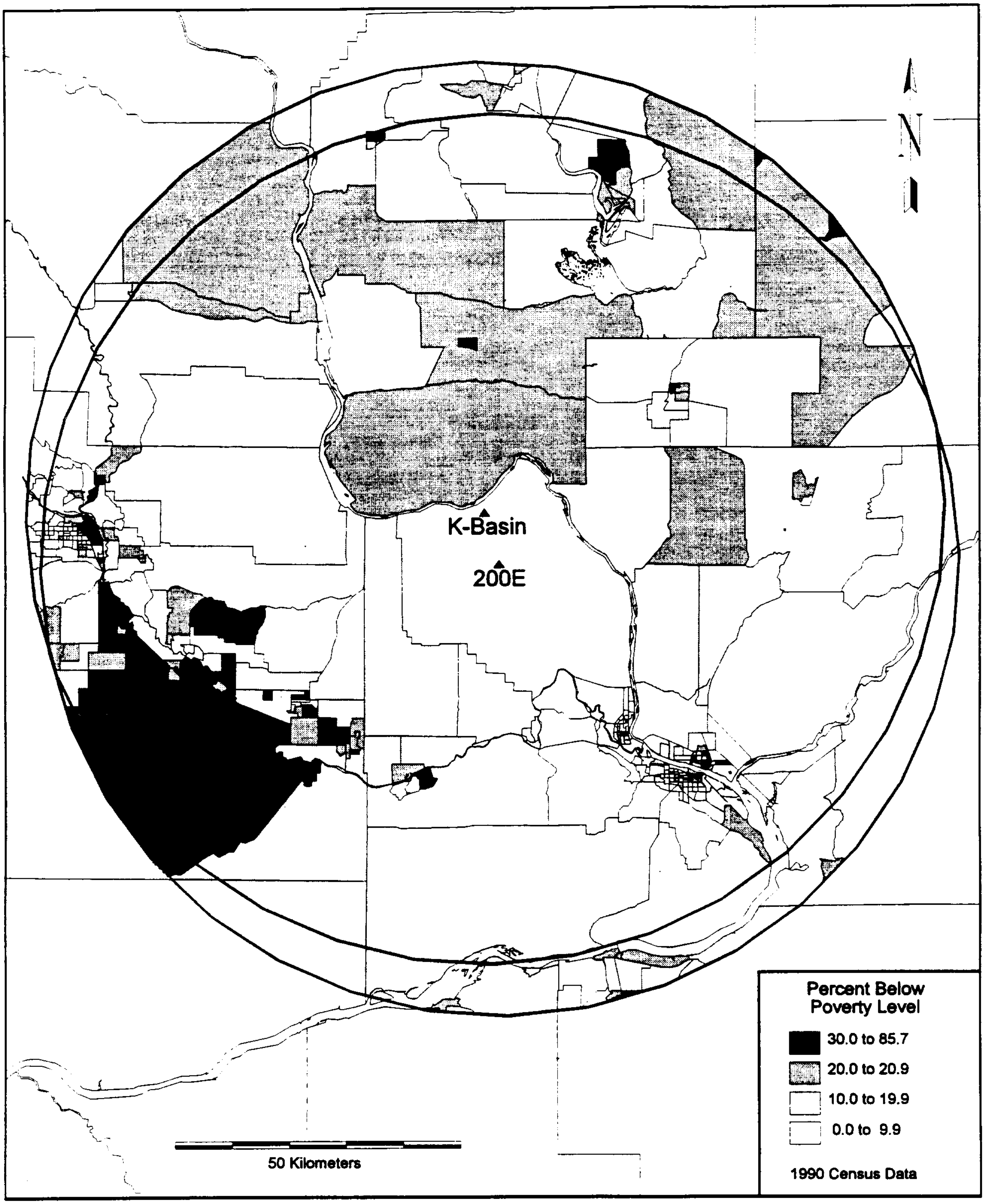


Figure 5-3. Location of low-income persons surrounding the K Basins and 200 East Area (CSB site)

Table 5-75. Location of minority and low-income populations surrounding K Basins by distance and direction

	Minority Persons			Low-Income Persons		
	Distance from K Basins			Distance from K Basins		
Direction	0-16 km (0 -10 mi)	16-48 km (10-30 mi)	48-80 km (30-50 mi)	0-16 km (0 -10 mi)	16-48 km (10-30 mi)	48-80 km (30-50 mi)
N	64	1,013	402	37	717	930
NNE	52	338	4,566	30	243	4,577
NE	23	859	1,177	13	420	575
ENE	15	3,744	127	9	1,480	129
E	2	619	881	2	370	401
ESE	0	530	146	0	288	88
SE	0	1,488	16,602	0	832	14,104
SSE	0	1,849	1,084	0	2,331	654
S	0	701	147	0	367	122
SSW	0	2,710	5,013	0	1,631	2,799
SW	0	7,549	5,022	0	3,331	2,783
WSW	0	325	16,341	0	114	7,758
W	19	96	17,847	11	44	17,741
WNW	62	164	246	36	95	313
NW	65	236	74	38	161	208
NNW	65	267	1,810	38	188	1,409
Total	369	22,487	71,485	213	12,611	54,509
Total, 0-80 km (0-50 mi)			94,341			67,414

Detail may not add to total because of rounding error.

minority residents whether the standard ought to be 50% minority residents, more than the national average of minority residents (24.2%), more than the state average, or some other number that takes into account other regional population characteristics. It is even more problematic to define low-income residents, since less income is needed to maintain a given living standard in areas with a relatively low cost of living. Several different definitions have been proposed, but each potential definition has strengths and weaknesses. Therefore, Figures 5-2 and 5-3 each employ a graduated shading scheme that indicates those areas of small and roughly equal numbers of housing units that have heavy concentrations of minority and low-income residents as well as those areas that have lighter concentrations of such residents. Shaded areas generally indicate those census block groups that have more than the national average percentages of minority and low-income populations, with heavier shading showing heavier concentrations. There are no residents within the irregularly shaped census block shown in Figures 5-2 and 5-3 that contains the K Basins and 200 East locations. This block is the Hanford Site.

Figure 5-2 and Table 5-75 together indicate that the largest numbers and heaviest concentrations of minority populations generally are located southwest and west-southwest of the K Basins in the Yakima Valley and Yakama Indian Reservation [most between 48 and 80 km (30 and 50 mi) distant], with two large pockets to the southeast (Pasco area) and west (Yakima area) beyond 48 km (30 mi) from the K Basins. Lighter scatterings of minority populations are located to the north, east, and west of the K Basins. Virtually all of the residents (including minority residents) of the darker-shaded census block to the west of the Hanford Site in Figure 5-2 actually reside near the extreme southern boundary of that area. Figure 5-3 and Table 5-75 together indicate that some low-income residents are scattered in all directions from the facilities, again with the largest numbers at the edges of the 80-km (50-mi) rings, and again with highest concentrations to the southwest and west-southwest in the Yakima Valley and Yakama Indian Reservation. The census block shown in Figure 5-3 just to the north of the K Basins that contains over 20% low-income residents is somewhat misleading, in that most residents in this area actually are located along the Columbia River at the extreme western edge of the block.

Although some minority and low-income populations live relatively near the K Basins and 200 East facilities, Sections 5.7 and 5.8 indicate that it is very unlikely that routine operations would affect them with radiological and nonradiological health impacts and other risks. These risks would be insignificant for any offsite population for any alternative discussed in this EIS. Therefore, it is unlikely that any minority or low-income population would be disproportionately affected by routine operations of any of the alternatives at Hanford.

Some accident scenarios whose effects are described in Section 5.15 could result in significant air releases of radionuclides that, in turn, could significantly affect some offsite populations. Whether the effect on minority and low-income residents would be disproportionate would depend very much on atmospheric conditions (especially wind directions) at the time of such a release. Most of the concentrations of minority and low-income areas are located to the west of the Hanford Site, while winds from the east are highly unlikely (Section 4.7.1). Prevailing winds from the west, northwest, or southwest would ordinarily carry any airborne release to the east, southeast, or northeast. A small, but still potentially disproportionate, number of minority and low-income persons could be affected in the event of south-westerly and westerly winds, depending on the exact wind direction and speed. The maximum reasonably foreseen impact scenario for an accident discussed in Section 5.15 is one in which the wind is from the northwest or north and carries an airborne release over the Richland-Pasco-Kennewick area to the immediate south and southeast of Hanford. In that case, majority and upper-income populations are at least as likely to be affected as minority and low-income populations.

The maximum reasonably foreseen water-related radiological accident in Section 5.15 is an overflow accident at the K Basins. This has insignificant consequences for any downstream population, including recreationists on the Columbia River in the immediate vicinity of the facility, so it is unlikely that minority or low-income populations would be adversely and disproportionately affected through this pathway.

Radiological accidents that exceed 0.5 rem to the MEI could have some secondary impacts from environmental contamination and mitigative actions under protective action guidelines (Section 5.15.7). These could include temporary loss of access to traditional fishing rights by Native American groups and possible loss of some agricultural crops and loss of income by minority and low-income farm workers. It is not clear whether this impact would be disproportionate.

Nonradiological accidental releases would cause odor and irritation problems and some irreversible health impacts under some alternatives at the nearest point of public access, while release of all of the PCBs at the K Basins could cause harm at the nearest residence under all of the alternatives (Section 5.15.8). In general, however, there is no reason for minorities and low-income persons to be disproportionately affected.

5.21.2 Port Facilities (Foreign Processing)

The DOE *Draft Environmental Impact Statement on the Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor (FRR) Spent Nuclear Fuel* (DOE 1995h) provides information on the numbers and spatial locations of minority and low-income populations surrounding the ports of Tacoma, Washington; Portland, Oregon; and Norfolk, Virginia (Hampton Roads). Because the FRR EIS utilized somewhat different analytical methodologies for environmental justice purposes than those utilized in this document, some data may vary. For example, the definition used for low income in FRR EIS is the U.S. Department of Housing and Urban Development standard, defined as 80% or less of the median household income for the Metropolitan Statistical Area. Utilizing demographic data entirely from the FRR EIS allows for comparison of the ports of interest under consistent definitions and assumptions using readily available data. The reader is referred to the draft FRR EIS for maps locating the spatial distribution of minority and low-income populations.

Table 5-76 lists information on selected populations of interest for regions surrounding the ports. Regions surrounding each port are areas that lie at least partially within a 16-km (10-mi) radius of the port. Population characteristics shown in the table were extracted from detailed, block-group statistical population data of the 1990 census.

Because the impacts as a result of transportation and facility operations are small and reasonably foreseeable accidents present no significant risk to the public (Section 5.15), no reasonably foreseeable adverse impacts have been identified to the surrounding population. Therefore, no disproportionately high and adverse effects would be expected for any particular segment of the population, including minority and low-income populations.

5.22 Estimated 40-Year Storage and Life-Cycle Costs

The estimated costs of achieving proper disposition of the SNF currently stored in the K Basins via the postulated alternatives are presented in this section. The costs for all of the activities except final transport and disposal in a geologic repository are derived from the *K Basin Environmental Impact Statement Technical Input* (Bergsman et al. 1995). The costs for the final transport and disposal of the SNF are derived from information contained in *Revised Analyses of Decommissioning for the Reference Pressurized Water Reactor Power Station* (Konzek et al. 1993). Costs are presented for the 40-year storage period considered by the basic alternatives in this EIS. In addition, the total life-cycle cost of each alternative is presented, which

Table 5-76. Characterization of populations residing near candidate facilities (Hanford Site and candidate ports of embarkation)[a]

Facility	Total population within 16 km of facility	Total minority population within 16 km of facility		Households within 16 km of facility	Low-income households within 16 km of facility	
	Number	Number	Percent	Number	Number	Percent
Tacoma, Washington	511,575	85,341	16.7	198,458	83,101	41.9
Portland, Oregon	356,064	54,704	15.4	146,047	66,186	45.3
Norfolk, Virginia	681,864	300,179	44.0	206,464	90,723	43.9

(a) Data based on draft FRR EIS (DOE 1995h).

includes treatment and eventual transport to and disposal in a geologic repository. It is appropriate to present both sets of costs because two of the alternatives include treatment activities within the 40-year period and the remaining three alternatives place those treatment activities after the 40-year period. Thus, the life-cycle cost estimates better reflect the true cost of a given alternative, even though some of these costs occur beyond the 40-year period that is defined in the scope of this EIS. However, because the final transport and disposal activities occur after the 40-year period considered in this EIS, none of the health and safety considerations associated with these activities are included in this EIS.

The costs presented herein are still somewhat incomplete because the costs for decommissioning the empty K Basins, for storing and vitrifying the fission product solutions arising from the onsite processing treatment, and the ongoing costs for storage of recovered uranium trioxide and plutonium dioxide from both onsite and foreign processing are not included in this analysis.

The estimated costs for accomplishing each of the alternatives selected for consideration in this EIS are presented in the following subsections.

5.22.1 No Action Alternative

The activities postulated for the no action alternative are described in Chapter 3.0 of this EIS and are displayed graphically in Figure 5-4. The distribution of these costs by cost component is also illustrated in Figure 5-4. The cost for the 40-year storage period is estimated to be $1.750 billion. The total life-cycle costs estimated for this alternative, by

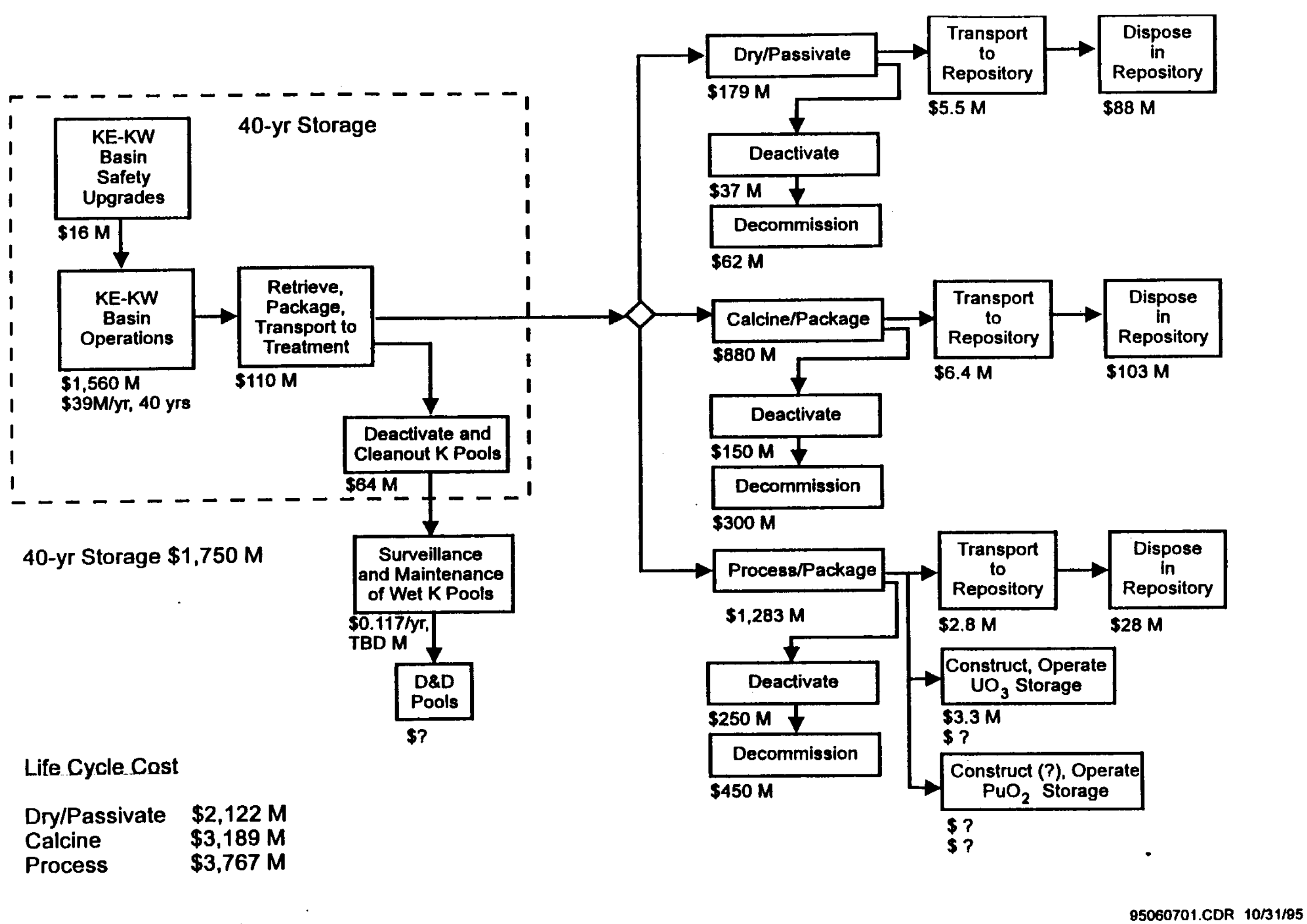


Figure 5-4. Costs associated with the no action alternative

treatment option, are $2.122 billion (dry/passivation), $3.189 billion (calcination), and $3.767 billion (onsite processing).

5.22.2 Enhanced K Basin Storage Alternative

The activities postulated for the enhanced K Basin storage alternative are described in Chapter 3.0 of this EIS and are displayed graphically in Figure 5-5. The distribution of these costs by cost component is also illustrated in Figure 5-5. The cost for the 40-year storage period is estimated to be $1.226 billion. The total life-cycle costs estimated for this alternative, by treatment option, are $1.597 billion (dry/passivation), $2.665 billion (calcination), and $3.243 billion (onsite processing).

5.22.3 New Wet Storage Alternative

The activities postulated for the new wet storage alternative are described in Chapter 3.0 of this EIS and are displayed graphically in Figure 5-6. The distribution of these costs by cost component is also illustrated in Figure 5-6. The cost for the 40-year storage period is estimated to be $0.963 billion. The total life-cycle costs estimated for this alternative, by treatment option, are $1.334 billion (dry/passivation), $2.402 billion (calcination), and $2.980 billion (onsite processing).

5.22.4 Dry Storage Alternative

The activities postulated for the dry storage alternative are described in Chapter 3.0 of this EIS and are displayed graphically in Figure 5-7. The distribution of these costs by cost component is also illustrated in Figure 5-7. The cost for the 40-year storage period is estimated to be $0.986 billion for the dry/passivation option, $2.038 billion for the calcination option, and $2.661 billion for the onsite processing option (not including any high-level waste vitrification costs). The total life-cycle costs estimated for this alternative, by treatment option, are $1.079 billion (dry/passivation), $2.147 billion (calcination), and $2.692 billion (onsite processing, not including any high-level waste vitrification costs).

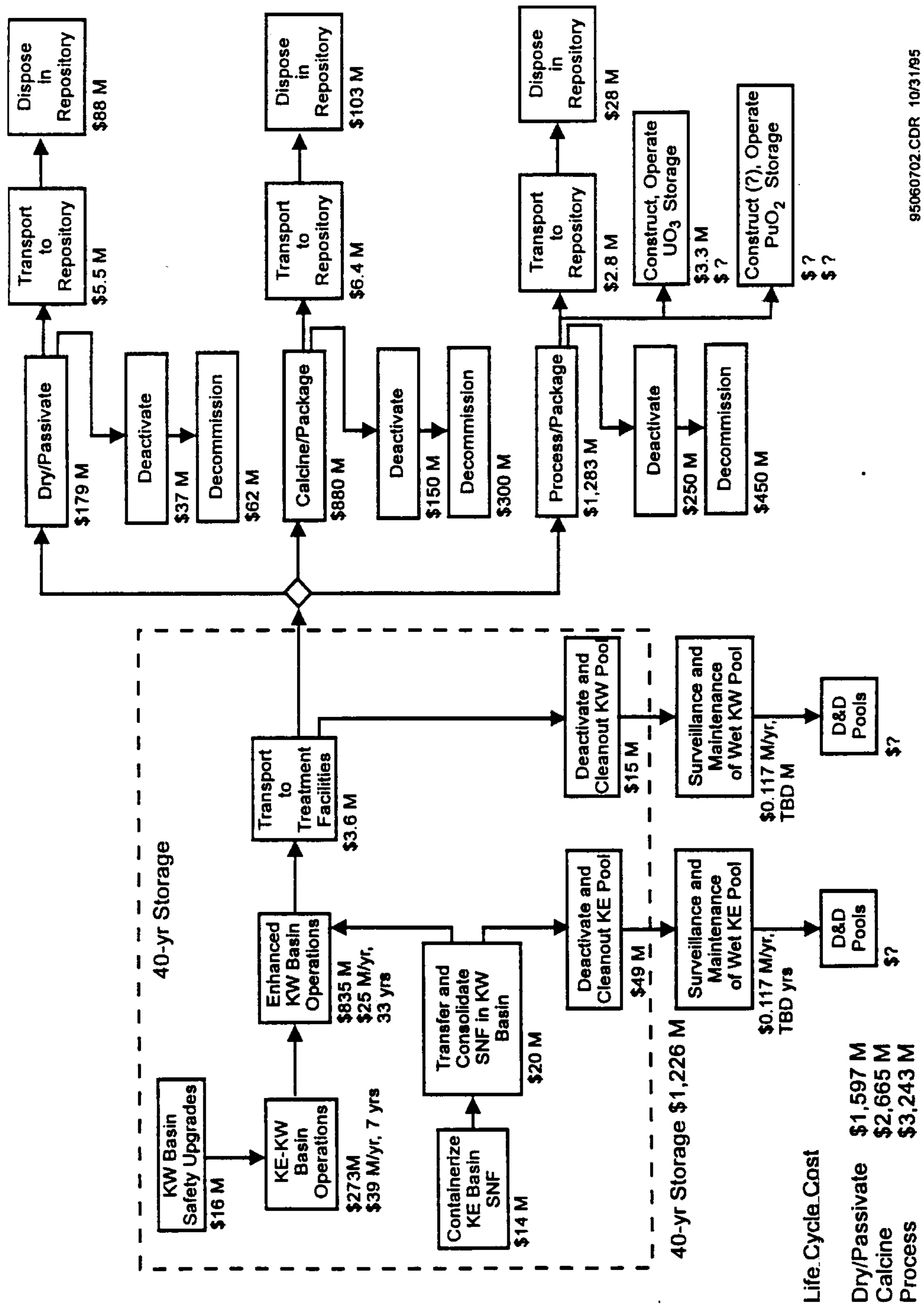


Figure 5-5. Costs associated with the enhanced K Basins storage alternative

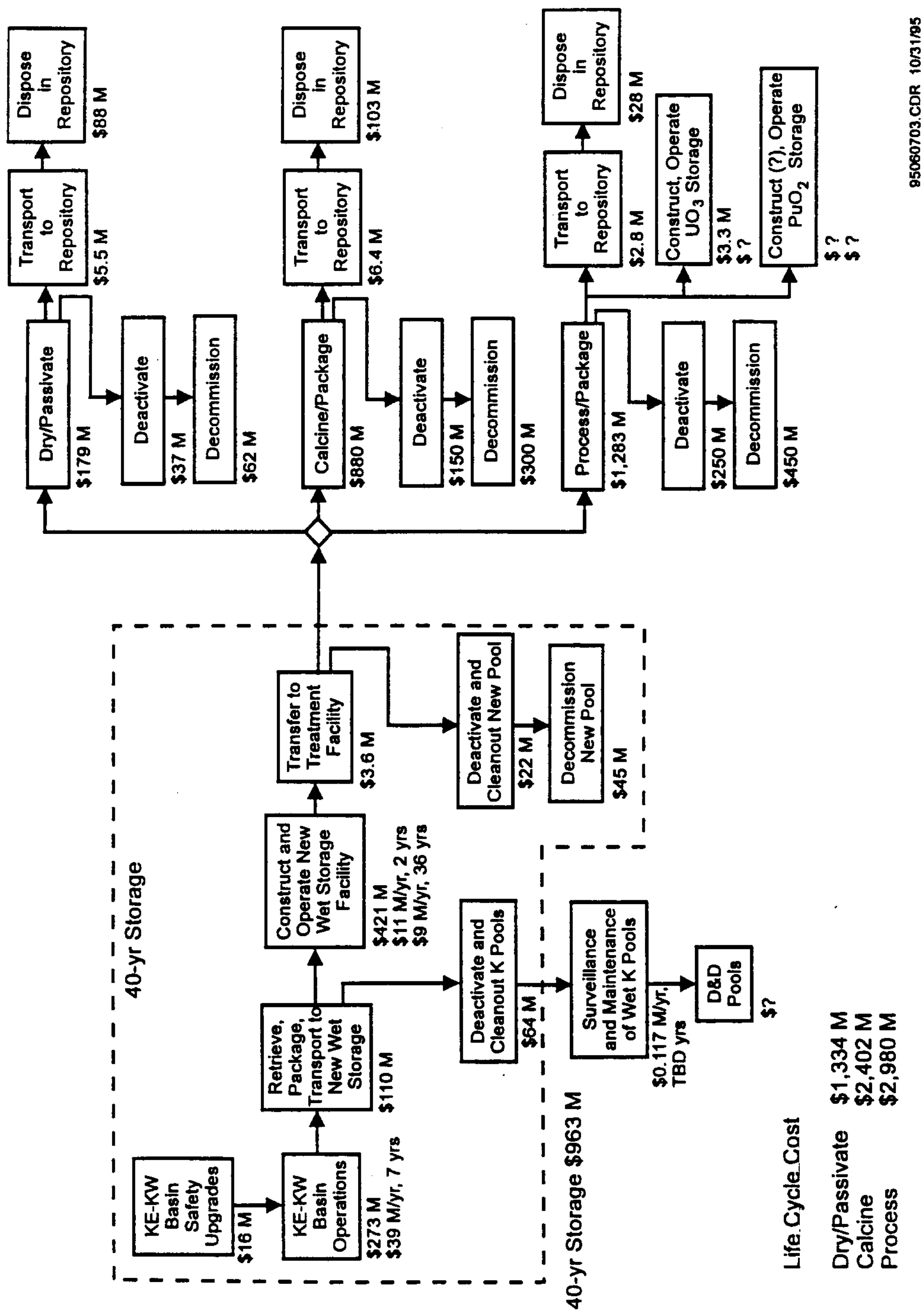


Figure 5-6. Costs associated with the new wet storage alternative

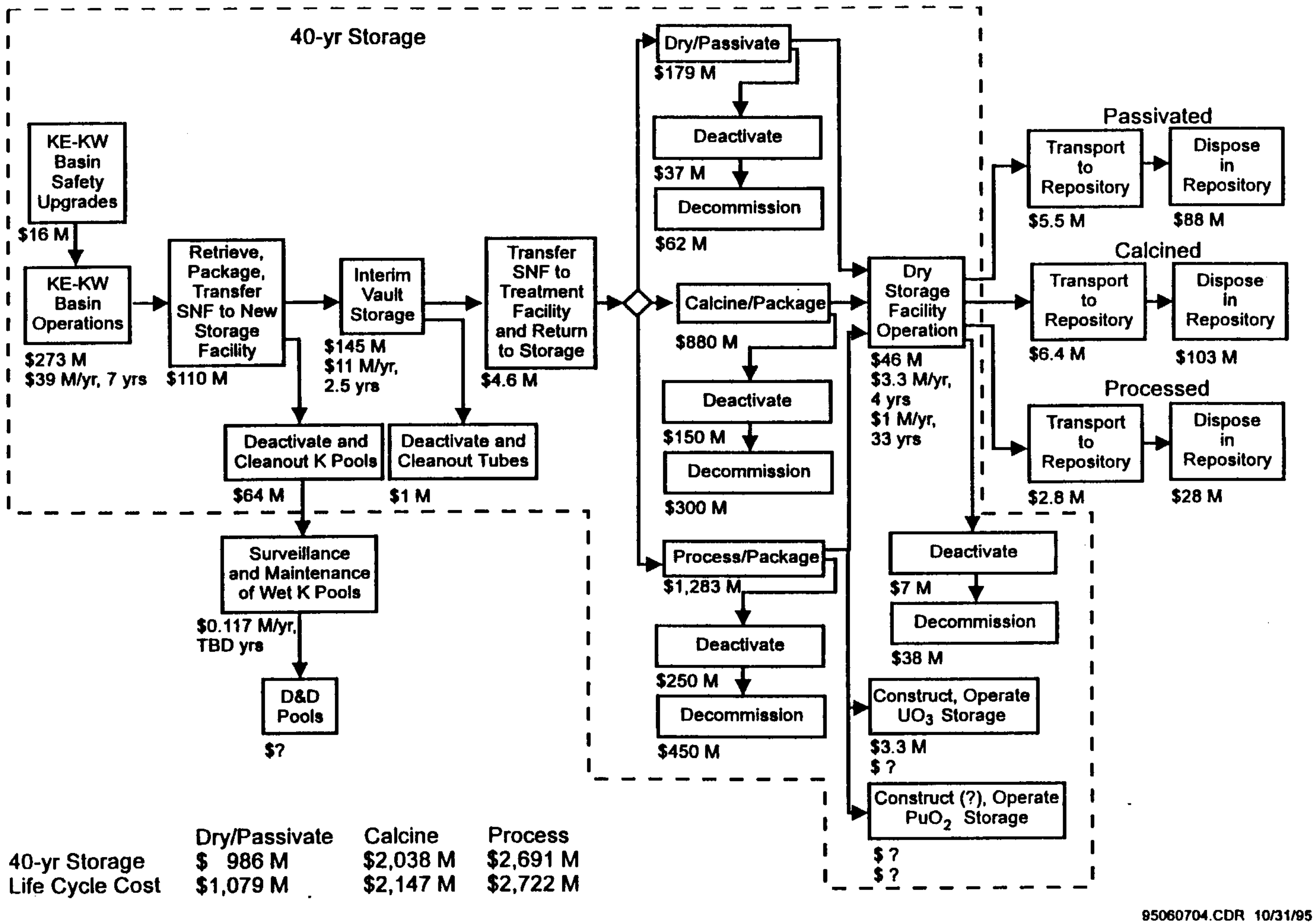


Figure 5-7. Costs associated with the dry storage alternative

5.22.5 Foreign Processing Alternative

The activities postulated for the foreign processing alternative are described in Chapter 3.0 of this EIS and are displayed graphically in Figure 5-8. The distribution of these costs by cost component is also illustrated in Figure 5-8. The 40-year storage costs (including foreign processing are estimated to range from $2.102 to $3.802 billion. The total life-cycle cost estimated for this alternative ranges from $2.185 to $3.885 billion.

5.22.6 Description of the Treatment Options

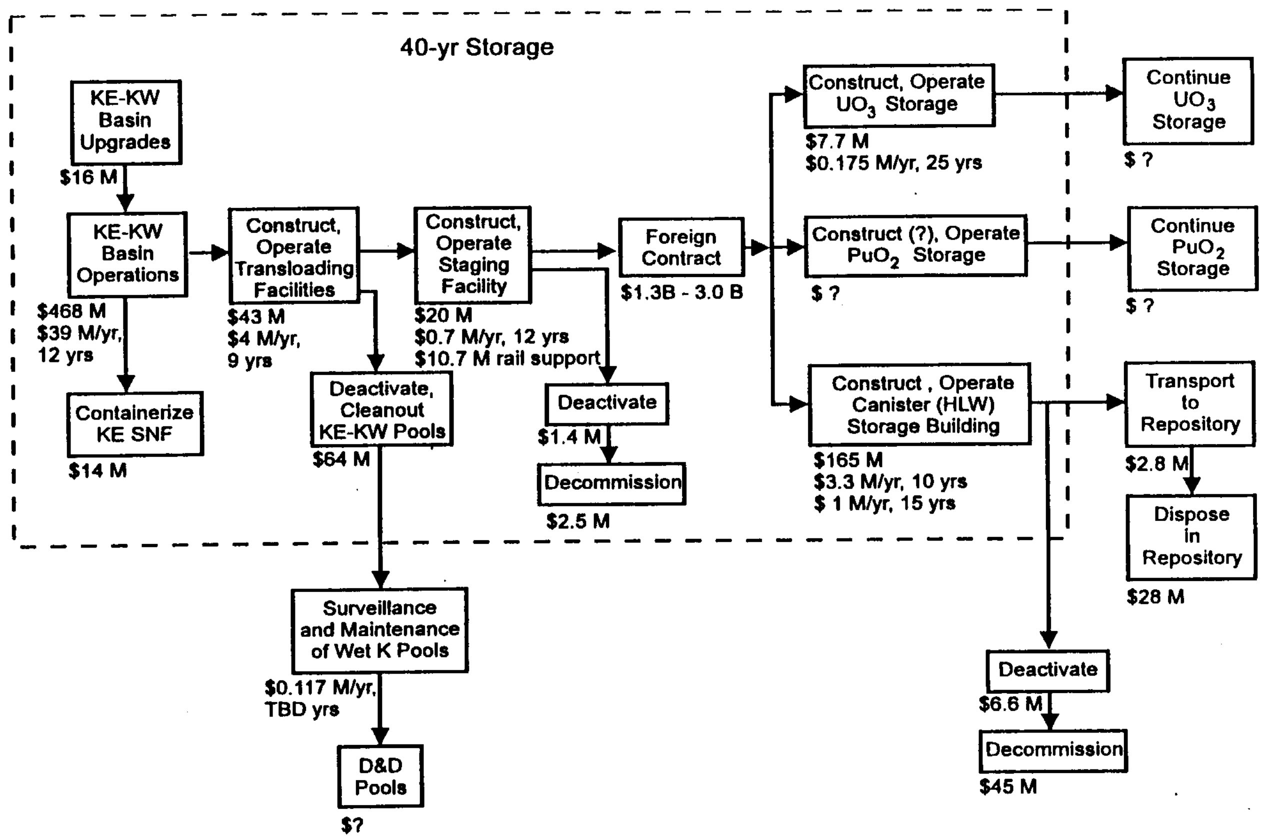
Assuming that the SNF will eventually be placed into the geologic repository, it must be placed into a condition that is acceptable for disposal in the geological repository. Three possible methods of treatment to achieve this condition are considered, in order of increasing complexity and cost:

- **drying and passivation**--This process removes any free water from the packages of SNF by drying, and passivates the exposed surfaces of the SNF to prevent further oxidation or hydration, thus eliminating the potential for ignition of the SNF while in storage or after placement in the repository. A new process facility must be built and operated to process the SNF, at an estimated cost of $179 million.

- **calcination**--This process dissolves the SNF and converts the resulting solution to a dry calcine powder that is very stable and nonreactive. The product powder would be compacted into appropriate containers suitable for long-term storage and/or disposal. A new process facility must be built and operated to process the SNF, at an estimated cost of $880 million.

- **onsite processing**--This process dissolves the SNF, removes the plutonium and uranium from the solution for stabilization and storage as special nuclear materials, and delivers the remaining fission product solutions to a storage tank pending future vitrification as high-level waste. The vitrified high-level waste is stored in the dry storage facility. A new process facility must be built and operated to process the SNF, at an estimated cost of $1.283 billion.

- **foreign processing**--This process is essentially the same as onsite processing except that the SNF is transported to an foreign processor who



40-yr Storage $ 2.102B - $3.802 B
Life Cycle Cost $2.185 B - $3.885 B

95060705.CDR 10/31/95

Figure 5-8. Costs associated with the foreign processing alternative

separates and vitrifies the fission products and returns the vitrified high-level waste and the recovered uranium trioxide and plutonium dioxide to Hanford for long-term storage. A new transloading facility, staging facility, and dry uranium trioxide and plutonium dioxide storage facilities must be built and operated at Hanford, at a cost of about $236 million, in addition to the foreign processing contract of $1.3 to $3.0 billion.

5.22.7 Final Transport and Disposal

The final efforts in the disposal of the SNF are to transport the containers of fuel or product from storage or from the treatment facility to the geologic repository and to dispose of the containers in that repository. The costs for these actions depend upon the mass and volume of the material to be transported and disposed, and are derived using information and algorithms presented in Konzek et al. (1993) and estimates of the volumes of the treated and packaged SNF materials. The fission product solutions from onsite processing are presumed to have been vitrified before storage and shipment, but vitrification costs are not expressly identified and included in this analysis. The estimated costs for transport to and disposal in the geologic repository are presented by treatment option in Table 5-77.

The estimated 40-year storage costs and the estimated total life-cycle costs for the five postulated alternatives and the four treatment options are summarized in Table 5-78. The 40-year storage costs for the new wet storage alternative are slightly smaller than for the dry storage alternative (including passivation). However, the life-cycle costs, which incorporate the cost impacts of SNF treatment, transport, and disposal into all of the alternatives, show that the dry storage alternative is the least-cost alternative, regardless of which SNF treatment option is employed.

Table 5-77. Estimated transport and disposal costs for treated SNF

Treatment Option	Transport[a]	Disposal
Drying/passivation	$5.5 million	$ 88 million
Calcination	$6.4 million	$103 million
Onsite processing	$2.8 million	$ 28 million
Foreign processing	$2.8 million	$ 28 million

(a) Transport from the Hanford dry storage facility to the Yucca Mountain geologic repository.

Table 5-78. Summary of the estimated 40-year storage costs and the total life-cycle costs for disposition of K Basins SNF (in billions of dollars)

Alternatives for Spent Fuel Disposition	No Action	Enhanced K Basin Storage	New Wet Storage	Passivation/ Dry Storage	Calcination/ Dry Storage	Onsite Processing	Foreign Processing
40-Year storage[(a)]	$1.750	$1.226	$0.963	$0.986	$2.086	$2.691	$2.1-3.8
Life-cycle costs[(b)]							
Drying/passivation	$2.122	$1.597	$1.334	$1.079			
Calcination	$3.189	$2.665	$2.402		$2.147		
Processing	$3.767	$3.243	$2.980			$2.722	$2.2-3.9

(a) Estimate includes all costs incurred during the 40-year storage period for each alternative, including treatment where applicable. Does not include transport to the geologic repository and disposal therein.
(b) Estimate includes all of the 40-year storage costs plus post-storage treatment where applicable and does include transport to the geologic repository and disposal therein.

6.0 REGULATORY REQUIREMENTS

It is DOE's policy to conduct its operations in an environmentally safe and sound manner in compliance with the letter and spirit of applicable environmental statutes, regulations, and standards. Statutory, regulatory, and potential permit requirements relative to the management of K Basins SNF are discussed in this chapter.

6.1 Transportation Requirements

All alternatives other than the no action alternative involve transportation of SNF and waste products from the K Basins. Shipment of the SNF and waste products stored at the K Basins is not directly subject to the Nuclear Regulatory Commission's (NRC's) requirements for packaging and transportation of radioactive material at 10 CFR 71 because the SNF and waste products are not material that is licensed by the NRC or an Agreement State. Shipment of SNF and waste products from the K Basins for all but the foreign processing alternative is also not directly subject to the Department of Transportation's (DOT's) requirements for the transportation of hazardous materials at 49 CFR 171-180 because the shipments would occur exclusively on federal government property (i.e., the Hanford Site) over portions of the property where access is controlled at all times through the use of gates and guards.

All shipments of SNF and waste products on the Hanford Site will comply with the requirements of DOE Order 1540.2 ("Hazardous Material Packaging for Transport - Administrative Procedures") and DOE Order 5480.3 ("Safety Requirements for the Packaging and Transportation of Hazardous Materials, Hazardous Substances, and Hazardous Wastes"). DOE policy is to ensure that all packagings used in transporting radioactive and other hazardous materials meet all applicable safety requirements (DOE Order 1540.2, Section 8). The Hanford administrative process specifies packaging design that provides equivalent safety to that required in 10 CFR 71.

Significant international and federal laws, regulations, and requirements that apply to the transportation of hazardous and radioactive materials include the following:

- International Convention on the Safety of Life at Sea of 1960 (as amended)
- Atomic Energy Act (42 USC 2011 et seq.)
- Hazardous Materials Transportation Act (49 USC 1801 et seq.)

- Resource Conservation and Recovery Act, as amended by the Hazardous and Solid Waste Amendments (42 USC 26901 et seq.)

- Executive Order 12114 (Environmental Effects Abroad of Major Federal Actions).

Offsite transportation of hazardous and radioactive materials, substances, and wastes are subject to the regulations of the DOT (49 CFR 171-178, 383-397), the NRC (10 CFR 71), and the EPA (40 CFR 262, 265).

DOT regulations contain requirements for identifying a material as hazardous or radioactive. These regulations interface with NRC and EPA regulations for identifying material, but the DOT regulations govern hazard communication via placarding, labeling, reporting, and shipping requirements (see especially 10 CFR 71.5, in which DOT regulations are applied by NRC regulations to shipping of radioactive materials).

• NRC regulations address packaging design and certification requirements. Certification is based on safety analysis report data on the packaging design for various hypothetical accident conditions.

EPA hazardous waste transportation regulations address labeling and record keeping, including shipping documentation (waste manifest).

General overland carriage is subject to specific regulations dealing with packaging notification, escorts, and communication. There are specific provisions for truck and for rail. For carriage by truck, the carrier must use interstate highways or state-designated preferred routes. DOT regulations found in 49 CFR 397.101 establish routing and driver training requirements for highway carriers of packages containing "highway-route-controlled quantities" of radioactive materials. SNF shipments constitute such controlled shipments. For carriage by rail car, each shipment by the railroad must comply with 49 CFR 174 Subpart K "Detailed Requirements for Radioactive Materials."

For overseas transportation, the NRC and DOT conform their regulations to the model regulations of the International Atomic Energy Agency to the extent feasible. These model international regulations are also incorporated into the International Maritime Dangerous Goods Code, which was developed to supplement the International Convention on the Safety of Life at Sea, to which the U.S. is a signatory. Transportation risk in the global commons must be evaluated in accordance with Executive Order 12114, Environmental Effects Abroad of Major Federal Actions (44 FR 1957).

Transportation of dangerous cargoes through the Panama Canal is governed by the International Maritime Dangerous Goods Code and is addressed in 35 USC 113. General provisions for passage through the Panama Canal are found at 35 USC 101-135. General regulations governing navigation, including the applicability of the International Regulations for the Prevention of Collisions at Sea (1972), are found throughout 33 CFR.

Relevant regulations applying to transport of SNF by vessel are found in 10 CFR 71 and 73 (NRC) and 49 CFR 176 (DOT). These regulations address prenotification to the U.S. Coast Guard for inspection and provide specifications for packaging, labeling, and other preparation for shipment. A Certification of Competent Authority must be obtained in compliance with International Atomic Energy Agency requirements. Specific provisions are made for stowage, including package surface temperature limitations, spacing, and total aggregate volume and number of freight containers.

6.2 Occupational Radiation Exposure

DOE's radiation protection standards, limits, and program requirements for protecting occupational workers from ionizing radiation resulting from the conduct of DOE activities are at 10 CFR 835. All activities associated with any alternative will be conducted consistent with these requirements. The annual total effective dose equivalent limit for general employees is 0.05 Sv (5 rem) [10 CFR 835.202(a)(1)]. The DOE is committed to measures that will "maintain radiation exposure in controlled areas as low as reasonably achievable (ALARA) through facility and equipment design and administrative control" (10 CFR 835.1001).

6.3 Radiation Exposure to Members of the Public

Chapter II of DOE Order 5400.5 provides that DOE activities shall be conducted so that the exposure of members of the public to radiation sources as a consequence of all routine DOE activities shall not cause an effective dose equivalent exceeding 1 mSv/year (100 mrem/year).

Activities associated with any of the alternatives will be managed so that radiation exposure to any member of the public authorized to enter the controlled area where activities associated with implementation of any alternative are conducted will not exceed 1 mSv (100 mrem) total effective dose equivalent in a year (10 CFR 835.208). Air emissions resulting from the implementation of any alternative will comply with the 0.1-mSv/year (10-mrem/year) standard at 40 CFR 61.92.

6.4 Noise

Federal efforts to regulate noise largely derive from the Noise Control Act of 1972 (42 USC 4901-4918). Under the Act, federal agencies such as DOE are to carry out their programs to further the Act's purpose of promoting an environment for all Americans that is free from noise that jeopardizes health or welfare [42 USC 4903(a)]. Beyond the general obligation in the Noise Control Act, no specific requirements in the Noise Control Act or in any regulations implemented under the Act prohibit or regulate the activities conducted under any of the alternatives.

The Noise Control Act requires federal agencies to meet state and local requirements relating to the abatement of noise [42 USC 4903(b)]. The state of Washington has adopted maximum environmental noise levels. No activities associated with any alternative will violate Washington's maximum permissible environmental noise levels (WAC 173-60-040). In addition, no requirements of Benton County, Washington, will prohibit or regulate the noise associated with operation of any alternative.

The Occupational Safety and Health Administration (OSHA) has established regulations to regulate the noise exposure of occupational workers (29 CFR 1910.95). DOE Order 5480.4 specifies that DOE contractor operations, such as those to be conducted under any alternative, are to meet all OSHA standards in 29 CFR 1910.

6.5 Floodplain Management and Protection of Wetlands

Executive Order 11988, issued by President Carter in 1977 (42 FR 26951), requires an executive branch agency such as DOE to evaluate the potential effects of any actions it may take in a floodplain and ensure that its planning and programs reflect consideration of flood hazards and floodplain management. DOE policy is to avoid to the extent possible the long- and short-term adverse impacts associated with the occupancy and modification of floodplains and avoid direct and indirect support of floodplain development wherever there is a practicable alternative [10 CFR 1022.3(a)]. Information on the flood plain status of the K Basins and the reference and CSB storage sites is in Section 4.8.1. DOE has determined that the elevation of a 500-year flood will reach neither the elevation of the bottom of the K Basins nor the elevation of the bottom of any SNF facility at the CSB or reference site.

6.6 Hazardous Waste Management

Nonradioactive hazardous (dangerous) wastes are temporarily stored at the nonradioactive dangerous waste storage facility in the 200 West Area. The wastes are subsequently transported from the Hanford Site pursuant to an existing contract with Burlington Environmental Inc. and disposed of offsite at a hazardous waste disposal site(s) with appropriate Resource Conservation and Recovery Act (RCRA) or state permits.

Most of the authority to administer the RCRA program, including treatment, storage and disposal standards, and permit requirements, has been delegated by EPA to the State of Washington, except for corrective action (cleanup). Washington State RCRA (WSHWMA) Dangerous Waste Regulations are found in WAC 173-303 (Washington Administrative Code). Generally, RCRA does not apply to source material, special nuclear material, by-product material, SNF, or radioactive-only wastes. Should SNF be processed into or commingled with a hazardous waste as defined by Subtitle C of RCRA, then the generation, treatment, storage, and disposal of the hazardous waste portion of such mixed waste would be subject to EPA regulations in 40 CFR 260-268 and 270-272 or to the applicable state regulations in WAC 173-303 and potentially to the terms of a RCRA treatment, storage, or disposal permit.

6.7 Protection of Wetlands

Executive Order 11990, issued by President Carter in 1977 (42 FR 26961), requires executive branch agencies such as DOE to minimize destruction, loss, or degradation of wetlands in carrying out the agency's responsibilities. Agencies are to avoid new construction on wetlands unless there is no practicable alternative. DOE has determined that no wetlands are present on land that would be occupied if any alternative is implemented.

6.8 Species Protection

The Endangered Species Act of 1973 requires that federal agencies not take any action that is likely to jeopardize the continued existence of any endangered species or threatened species or result in destruction or adverse modification of critical habitat for such species [16 USC 1536(a)(2)]. DOE has conducted biological surveys of the two sites where construction might occur (the reference and CSB sites). Based on these surveys, DOE has concluded that implementation of any alternative will not jeopardize 1) the continued existence of any species listed as threatened or endangered under the Endangered Species Act of 1973 at 50 CFR 17 Subpart B, or 2) any critical habitat of such species. No critical habitat exists for any species on the Hanford Site.

Unless otherwise permitted by regulation, the Migratory Bird Treaty Act (16 USC 703) makes it unlawful to pursue, hunt, take, capture, kill (or to attempt any of the preceding) any migratory bird or nest or eggs of such bird. The Bald and Golden Eagle Protection Act (16 USC 668) protects bald and golden eagles. DOE has determined that implementation of any of the alternatives under consideration in this EIS would not violate either of these statutes.

6.9 Native American, Archaeological, and Historic Preservation Statutes

DOE's American Indian Tribal Government Policy is in DOE Order 1230.2, issued April 8, 1992. DOE commits in the Order to consult with tribal governments to ensure that tribal rights and concerns are considered before DOE takes actions that may affect tribes. DOE also commits to avoid unnecessary interference with traditional tribal religious practices.

The American Indian Religious Freedom Act (42 USC 1996) establishes that it is the United States' policy to protect and preserve for American Indians their inherent right of freedom to believe, express, and exercise their traditional religions including access to sites, use and possession of sacred objects, and the freedom to worship through ceremonies and traditional rites. The Native American Graves Protection and Repatriation Act provides that tribal descendants shall own Native American human remains and cultural items discovered on federal lands after November 16, 1990 (25 USC 3002). When items are discovered during an activity on federal lands, the activity is to cease and appropriate tribal governments are to be notified. Work on the activity can resume 30 days after receipt of certification that notice has been received by the tribal governments.

The Archaeological Resources Preservation Act of 1979 prohibits the excavation of material remains of past human life that have archaeological interest and are at least 100 years old without a permit from the appropriate federal land manager or an exemption (16 USC 470bb, 470ee). The federal land manager for the Hanford Site is DOE.

The National Historic Preservation Act authorizes the Secretary of the Interior to maintain a National Register of Historic Places [16 USC 470a(a) (1)]. Federal agencies are to take into account the effect of their actions on properties included in or eligible for inclusion in the Register and afford the Advisory Council on Historic Preservation a reasonable opportunity to comment on such actions (16 USC 470f). DOE will review facilities in the 100 K Area to determine eligibility for inclusion in the National Register of Historic Places.

DOE has reviewed the preceding statutes and has determined that implementation of any alternative would be consistent with the statutes through implementation of appropriate mitigating measures.

6.10 Radioactive Air Emissions

Radioactive emissions from facilities at Hanford are subject to EPA's National Emission Standards for Hazardous Air Pollutants (NESHAP) requirements at 40 CFR 61. In particular, Subpart A, "General Provisions," and Subpart H, "National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities," are applicable to all alternatives. Emissions of radionuclides to the ambient air from a DOE facility are not to exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 0.1 mSv/year (10 mrem/year) (40 CFR 61.92). For any alternative selected for implementation, DOE Richland Operations Office will submit an application for approval of construction or modification to EPA Region 10 under the NESHAP requirements at 40 CFR 61.07 for any new or modified facility associated with the alternative with projected radioactive emissions that are estimated to exceed 1% of the 0.1 mSv/year (10 mrem/year) standard [40 CFR 61.96(b)]. The only alternatives with radioactive emissions projected to exceed this level are the calcination and processing alternatives (see Table 5-14).

New sources of radioactive emissions at Hanford are also subject to the licensing requirements of the Washington State Department of Health at WAC 246-247. DOE Richland Operations Office holds a license (No. FF-01) issued by the Department of Health covering airborne radioactive effluents from Hanford operations. This license will be incorporated into DOE's operating permit for the Hanford Site when the permit is issued (WAC 246-247-060). DOE Richland Operations Office will submit a notice of construction to the Department of Health as required by WAC 246-247-060 before constructing or modifying any facility associated with any alternative under consideration in this EIS with projected radioactive emissions. All new construction and significant modifications of emission units will utilize best available radionuclide control technology [WAC 246-247-040(3)].

6.11 Nonradioactive Air Emissions

All of the Hanford Site has attainment status for the National Ambient Air Quality Standards listed at 40 CFR 50. Consequently, a written determination consistent with 40 CFR 93 Subpart B indicating any alternative conforms to Washington's Implementation Plan for achieving the standards does not need to be prepared.

Major new sources of pollutants in attainment areas are subject to prevention of significant deterioration (PSD) permit requirements. The only facilities under consideration in this EIS that could potentially require a PSD permit are a processing or a calcination facility. Nitrogen oxide emissions from each of these facilities are projected to be approximately 16,000 kg/year (18 tons/year). These levels of emissions would not by themselves trigger the PSD permit requirements at 40 CFR 52.21 or WAC 173-400-141. When combined with other nitrogen oxide emissions at Hanford, however, these level of emissions could potentially cause the Hanford Site baseline nitrogen dioxide emissions to exceed 36,000 kg/year (40 tons/year) [40 CFR 52.21(b)(23)], thus triggering the need for a modification to Hanford's existing PSD permit (permit No. PSD-X80-14) issued to DOE Richland Operations Office by EPA Region 10 in 1980. If a decision is made to construct a processing or calcination facility at Hanford, total Hanford Site emissions of nitrogen oxides will be analyzed to determine the need for a PSD permit modification.

The alternatives under consideration is this EIS are not included within the source categories subject to the standards of performance for new stationary sources at 40 CFR 60 or WAC 173-400-115.

Nonradioactive emissions from any of the alternatives will not be emitted in sufficiently high quantities to subject the facilities to the new source review requirements at WAC 173-400-110(1) or WAC 173-460-040(1).

Both radioactive and nonradioactive emissions from any alternative selected for implementation will eventually be covered in an operating permit issued by Ecology for the entire Hanford Site under the procedures in WAC 173-401. DOE Richland Operations Office submitted an operating permit application for the Hanford Site to Ecology in May 1995 (DOE 1995i).

6.12 Liquid Discharges to Surface Water

Small quantities of radionuclides would continue to be discharged to the Columbia River under the no action and enhanced storage alternatives and under the other alternatives until SNF is completely removed from the K Basins.

Water is withdrawn from the Columbia River to supply makeup water for the K Basins; excess water is returned to the Columbia River through the 1908-KE outfall. The source of the radionuclides is residual contamination in the water piping, which was formerly used to support reactor operations in the 100-K Area. Discharges at the 1908-KE outfall are in compliance with 1) the NPDES Permit (Permit No. WA-000374-3) incorporating the 1908-KE outfall (the permit was issued to DOE by EPA Region 10) and 2) DOE Order 5480.4 ("Environmental Protection, Safety, and Health Protection Standards").

6.13 Liquid Discharges to the Ground

Water remaining in the K Basins after removal of the SNF would be treated with filters and ion exchange processes to remove radionuclides. After treatment, the water would still contain tritium. This water would be transported to the 200 Area Effluent Treatment Facility (ETF) where it would be further treated before final disposal in the 200 Area State-Approved Land Disposal Site (SALDS). Under the dry storage alternative, contaminated water would result from pumping water from the storage tubes and as a result of decontamination of the tubes. This water may also be treated to remove contamination and then transported to the 200 Area ETF before final treatment and disposal in the 200 Area SALDS. DOE received a waste discharge permit (No. ST 4500) for the ETF from Ecology in June 1995. Nonradioactive liquid effluents from the calcination facility would be routed to the 200 Area Treated Effluent Disposal Facility (TEDF). A waste discharge permit (No. ST 4502) for the TEDF was issued by Ecology to DOE in April 1995. Permits ST 4500 and ST 4502 both contain provisions to be followed to obtain approval of new influent streams not addressed in the original permit applications.

Any alternative that involves construction of a new facility could also involve construction of a septic system to dispose of sanitary wastes. For any such system, the DOE Richland Operations Office policy is to seek approval from the Washington State Department of Health and follow the requirements at WAC 246-272 ("On-Site Sewage Systems").

7.0 REFERENCES

42 FR 26961. May 25, 1977. "Protection of Wetlands." Executive Order 11990 (May 24, 1977). *Federal Register.*

42 FR 26951. May 25, 1977. "Floodplain Management." Executive Order 11988 (May 24, 1977). *Federal Register.*

44 FR 1957. January 4, 1979. "Environmental Effects Abroad of Major Federal Actions." Executive Order 12114. *Federal Register.*

58 FR 41981. August 3, 1993. "Federal Compliance With Right-to-Know Laws and Pollution Prevention Requirements." Executive Order 12856. *Federal Register.*

59 FR 7629. February 16, 1994. "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations." Executive Order 12898 (February 11, 1994). *Federal Register.*

Bergsman, K. H. 1995. *Preliminary Hanford Technical Input for the Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement.* WHC-EP-0848, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Bergsman, K. H., T. B. Bergman, D. W. Bergmann, G. E. Costley, M. T. Jansky, D. S. Leach, R. L. McCormack, M. J. Monthey, A. N. Praga, I. K. Ullah, W. L. Willis, and A. G. Hosler. 1995. *K Basin Environmental Impact Statement Technical Input.* WHC-SD-SNF-TI-013, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Bureau of Economic Analysis. 1994. *Regional Economic Information System.* U.S. Department of Commerce, Bureau of Economic Analysis, Washington, D.C.

BNFL (British Nuclear Fuels Limited). 1994. Testimony by Marilyn Meigs representing BNFL Ltd. at the Pasco, Washington hearing on the U.S. Department of Energy's Draft Programmatic Environmental Impact Statement on Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs.

Chatters, J. C. (ed.). 1989. *Hanford Cultural Resources Management Plan.* PNL-6942, Pacific Northwest Laboratory, Richland, Washington.

Chatters, J. C., and N. A. Cadoret. 1990. *Archeological Survey of the 200-East and 200-West Areas, Hanford Site, Washington.* PNL-7264, Pacific Northwest Laboratory, Richland, Washington.

Connelly, M. P., J. V. Borghese, C. D. Delaney, B. H. Ford, J. W. Lindberg, and S. J. Trent. 1992. *Hydrogeologic Model for the 200 East Groundwater Aggregate Area.* WHC-SD-EN-TI-019, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Cushing, C. E., (ed.). 1995. *Hanford Site National Environmental Policy Act (NEPA) Characterization*. PNL-6415, Rev. 7, Pacific Northwest Laboratory, Richland, Washington.

Daling, P. M., and M. S. Harris. 1994. *Transportation Impact Analysis for Shipment of Irradiated N-Reactor Fuel and Associated Materials*. PNL-10249, Pacific Northwest Laboratory, Richland, Washington.

Davis, J. D., D. B. Barnett, L. C. Swanson, W. J. McMahon, and C. D. Palomares. 1993. *Site Characterization Report: Results of Detailed Evaluation of the Suitability of the Site Proposed for Disposal of 200 Areas Treated Effluent*. WHC-SD-EN-SE-004, Westinghouse Hanford Company, Richland, Washington.

Dean Runyan Associates. 1994. *Washington 1991-1993: Economic Impacts of Travel and Visitor Volume*. Prepared for Washington State Tourism, Department of Community, Trade, and Economic Development, by Dean Runyan Associates, Portland, Oregon.

Dirkes, R.L., and R. W. Hanf. 1995. *Hanford Site Environmental Report for Calendar Year 1994*. PNL-10574, Pacific Northwest Laboratory, Richland, Washington.

Dirkes, R. L., R. W. Hanf, R. K. Woodruff, and R. E. Lundgren (eds). 1994. *Hanford Site Environmental Report for Calendar Year 1993*. PNL-9823, Pacific Northwest Laboratory, Richland, Washington.

DNFSB (Defense Nuclear Facilities Safety Board). 1994. Recommendation 94-1 in a letter from the Defense Nuclear Facilities Safety Board to the Secretary of Energy dated May 26, 1994.

DOE (U.S. Department of Energy). 1988. *Consultation Draft: Site Characterization Plan, Reference Repository Location, Hanford Site, Washington*. Vol. 1 of 9, DOE/RW-0164, U.S. Department of Energy, Washington, D.C.

DOE (U.S. Department of Energy). 1989. *Decommissioning of Eight Surplus Production Reactors at the Hanford Site, Richland, Washington*. DOE/EIS-0119D, U.S. Department of Energy, Washington, D.C.

DOE (U.S. Department of Energy). 1991a. *Environmental Restoration and Waste Management Site-Specific Plan for the Richland Operations Office*. DOE/RL-91-25, U.S. Department of Energy, Richland, Washington.

DOE (U.S. Department of Energy). 1991b. *Overview of the Hanford Cleanup Five-Year Plan*. U.S. Department of Energy, Richland, Washington.

DOE (U.S. Department of Energy). 1992a. *Emergency Response Plan for U.S. Department of Energy, Richland Field Office*. Prepared for the U.S. Department of Energy by Pacific Northwest Laboratory, Richland, Washington.

DOE (U.S. Department of Energy). 1992b. *Environmental Assessment of 105-KE and 105-KW Basins Fuel Encapsulation and Repackaging, 100-K Area, Hanford Site, Richland, Washington.* DOE/EA-0535, U.S. Department of Energy, Richland, Washington.

DOE (U.S. Department of Energy). 1993a. *Hanford Site Development Plan.* DOE/RL-93-19, U.S. Department of Energy, Richland, Washington.

DOE (U.S. Department of Energy). 1993b. *U.S. Department of Energy Interim Mixed Waste Inventory Report: Waste Streams, Treatment Capacities and Technologies.* DOE/NBM-1100, U.S. Department of Energy, Washington, D.C.

DOE (U.S. Department of Energy). 1994a. *Hanford Site Waste Minimization and Pollution Prevention Awareness Program Plan.* DOE/RL-91-31, Rev. 1, U.S. Department of Energy, Richland, Washington.

DOE (U.S. Department of Energy). 1994b. *Integrated Data Base for 1993: U.S. Spent Nuclear Fuel and Radioactive Waste Inventories, Projections, and Characteristics.* DOE/RW-0006, Rev. 10, U.S. Department of Energy, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

DOE (U.S. Department of Energy). 1995a. *Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement.* The Programmatic EIS includes Vol. 1, Appendix A, Hanford Site Spent Nuclear Fuel Management Program. DOE/EIS-0203-F, U.S. Department of Energy, Washington, D.C.

DOE (U.S. Department of Energy). 1995b. *Notice of Intent to Prepare an Environmental Impact Statement for the Management of Spent Nuclear Fuel from the K Basins at the Hanford Site.* U.S. Department of Energy, Richland, Washington. 60 FR 15905, March 28, 1995.

DOE (U.S. Department of Energy). 1995c. *Implementation Plan for the Preparation of an Environmental Impact Statement on the Management of Spent Nuclear Fuel from the K Basins at the Hanford Site.* U.S. Department of Energy, Richland, Washington.

DOE (U.S. Department of Energy). 1995d. Memorandum for the Secretary from Thomas D. Grumbly and Tara O'Toole to Secretary of Energy, Hazel O'Leary. Approved by Secretary O'Leary. March 31, 1995.

DOE (U.S. Department of Energy). 1995e. *Tank Waste Remediation System Integrated Technology Plan.* Prepared by the Technology Development Program Office of the TWRS Program, DOE/RL-92-61, Rev. 2, U.S. Department of Energy, Richland, Washington.

DOE (U.S. Department of Energy). 1995f. *Environmental Assessment for Characterization of Stored Defense Production Spent Nuclear Fuel and Associated Materials at the Hanford Site.* DOE/EA-1030, U.S. Department of Energy, Richland, Washington.

DOE (U.S. Department of Energy). 1995g. *Environmental Assessment: Transfer of Plutonium Uranium Extraction Plant and 105 N Reactor Irradiated Fuel for Encapsulation and Storage at the 105 KE and 105 KW Reactor Fuel Storage Basins, 100 and 200 Areas, Hanford Site*. DOE/EA-0988, U.S. Department of Energy, Richland, Washington.

DOE (U.S. Department of Energy). 1995h. *Draft Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel*. DOE/EIS-0218D, U.S. Department of Energy, Washington, D.C.

DOE (U.S. Department of Energy). 1995i. *Hanford Site Air Operating Permit Application*. DOE/RL-95-07, U.S. Department of Energy, Richland, Washington.

DOE (U.S. Department of Energy) and Ecology (Washington State Department of Ecology). 1995. *Final Environmental Impact Statement, Safe Interim Storage of Hanford Tank Wastes*. DOE/EIS-0212, U.S. Department of Energy, Richland, Washington.

Dresel, P. E., S. P. Luttrell, J. C. Evans, W. D. Webber, P. D. Thorne, M. A. Chamness, B. M. Gillespie, B. E. Opitz, J. T. Rieger, and J. K. Merz. 1994. *Hanford Site Ground-Water Monitoring for 1993*. PNL-10082, Pacific Northwest Laboratory, Richland, Washington.

EPA (U.S. Environmental Protection Agency). 1988a. *Gap Filling PM_{10} Emission Factors for Selected Open Area Dust Sources*. EPA-450/4-88-003, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina.

EPA (U.S. Environmental Protection Agency). 1988b. *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Directive 9355.3-01*. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, D.C. (draft).

EPA (U.S. Environmental Protection Agency). 1991. *Compilation of Air Pollutant Emission Factors Volume II: Mobile Sources*. AP-42, Suppl. A, Office of Air and Radiation, Office of Mobile Sources, Test and Evaluation Branch, Ann Arbor, Michigan.

EPA (U.S. Environmental Protection Agency). 1992. *User's Guide for the Industrial Source Complex (ISC2) Dispersion Models Volume I--User Instructions*. EPA-450/4-92-008a, Office of Air Quality Planning and Standards, Technical Support Division, Research Triangle Park, North Carolina.

EPA (U.S. Environmental Protection Agency). 1993. *Compilation of Air Pollutant Emission Factors Volume I: Stationary Point and Area Sources*. AP-42, Suppl. F, Office of Air Quality Planning and Standards, Office of Air and Radiation, Research Triangle Park, North Carolina.

Ertec Northwest, Inc. 1981. *A Cultural Resources Overview and Scenic and Natural Resources Assessment for the Skagit-Hanford Nuclear Power Project*. Ertec Northwest, Inc., Seattle, Washington.

Fayer, M. J., and T. B. Walters. 1995. *Estimated Recharge Rates at the Hanford Site*. PNL-10285, Pacific Northwest Laboratory, Richland, Washington.

Fitzner, R. E., and S. G. Weiss. 1994. *Bald Eagle Site Management Plan for the Hanford Site, South-Central Washington*. DOE/RL-94-150, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Fulton, J. C. 1994. *Hanford Spent Nuclear Fuel Project, Recommended Path Forward*. WHC-EP-0830, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Glantz, C. S., and M. M. Islam. 1988. *The Data Collection Component of the Hanford Meteorology Monitoring Program*. PNL-6684, Pacific Northwest Laboratory, Richland, Washington.

Glantz, C. S., and P. J. Perrault. 1991. *Climatological Summary of the 300 Area for the 300-FF-1 Operable Unit Remedial Investigation*. WHC-SD-EN-TI-005, Westinghouse Hanford Company, Richland, Washington.

Glantz, C. S., M. N. Schwartz, K. W. Burk, R. B. Kasper, M. W. Ligotke, and P. J. Perrault. 1990. *Climatological Summary of Wind and Temperature Data for the Hanford Meteorology Monitoring Network*. PNL-7471, Pacific Northwest Laboratory, Richland, Washington.

Green, J. R., and B. D. Flanagan. 1995. *Hanford Site Truck Accident Rate, 1990-1994*. Westinghouse Hanford Company, Richland, Washington.

HAB (Hanford Advisory Board). 1994. Letter from Sue Gould to John Wagoner (DOE/RL), Chuck Clarke (EPA), and Mary Riveland (Department of Ecology), dated November 1994.

Hajek, B. F. 1966. *Soil Survey: Hanford Project in Benton County, Washington*. BNWL-243, Pacific Northwest Laboratory, Richland, Washington.

Hanlon, B. M. 1995. *Waste Tank Summary for Month Ending December 31, 1994*. WHC-EP-0182-81, Westinghouse Hanford Company, Richland, Washington.

HFSUWG (Hanford Future Site Uses Working Group). 1992. *The Future for Hanford: Uses and Cleanup*. Final Report of the Hanford Future Site Uses Working Group. U.S. Department of Energy, Richland, Washington.

Hoitink, D. J., and K. W. Burk. 1994. *Climatological Data Summary 1993 with Historical Data*. PNL-9809, Pacific Northwest Laboratory, Richland, Washington.

Holdren, G. R., C. S. Glantz, L. K. Berg, K. Delinger, S. M. Goodwin, J. R. Rustad, R. Schalla, and J. A. Schramke. 1994. *Environmental Settings for Selected U.S. Department of Energy Installations-Support Information for the Programmatic Environmental Impact Statement*. PNL-10180, Pacific Northwest Laboratory, Richland, Washington.

Holloman, W. D., and C. M. Motzko. 1992. *Westinghouse Hanford Company Performance Indicators December 1991*. WHC-SP-0440-39, Westinghouse Hanford Company, Richland, Washington.

Holloman, W. D., and C. M. Motzko. 1993. *Westinghouse Hanford Company Performance Indicators December 1992*. WHC-SP-0440-51, Westinghouse Hanford Company, Richland, Washington.

Holt, R. G., L. E. Gadbois, and D. P. Holland. 1995. "Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement) Unit Managers' Recommendation to Resume Discussions on M-34 Basin Changes." Letter to K. M. Thompson (U.S. Department of Energy), D. R. Sherwood (U.S. Environmental Protection Agency), and R. F. Stanley (Washington State Department of Ecology), June 26, 1995.

Homann Associates Incorporated. 1988. *EPI Code*. Homann Associates Incorporated, Fremont, California.

ICRP (International Commission on Radiological Protection). 1991. *1990 Recommendations of the International Commission on Radiological Protection*. ICRP Publication 60, Pergamon Press, Elmford, New York.

ITAT (Independent Technical Assessment Team). 1994. *Dry Storage of N Reactor Fuel, Independent Technical Assessment*. Vol. 1, Independent Technical Assessment Team. MAC Technical Services Co., Richland, Washington.

Johnson, V. G., D. L. Graham, and S. P. Reidel. 1993. "Methane in Columbia River Basalt Aquifers: Isotopic and Geohydrologic Evidence for a Deep Coal-Bed Gas Source in the Columbia Basin, Washington." *American Association of Petroleum Geologist Bulletin*, Vol. 77, pp. 1192-1207.

Kasza, G. L., M. J. Hartman, W. A. Jordan, and J. V. Borghese. 1994. *Groundwater Maps of the Hanford Site, December 1993*. WHC-EP-0394-8, Westinghouse Hanford Company, Richland, Washington.

Konzek, G. J., R. I. Smith, M. C. Bierschbach, and P. N. McDuffie. 1993. *Revised Analyses of Decommissioning for the Reference Pressurized Water Reactor Power Station*. NUREG/CR-5884, Draft for Comment. U.S. Nuclear Regulatory Commission report by Pacific Northwest Laboratory, Richland, Washington.

Lansing, K. A., T. L. Aldridge, D. S. Cunningham, D. A. Hammond, J. E. Lindsey, J. L. Newcomb, I. L. Scrimsher, and J. J. Severud. 1992. *Westinghouse Hanford Company Health and Safety Report, 1991*. WHC-SP-0564-24, Westinghouse Hanford Company, Richland, Washington.

Latimer, W. M. 1952. *Oxidation Potentials*. Prentice-Hall, Inc., New York, New York.

Lindberg, J. W. 1993. *Geology of the 100-K Area, Hanford Site, South-Central Washington*. WHC-SD-EN-TI-155, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Luttrell, S. P. 1995. "Ground-Water Modeling for the C-018H Facility." Letter report to R. D. Hildebrand (U.S. Department of Energy), April 5, 1995, Pacific Northwest Laboratory, Richland, Washington.

MIG (Minnesota IMPLAN Group). 1993. *Micro IMPAN User's Guide*. Micro IMPLAN Group, St. Paul, Minnesota.

Napier, B. A., R. A. Peloquin, D. L. Strenge, and J. V. Ramsdell. 1988. *GENII - The Hanford Environmental Radiation Dosimetry Software System*. PNL-6584, Vols. 1-3, Pacific Northwest Laboratory, Richland, Washington.

National Park Service. 1994. *Hanford Reach of the Columbia River: Comprehensive River Conservation Study and Environmental Impact Statement*. U.S. Department of the Interior, Washington, D.C.

Neuhauser, K. S., and F. L. Kanipe. 1992. *RADTRAN 4: Volume 3 User's Guide*. SAND89-2370, Sandia National Laboratories, Albuquerque, New Mexico.

NRC (U.S. Nuclear Regulatory Commission). 1980. *Proposed Revision 1 to Regulatory 1,23, Meteorology Programs in Support of Nuclear Power Plants*. U.S. Nuclear Regulatory Commission, Washington D.C.

NRC (U.S. Nuclear Regulatory Commission). 1982. *Draft Environmental Statement Related to the Construction of Skagit/Hanford Nuclear Project, Units 1 and 2, Prepared by Puget Sound Power & Light Company, Pacific Power and Light Company, the Washington Water Power Company, and Portland General Electric Company*. NUREG-0894, U.S. Nuclear Regulatory Commission, Washington, D.C.

OFM (Office of Financial Management). 1994a. *1994 Population Trends for Washington State*. Office of Financial Management, Forecasting Division. Olympia, Washington.

OFM (Office of Financial Management). 1994b. *Inter-Censal and Post-Censal Estimates of County Populations by Age and Sex: State of Washington 1980-1994*. Office of Financial Management, Forecasting Division. Olympia, Washington.

PNL (Pacific Northwest Laboratory). 1992. *Safety Analysis Report for 324 Building Waste Technology, Engineering Laboratory*. PNL-7989, Pacific Northwest Laboratory, Richland, Washington.

Poole, L. D. 1992. *Reproductive Success and Nesting Habitat of Loggerhead Shrikes in Shrubsteppe Communities*. M.S. Thesis, Oregon State University, Corvallis, Oregon.

Rao, R. K., E. L. Wilmot, and R. E. Luna. 1982. *Non-Radiological Impacts of Transporting Radioactive Material*. SAND81-1703, Sandia National Laboratories, Albuquerque, New Mexico.

Relander, C. 1956. *Drummers and Dreamers*. Caxton Printers, Caldwell, Idaho.

Rice, D. G. 1968a. *Archaeological Reconnaissance: Ben Franklin Reservoir Area, 1968*. Washington State University, Laboratory of Anthropology, Pullman, Washington.

Rice, D. G. 1968b. *Archaeological Reconnaissance: Hanford Atomic Works*. U.S. Atomic Energy Commission, National Park Service and Washington State University, Pullman, Washington.

Rice, D. G. 1980. *Overview of Cultural Resources on the Hanford Reservation in South Central Washington State*. Report submitted to U.S. Department of Energy, Richland Operations Office, Richland, Washington.

Rickard, W. H., and D. G. Watson. 1985. "Four Decades of Environmental Change and Their Influences Upon Native Wildlife and Fish on the Mid-Columbia River, Washington, U.S.A." *Environ. Conserv.* 12:241-238.

Rohay, A. C. 1989. *Earthquake Recurrence Rate Estimates for Eastern Washington and the Hanford Site*. PNL-6956, Pacific Northwest Laboratory, Richland, Washington.

Schramke, J. A. 1993. *Hanford Hydrologic Data for the PEIS*. Pacific Northwest Laboratory, Richland, Washington.

Schramke, J. A., C. S. Glantz, and G. R. Holdren. 1994. *Hanford Site Environmental Setting Data Developed for the Unit Risk Factor Methodology in Support of the Programmatic Environmental Impact Statement (PEIS)*. PNL-9801, Pacific Northwest Laboratory, Richland, Washington.

Schreckhise, R. G., K. Rhoads, J. S. Davis, B. A. Napier, and J. V. Ramsdell. 1993. *Recommended Environmental Dose Calculation Methods and Hanford-Specific Parameters*. PNL-3777, Rev. 2, Pacific Northwest Laboratory, Richland, Washington.

Scott, M. J., D. B. Belzer, R. J. Nesse, R. W. Schultz, P. A. Stokowski, and D. C. Clark. 1987. *The Economic and Community Impacts of Closing Hanford's N Reactor and Nuclear Materials Production Facilities*. PNL-6295, Pacific Northwest Laboratory, Richland, Washington.

Seinfeld, J. H. 1986. *Atmospheric Chemistry and Physics of Air Pollution*. John Wiley and Sons, Inc., New York.

Spier, L. 1936. *Tribal Distribution in Washington*. General Series in Anthropology No. 3, George Banta Publishing Co., Menasha, Wisconsin.

Stone, W. A., J. M. Thorp, O. P. Gifford, and D. J. Hoitink. 1983. *Climatological Summary for the Hanford Area*. PNL-4622, Pacific Northwest Laboratory, Richland, Washington.

Tallman, A. M., K. R. Fecht, M. C. Marratt, and G. V. Last. 1979. *Geology of the Separation Areas Hanford Site, South-Central Washington*. RHO-ST-23, Rockwell Hanford Operations, Richland, Washington.

Thorne, P. D. 1993. Pacific Northwest Laboratory, Richland, Washington, memorandum to J. A. Schramke, Pacific Northwest Laboratory, Richland, Washington, "Information to Support Hanford PEIS," April 15.

Trafzer, C. E., and R. D. Scheuerman. 1986. *Renegade Tribe: The Palouse Indians and the Invasion of the Inland Pacific Northwest*. Washington State University Press, Pullman, Washington.

TSP (Technical Steering Panel of the Hanford Environmental Dose Reconstruction Project). 1994. *Summary: Radiation Dose Estimates from Hanford Radioactive Material Releases to the Air and to the Columbia River*. Centers for Disease Control and Prevention, Atlanta, Georgia.

U.S. Department of Labor. 1994. "Domestic Agricultural In-Season Farm Labor Report, Washington State - Farm Labor Abstract." Issued monthly by the U.S. Department of Labor, Employment and Training Administration.

Valero, O. J., T. J. DeFrost, and K. J. Templeton. 1995. *1995 Solid Waste 30-Year Volume Summary*. WHC-EP-0865, Westinghouse Hanford Company, Richland, Washington.

Washington Natural Heritage Program. 1994. *Endangered, Threatened and Sensitive Vascular Plants of Washington*. Washington State Department of Natural Resources, Olympia, Washington.

Washington State Employment Security. February 1994 - February 1995. *Labor Area Summaries*. Washington State Employment Security, Olympia, Washington.

WHC (Westinghouse Hanford Company). 1990. Draft Revision B, *Interim Safety Basis for the 308 Building*. WHC-SD-FL-ISB-001, Westinghouse Hanford Company, Richland, Washington.

WHC (Westinghouse Hanford Company). 1993a. Letter report: *Annual Report for Solid Waste Landfill Operations*. 8701982B R6, January 14, Westinghouse Hanford Company, Richland, Washington.

WHC (Westinghouse Hanford Company). 1993b. *UO3 Plant Safety Analysis Report*. WHC-SD-CP-SAR-002, Rev. 6G, Westinghouse Hanford Company, Richland, Washington.

WHC (Westinghouse Hanford Company). 1995. *PFP Safety Analysis Report*. WHC-SD-CP-SAR-021, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Whelan, G., D. W. Damschen, and R. D. Brockhaus. 1987. *Columbia River Statistical Update Model - Version 4.0 (COLSTAT4): Background Documentation and User's Guide*. PNL-6041, Pacific Northwest Laboratory, Richland, Washington.

Whelan, G., J. P. McDonald, and C. Sato. 1994. *Environmental Consequences to Water Resources from Alternatives of Managing Spent Nuclear Fuel at Hanford.* PNL-10053, Pacific Northwest Laboratory, Richland, Washington.

Woodruff, R. K., R. W. Hanf, and R. E. Lundgren (eds). 1993. *Hanford Site Environmental Report for Calendar Year 1992.* PNL-8682, Pacific Northwest Laboratory, Richland, Washington.

8.0 PREPARERS

The following staff of the Pacific Northwest Laboratory were key contributors to the preparation of this EIS:

Roseanne L. Aaberg, dose calculations. B.S. (Chemical Engineering) University of Washington. Seventeen years of experience in dose calculations and EIS preparation.

John C. Abbott, affected environment and environmental impacts. B.A. (Geography) Southwest Texas State University, M.S. (Conservation of Natural Resources) University of Texas at San Antonio. Over 18 years of experience in the preparation of NEPA documents, NEPA audits, ecological risk assessments, regulatory compliance activities, program oversight, and assistance to President's Council on Environmental Quality (CEQ).

Cynthia W. Abrams, waste management on the Hanford Site and environmental consequences. B.A. (Environmental Studies and Biology) University of California at Santa Cruz. Nine years experience at Hanford specializing in the development and analysis of environmental policy, and the preparation of guidance for the implementation of that policy. Primary areas include ecological systems management, ecological risk assessment, public involvement, CERCLA policy analysis, and other project oversight activities.

Susan L. Blanton, references, preparers, and index. B.S. (Zoology) Miami University. Five years of experience in technical writing, and two years of experience in EIS preparation.

Michele A. Chamness, geology and hydrology. B.S. (Geology) Washington State University. Sixteen years of experience studying in geology and hydrology of the Hanford Site.

Jean M. Cheyney, communication support specialist. Four years of experience in document production and word processing.

Colbert E. Cushing, deputy project manager, ecological resources. B.S. (Fisheries Management) and M.S. (Limnology) Colorado State University, Ph.D. (Limnology) University of Saskatchewan. Thirty-four years of experience in freshwater ecological research in streams and radioecology, and over twenty years of experience in EIS preparation. Teaches university classes in stream ecology and writing journal articles.

Phil M. Daling, transportation consequence analysis. B.S. (Physical Metallurgy) Washington State University. Fifteen years experience in risk, safety, reliability, and statistical analysis techniques and in the preparation of safety analysis documents for a wide variety of nonnuclear and nuclear operations, facilities, and transportation.

Sharon M. Daly, lead communication support specialist. Twelve years of experience in word processing and graphic design.

Michelle Davis, waste management. B.S. (Industrial Engineering) University of Washington, M.S. (Environmental Science) Washington State University. Over four years of experience in hazardous, mixed and nuclear waste management, hazardous and radioactive inventory control, waste minimization and pollution prevention, and programmatic performance assessment for waste and materials management programs.

Christian J. Fosmire, nonradiological air quality impacts. B.S. (Meteorology) and M.S. (Meteorology) Pennsylvania State University. One year of experience in computer programming and data collection and analysis in the area of atmospheric diffusion modeling and risk assessment.

Clifford S. Glantz, nonradiological air quality impacts. B.S. (Physics and Atmospheric Sciences) State University of New York at Albany, M.S. (Atmospheric Sciences) University of Washington. Twelve years of experience in the analysis of nonradiological air quality impacts.

Paul L. Hendrickson, regulatory requirements. B.S. (Chemical Engineering) University of Washington, M.S. (Industrial Management) Purdue University, J.D. University of Washington School of Law. Twenty-two years of experience in energy and environmental studies. Special emphasis on regulatory issues including regulatory requirements analyses for EISs.

Jay C. Lavender, transportation consequence analysis. B.A. (Industrial Technology) Washington State University. Ten years of experience in risk, safety, reliability, and statistical analysis techniques and in the preparation of safety analysis documents for a wide variety of nonnuclear and nuclear operations, facilities, and transportation systems.

Regina E. Lundgren, lead communications specialist. B.A. (Scientific and Technical Communication/Environmental Studies) University of Washington. Over 10 years experience in the preparation of NEPA documents, risk communication, and documentation project management.

Kristin L. Manke, communication specialist. B.S. (Biochemistry) Washington State University. Over 6 years experience in environmental, scientific, and technical communications projects.

Emmett B. Moore, project manager. B.S. (Chemistry) Washington State University, Ph.D. (Physical Chemistry) University of Minnesota. Twenty years of experience in environmental regulation, participation in and management of the preparation of environmental permits and documentation (NEPA). University professor of physics, chemistry, and environmental sciences.

Kathy R. Neiderhiser, communication support specialist. A.A. (Business Management), Clark County Community College. Ten years of experience in document production and word processing.

Iral C. Nelson, deputy project manager, environmental consequences. B.S. (Mathematics) University of Oregon, M.A. (Physics) University of Oregon, diplomate, American Board of Health Physics. Forty years of experience in various aspects of health physics (radiation protection) and 24 years of experience in conducting NEPA reviews and preparing NEPA documentation.

Paul R. Nickens, cultural resources. B.A., M.A., and Ph.D. (Anthropology/archaeology), University of Colorado. Twenty-four years experience in various aspects of cultural resource management, including several years experience in preparing cultural resources and Native American sections for EISs.

Ted M. Poston, noise impact assessment. B.A. (Biology) Central Washington University, M.S. (Fisheries) University of Washington. Twenty years of experience in research, environmental assessment, and noise analysis.

Kathleen Rhoads, consequences analysis coordinator. B.S. (Microbiology) and M.S. (Radiological Sciences), University of Washington. Nineteen years of experience in the analysis of risk assessment variables, estimation of radiation dose following routine or accidental release of radionuclides to the environment, and evaluation of health effects from energy production.

Teresa A. Riley, publication assistant. A.A.S. (Executive Secretary Program), Columbia Basin College. Over 4 years experience coordinating the production of large documents.

Michael J. Scott, affected socioeconomic environment and impacts. B.A. (Economics), Washington State University, M.A. and Ph.D. (Economics), University of Washington. More than 20 years experience in regional socio-economic impact analysis, regional economic impact modeling, and regional economic forecasting.

Richard I. Smith, life-cycle costs for proposed alternatives. B.S. (Physics) Washington State University, M.S. (Applied Physics) University of California at Los Angeles. P.E. (Nuclear Engineering) State of Washington and State of California. Over 38 years of experience in research and development activities in the nuclear area, including neutronics studies for experimental reactors, analyses of decommissioning licensed nuclear facilities, analyses of the waste management system in support of the Nuclear Waste Policy Act, and in the planning of Hanford cleanup.

Betty J. Tegner, editor. B.A. (English) University of Washington, M.A. (English) California Polytechnical State University. Previous experience in journalism and university teaching. Five years of experience in technical editing.

Rose M. Watt, communication support specialist. Seventeen years of experience in page layout, document production, document design, and word processing.

Gene Whelan, water quality and related consequences. B.S. (Civil Engineering) Pennsylvania State University, M.S. (Mechanics and Hydraulics) University of Iowa, Ph.D. (Civil and Environmental Engineering) Utah State University. Seventeen years of experience in multimedia contaminant environmental exposure assessments.

9.0 DISTRIBUTION LIST

CONGRESS

United States Senate

Hon. Slade Gorton--Washington

Hon. Patty Murray--Washington

Hon. Mark Hatfield--Oregon

United States House of Representatives

Hon. Norman D. Dicks--Washington

Hon. Jennifer Dunn--Washington

Hon. Richard (Doc) Hastings--Washington

Hon. Jim McDermott--Washington

Hon. Jack Metcalf--Washington

Hon. George R. Nethercutt, Jr.--Washington

Hon. Linda Smith--Washington

Hon. Randy Tate--Washington

Hon. Rick White--Washington

Hon. Jim Bunn--Oregon

Hon. Elizabeth Furse--Oregon

FEDERAL AGENCIES

Mr. Chuck Clarke
Regional Administrator
U.S. Environmental Protection Agency
Region 10

Defense Nuclear Facilities Safety Board
John T. Conway, Chair

National Park Service

U.S. Fish and Wildlife Service

U.S. Fish and Wildlife Service
Region 1

U.S. Nuclear Regulatory Commission
Office of Nuclear Materials Safety and Safeguards
Spent Fuel Program Office

STATE GOVERNMENT

Washington State - Executive, Elected

Hon. Mike Lowry, Governor

Hon. Christine Gregoire, Attorney General

Washington State - Senate

Sen. Pat Hale

Sen. Valoria Loveland

STATE GOVERNMENT (contd)

Washington State - House of Representatives

Rep. Jerome Delvin

Rep. Bill Grant

Rep. Shirley Hankins

Rep. Dave Mastin

Washington State - Agencies

Department of Ecology

Ms. Mary Riveland, Director

Mr. Dan Silver, Asst. Director

Mr. Ron Effland

Ms. Barbara Ritchie

Mr. Tom Tebb

Department of Health

Mr. Al Conklin

Washington State - Local Government

Mr. Joe King
City of Richland

Mr. Gary Crutchfield
City of Pasco

Mr. Robert Kelly
City of Kennewick

STATE GOVERNMENT (contd)

Mr. Ray Isaacson, Chairman
Benton County Commissioner

Ms. Sue Miller
Franklin County Commissioner

Oregon State - Executive, Elected

Hon. John Kitzhaber, Governor

Oregon State - Agencies

Oregon Water Resources Department

Mr. Ralph Patt

Oregon Department of Energy

Mr. David Stewart-Smith, Administrator

Mr. Dirk Dunning

NATIVE AMERICAN TRIBES

Confederated Tribes of the Umatilla Indian Reservation

Nez Perce Tribe

Wanapum People

Yakama Indian Nation

HANFORD ADVISORY BOARD

LIBRARIES

Gonzaga University
Foley Library

Portland State University
Branford Price Miller Library

University of Washington Library

DOE Public Reading Room, Richland

DOE Public Reading Room,
Washington D.C.

INTERESTED INDIVIDUALS

Dr. Dick Belsey
Physicians for Social Responsibility

Walt Blair
Kennewick, WA

Bob Cook
Richland, WA

Dames and Moore
Denver, CO

Ken Ferguson
Greenpeace

Harold Heacock
TRIDEC

Maxine Hines
La Grande, OR

Les Jardine
LLNL

INTERESTED INDIVIDUALS (contd)

Russell Jim
Toppenish, WA

Paige Knight
Hanford Watch

Ken Kramer
Sheridan, OR

Richard Longmire
Spokane, WA

Jesus Mancilla
Richland, WA

Todd Martin
Hanford Education Action League

Clyde Nash, Jr.
Seattle, WA

Gerald Pollett
Heart of America NW

Ms. Donna L. Powaukee
ERWM Manager
Nez Perce Tribe

Merilyn Reeves, Chair
Hanford Advisory Board

Ray Robinson
Richland, WA

Gordon Rogers
Pasco, WA

Elizabeth Shedd
Seattle, WA

INTERESTED INDIVIDUALS (contd)

Lynn Sims
Portland, OR

Lance S. Soto
Portland, OR

Charles Sullivan
Portland, OR

David Talbert Huber
Seattle, WA

Ross Tewksbury
Portland, OR

INTERESTED INDIVIDUALS (contd)

Miles Uchida
Portland, OR

James E. Weber
Portland, OR

Edward Wenk
Kirkland, WA

Bob Williams
Portland, OR

APPENDIX A

INVENTORY AND FACILITY DESCRIPTIONS

APPENDIX A

INVENTORY AND FACILITY DESCRIPTIONS

This appendix provides information on facilities included in this Environmental Impact Statement (EIS). The data are intended to supplement the discussion presented in Chapter 3.0 of the EIS.

Existing facilities are discussed with regard to their function, condition, and service life. Proposed facilities are derived from the alternatives described in the EIS. Where relevant and applicable, information on facilities from the *DOE Spent Nuclear Fuel Programmatic EIS* (DOE 1995), from which this EIS is tiered, is integrated with this discussion. Information on the new facilities, or proposed modifications to existing facilities, is based primarily from on the *K Basins Environmental Impact Statement Technical Input* (Bergsman et al. 1995). Information from the *Hanford Spent Nuclear Fuel Project Recommended Path Forward* (Fulton 1994), the *Staging and Storage Facility Feasibility Study Final Report* (Fluor Daniel 1995), and the *Dry Storage of N Reactor Fuel Independent Technical Assessment* (ITAT 1994) have been considered where applicable.

The K East (KE) and K West (KW) Reactors and respective basins are about 430 m (1,400 ft) from the Columbia River (see Figures A-1 and A-2). They were constructed in the 1950s as part of the ongoing "Cold War" strategy to produce weapons-grade plutonium.

A.1 Inventory

The total inventory of irradiated N Reactor fuel at Hanford is approximately 2,100 MTU (Tables A-1 and A-2). The inventory contains 1,764.3 MTU of fuel-grade fuel and 331.2 MTU of weapon-grade fuel. An additional 0.3 MTU of weapon-grade fuel remains in the canyon of the Plutonium and Uranium Recovery through Extraction (PUREX) Plant, but will be going to the K Basins.

The KW Basin contains approximately 952 MTU of N Reactor fuel in 3,817 closed canisters; the basin water has a low degree of radionuclide contamination. The KE Basin contains approximately 1,144 MTU in 3,673 canisters; its water is contaminated with radionuclides. Each basin also contains a small amount of single-purpose reactor fuel: 0.1 MTU in KW and 0.4 MTU in KE (Bergsman 1993).

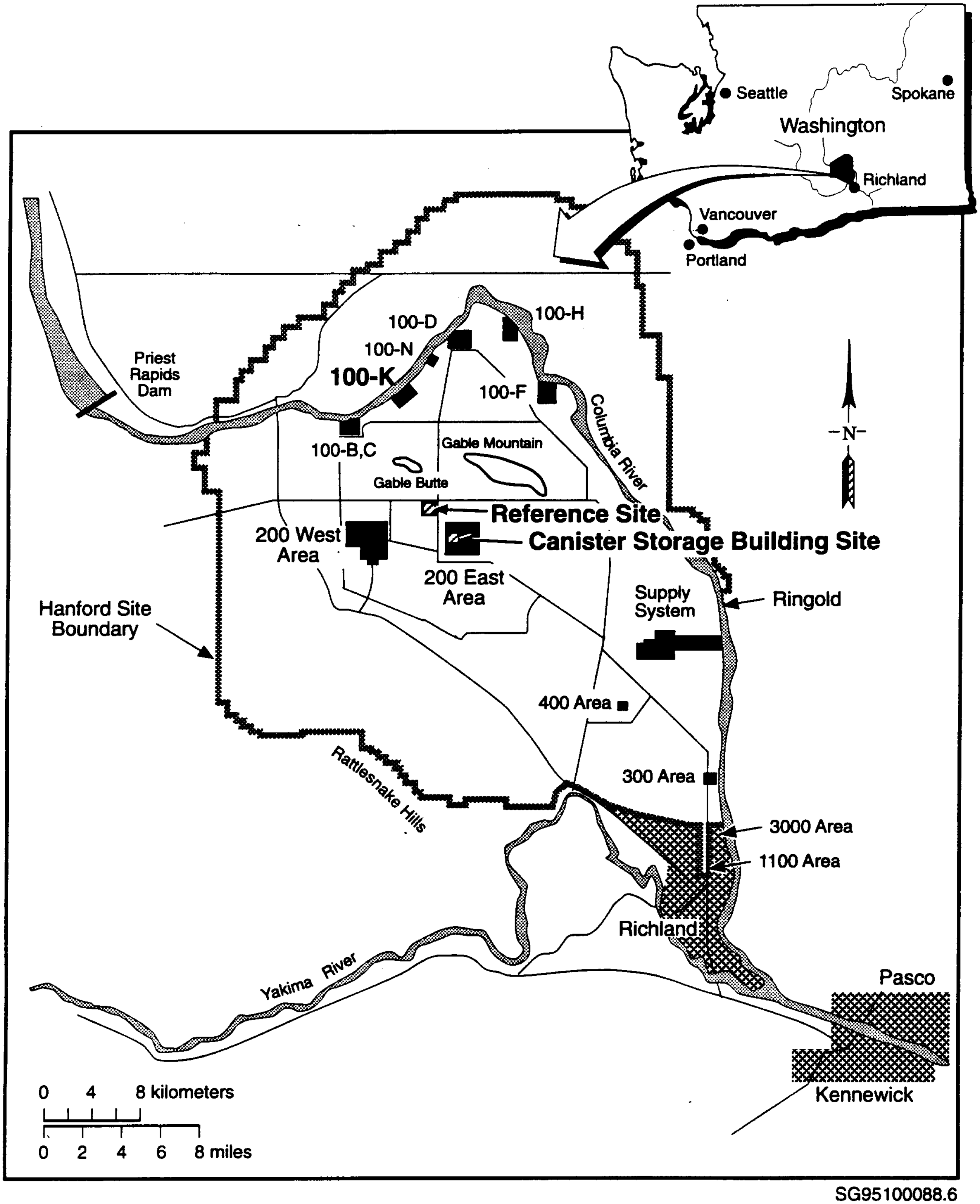


Figure A-1. Hanford Site in southcentral Washington

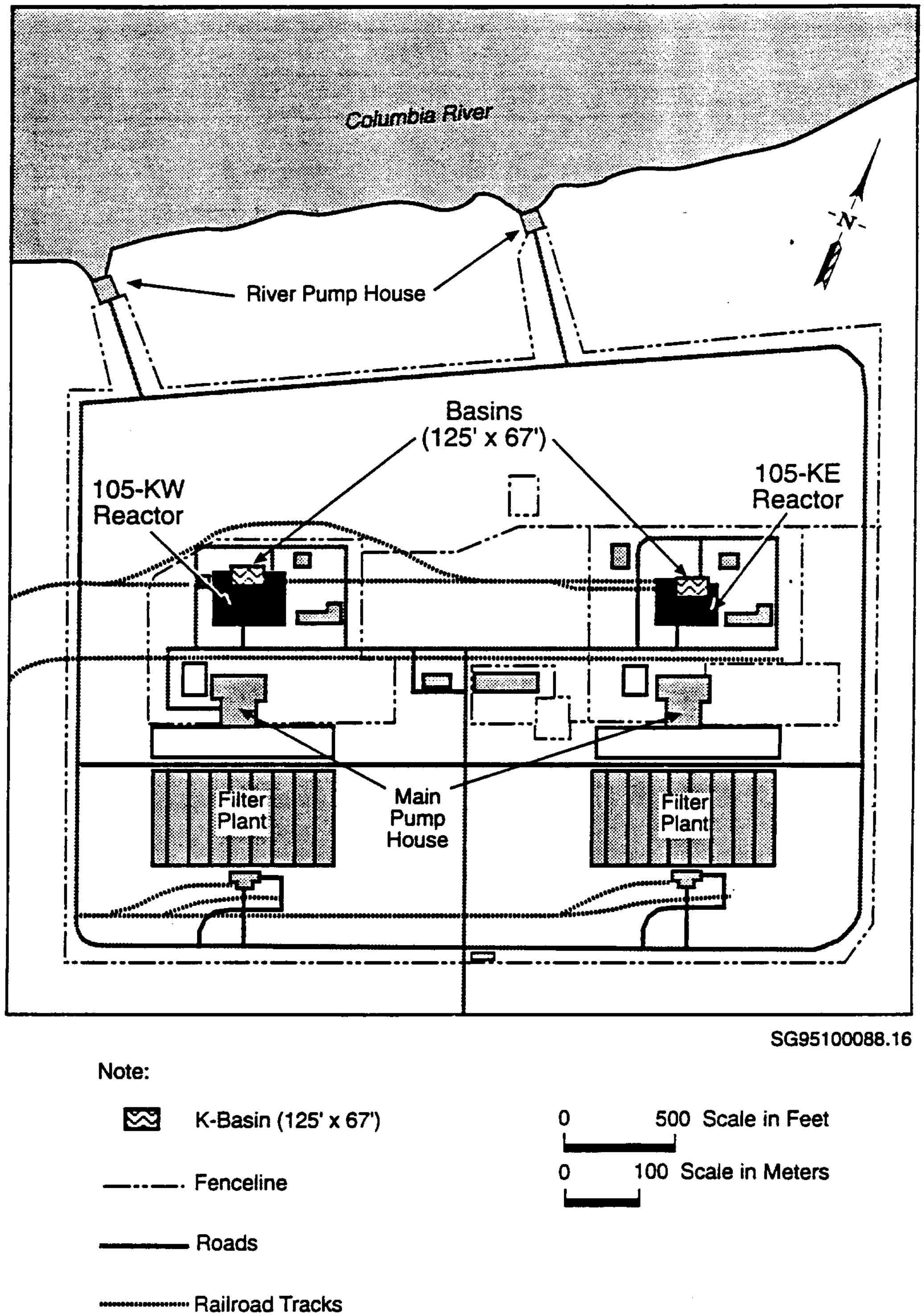


Figure A-2. Plan view of the K Basins

Table A-1. Inventory of fuel in K Basins and PUREX Plant

Fuel Type	Fuel Type: Mark IV (MTU)	Fuel Type: Mark IA (MTU)	Total (MTU)
Weapon grade	291.9	39.3	331.2
Fuel grade	1176.3	588.0	1764.3
Unknown (PUREX)	0.3	0.0	0.3
Total	1468.5	627.3	2095.8[a]

(a) Other documents have listed the N Reactor fuel inventory as 2100 MTU, which was a pre-irradiation inventory used in a Hanford Site 100 Area internal accounting system.

The N Reactor fuel elements consist of two concentric tubes of uranium metal co-extruded into Zircaloy-2 cladding. The two basic types of fuel elements are differentiated by their uranium enrichment. Mark IV elements have a pre-irradiation enrichment of 0.947% uranium-235 in both tubes and an average uranium weight of 22.7 kg (50 lb). They have an outside diameter of 6.1 cm (2.43 in.), and their length is 44, 59, 62, or 66 cm (17.4, 23.2, 24.6, or 26.1 in.). Mark IA elements have a pre-irradiation enrichment of 1.25% uranium-235 in the outer tube and 0.947% in the inner tube; their average uranium weight is 16.3 kg (35.9 lb). Their outside diameter is 6.1 cm (2.4 in.), and their length is 38, 50, or 53 cm (14.9, 19.6, or 20.9 in.). A small amount of Mark IV fuel has a uranium-235 content of 0.71%.

A.1.1 Sludge in the Storage Basins

Fuel handling operations and fuel oxidation have led to accumulation of sludge and some fuel on the floors of KE Basin. Some fuel elements broke into pieces during fuel discharges from the reactor. Fuel with breached cladding has oxidized and some uranium oxide has sloughed off and mixed with the sludge. Zirconium oxide, iron oxide, concrete grit, and other materials have also accumulated and mixed with the fuel to form sludge. However, the sludge is mostly composed of dirt that has blown in. Some of the oxidized fuel in Mark 0 canisters fell through screen bottoms to the basin floor. The estimated sludge volume in the KE Basin is 50 m^3 (1,800 ft^3); Table A-3 gives the average activity of radionuclides in the sludge. Some of the KE Basin fuel in open-topped canisters was repackaged into closed canisters and sent to the KW Basin, where all fuel is in closed canisters and about 4 m^3 (5.4 yd^3) sludge has accumulated on the floor.

Table A-2. Radionuclide inventory of the combined K Basins decayed to January 1, 1995 (Bergsman et al. 1995)

Isotope	Activity (Ci/MTU)	Mass (kg)	Heat Generation (W)	Isotope	Activity (Ci/MTU)	Mass (kg)	Heat Generation (W/MTU)
			Fission and Activation Products				
^{3}H	4.15×10^{4}	0.00430	1.39	^{123}Sn	0.0125	1.52×10^{-9}	3.90×10^{-5}
^{14}C	663	0.149	0.194	^{126}Sn	142	5.00	0.0437
^{55}Fe	4,360	0.00174	0.145	^{124}Sb	4.58×10^{-12}	2.62×10^{-19}	6.04×10^{-14}
^{60}Co	1.48×10^{5}	0.131	2,280	^{125}Sb	7.17×10^{4}	0.0694	225
^{59}Ni	39.2	0.517	0.00156	^{126}Sb	19.9	2.38×10^{-7}	0.360
^{63}Ni	4,410	0.0715	0.445	^{126m}Sb	142	1.81×10^{-9}	1.82
^{79}Se	81.3	1.17	0.0251	^{123m}Te	3.25×10^{-8}	3.66×10^{-15}	4.72×10^{-11}
^{85}Kr	7.03×10^{5}	1.79	1,050	^{125m}Te	1.74×10^{4}	9.69×10^{-4}	14.7
^{89}Sr	1.94×10^{-10}	6.68×10^{-18}	6.71×10^{-13}	^{127}Te	0.00241	9.13×10^{-13}	3.25×10^{-6}
^{90}Sr	1.05×10^{7}	77	1.22×10^{4}	^{127m}Te	0.00246	2.61×10^{-10}	1.22×10^{-6}
^{90}Y	1.05×10^{7}	0.0193	5.80×10^{4}	^{129}Te	0.00	0.00	0.00
^{91}Y	5.44×10^{-8}	2.22×10^{-15}	1.95×10^{-10}	^{129m}Te	0.00	0.00	0.00
^{93}Zr	381	151	0.0439	^{129}I	5.93	33.6	0.00278
^{95}Zr	1.16×10^{-6}	5.40×10^{-14}	5.86×10^{-9}	^{134}Cs	4.63×10^{4}	0.0358	472
^{93m}Nb	211	7.46×10^{-4}	0.0379	^{135}Cs	72.5	63	0.0242
^{95}Nb	2.57×10^{-6}	6.58×10^{-14}	1.24×10^{-8}	^{137}Cs	1.35×10^{7}	155	1.36×10^{4}
^{95m}Nb	8.61×10^{-9}	2.26×10^{-17}	1.14×10^{-11}	^{137m}Ba	1.28×10^{7}	2.38×10^{-5}	5.01×10^{4}
^{99}Tc	2,720	160	1.37	^{141}Ce	0.00	0.00	0.00
^{103}Ru	2.22×10^{-15}	6.88×10^{-23}	7.27×10^{-18}	^{144}Ce	1.80×10^{4}	0.00564	11.9
^{106}Ru	1.74×10^{4}	0.00520	1.04	^{143}Pr	0.00	0.00	0.00
^{103m}Rh	2.00×10^{-15}	6.15×10^{-26}	4.60×10^{-19}	^{144}Pr	1.78×10^{4}	2.36×10^{-7}	131
^{106}Rh	1.74×10^{4}	4.89×10^{-9}	167	^{144m}Pr	216	1.19×10^{-9}	0.0727
^{107}Pd	14.7	28.6	8.09×10^{-4}	^{147}Pm	1.08×10^{6}	1.16	398
^{110}Ag	0.00807	1.94×10^{-15}	6.07×10^{-8}	^{148}Pm	1.23×10^{-17}	7.49×10^{-26}	9.46×10^{-20}
^{110m}Ag	0.607	1.28×10^{-7}	0.0101	^{148m}Pm	2.18×10^{-16}	1.02×10^{-23}	2.73×10^{-18}
^{113m}Cd	3,760	0.0173	4.13	^{151}Sm	1.72×10^{5}	6.54	20.1
^{115m}Cd	1.22×10^{-15}	4.79×10^{-23}	4.54×10^{-18}	^{152}Eu	1,020	0.00590	4.60
^{113m}In	3.63×10^{-4}	2.17×10^{-14}	8.38×10^{-7}	^{154}Eu	1.28×10^{5}	0.474	1,150
^{113}Sn	3.63×10^{-4}	3.62×10^{-11}	6.04×10^{-8}	^{155}Eu	3.31×10^{4}	0.0712	24
^{119m}Sn	9.34	2.09×10^{-6}	0.00482	^{153}Gd	0.00416	1.18×10^{-9}	3.75×10^{-6}
^{121m}Sn	78.8	0.00133	0.0827	^{160}Tb	3.85×10^{-10}	3.41×10^{-17}	3.08×10^{-12}
	Fission and Activation Product Total				4.98×10^{7}	686	1.40×10^{5}
			Actinides				
^{234}U	878	141	24.8	^{241}Pu	7.38×10^{6}	71.6	229
^{235}U	34	1.57×10^{4}	92.3	^{242}Pu	59	15.5	1.72
^{236}U	127	1,960	3.40	^{241}Am	3.15×10^{5}	91.8	1.03×10^{4}
^{238}U	696	2.07×10^{6}	17.3	^{242}Am	350	4.33×10^{-7}	2.91
^{237}Np	65.4	92.8	1.88	^{242m}Am	352	0.0362	0.539
^{238}Pu	1.25×10^{5}	7.30	4,070	^{243}Am	55.1	0.276	1.74
^{239}Pu	2.25×10^{5}	3,620	6,860	^{242}Cm	290	8.77×10^{-5}	10.5
^{240}Pu	1.30×10^{5}	570	3,980	^{244}Cm	1.51×10^{4}	0.187	519
		Actinide Totals			8.19×10^{6}	2.09×10^{6}	2.60×10^{4}

Table A-3. Inventory of radionuclides in KE Basin sludge

Radionuclide	Ci[a]
^{3}H	N.A.
^{60}Co	23
^{90}Sr	1,280
^{90}Y	1,280
^{129}I	N.A.
^{135}Cs	N.A.
^{137}Cs	972
^{137m}Ba	920
^{154}Eu	26.1
^{155}Eu	13.5
^{234}U	N.A.
^{235}U	N.A.
^{236}U	N.A.
^{238}Pu	65.1
^{238}U	N.A.
^{239}Pu	260
^{240}Pu	143
^{241}Am	782
^{241}Pu	5,220
^{242}Pu	0.0436
Total	1.10×10^{4}

(a) N.A. = Information not available.

A.1.2 Condition of Fuel

The KW Basin was cleaned, refurbished, and epoxy-coated in 1981. The spent nuclear fuel (SNF) in the KW Basin is stored in closed stainless steel or aluminum canisters. Visually, these canisters appear to be in good condition. Most of the discussion therefore, will center on the KE Basin. Conditions in the KE Basin bound those in the KW Basin. In 1994, an examination covered about 70% of the total fuel inventory of the basin. The remaining fuel was obscured by various obstructions and debris in the basin. Approximately 98% of all canisters containing fuel were examined to some degree. Of the two-barreled canisters examined from the top, 85% contained at least one breached piece of fuel. Extrapolation of those findings to the unexamined bottom ends of the elements suggests that over 90% of the canisters contain at least one breached element. Nearly 6% of the canisters contained badly damaged fuel that could not be handled intact; extrapolation suggests that the true incidence is at least 10%.

A.2 Description of K Basins

The K Basins were constructed in the 1950s for the original purpose of temporarily storing SNF from the KE and KW Reactors; they were constructed approximately 1 year after the reactor buildings were completed. Each basin is immediately contiguous to and north of the KE and KW main reactor buildings (see Figure A-2). Each basin is enclosed by a one-story steel-framed building, which also houses the water treatment and cooling systems. The roof structure of the steel-framed building includes a monorail fuel transport system. A floor grating system, covering the entire basin, is suspended from the roof structural steel framing (Figure A-3).

Each basin is 38 m (125 ft) long, 20 m (67 ft) wide, and 6 m (21 ft) deep and is divided into 3 bays by 0.6-m (2 ft) concrete partitions, which are open at each end so that water moves freely between the bays (Figure A-4). The west end of each basin has a load out pit to the south and a sand-filter backwash pit to the north. The east ends have viewing pits. The water-retention boundary extends into auxiliary pits on the east and west ends of each basin. An asphalt membrane underlies each basin but does not extend beneath the discharge chutes (Figure A-5).

The walls of the KE Basin are a constant thickness of 69 cm (27 in.); the west wall of the KW Basin is also a uniform 69 cm (27 in.) thick, but the other three walls taper from 69 cm at the base to 46 cm at the top (27 to 18 in.). The concrete floor and walls of the KE Basin contain neither sealant nor liner; the KW Basin has an epoxy sealant but is not lined.

The discharge pickup chute provided access from the each reactor building to its fuel storage basin. The chute served as a fuel element discharge and packaging area during operation of the KE and KW Reactors.

An unreinforced vertical concrete construction joint filled with a water-wetted elastic polymer compound runs between each reactor and its basin along the entire width of the basin. This construction joint has leaked in the past. The reactor designs provided for the addition of the basins, including the joint, which was intended to be water-tight, between each basin and its reactor building. The primary barrier to leakage was a thick flexible

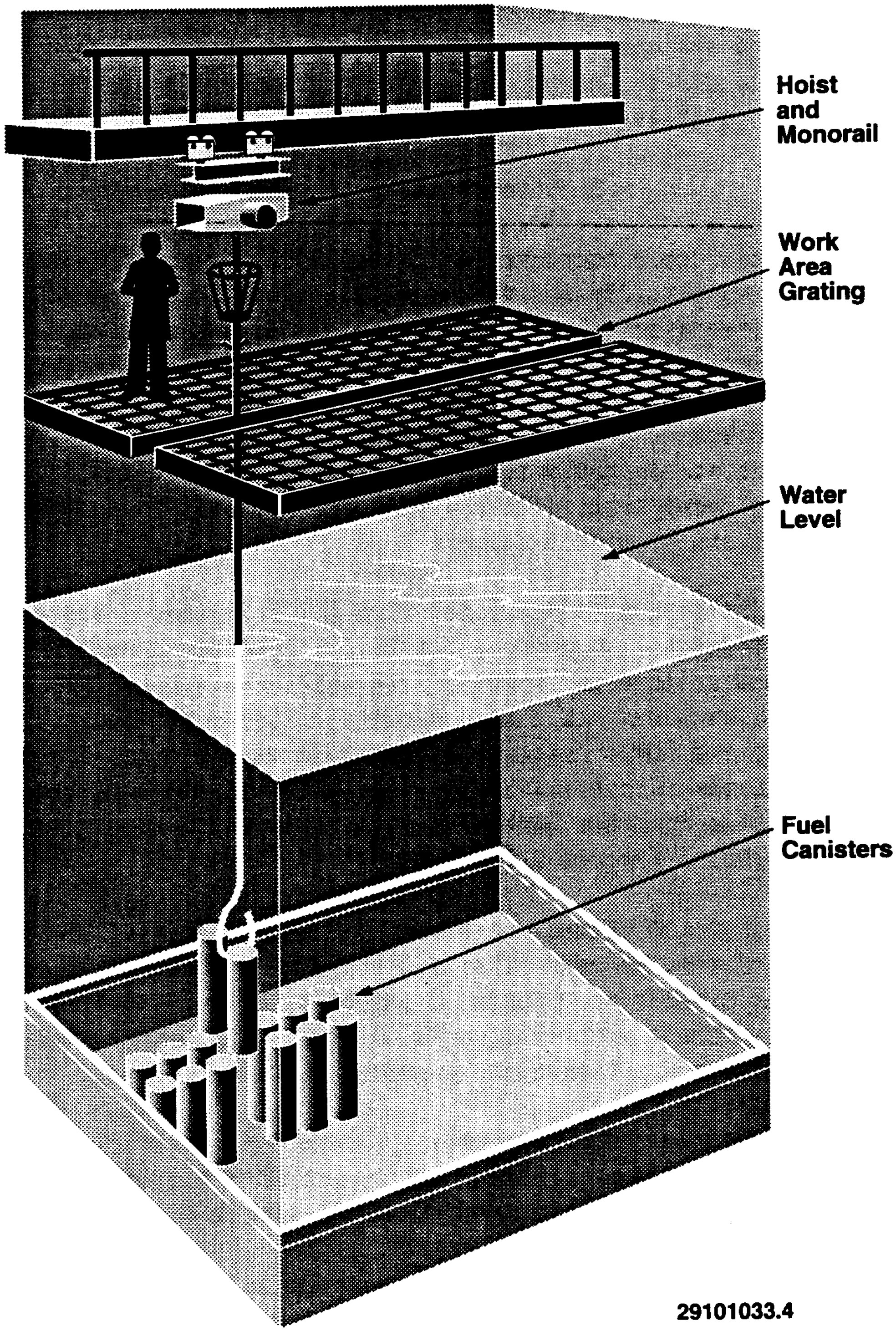


Figure A-3. Floor grating at the KE and KW Basins

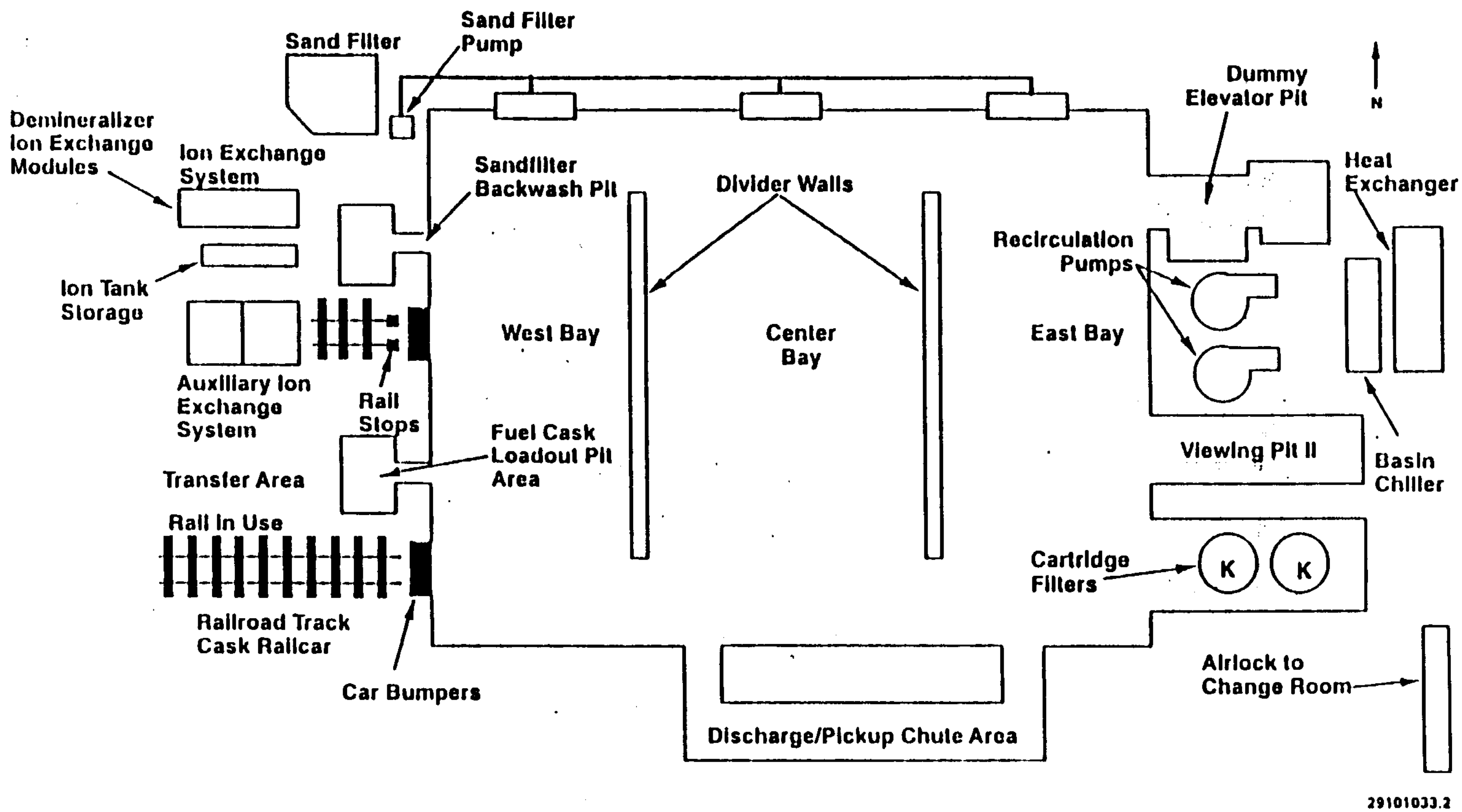


Figure A-4. Plan view of the KE and KW Basins

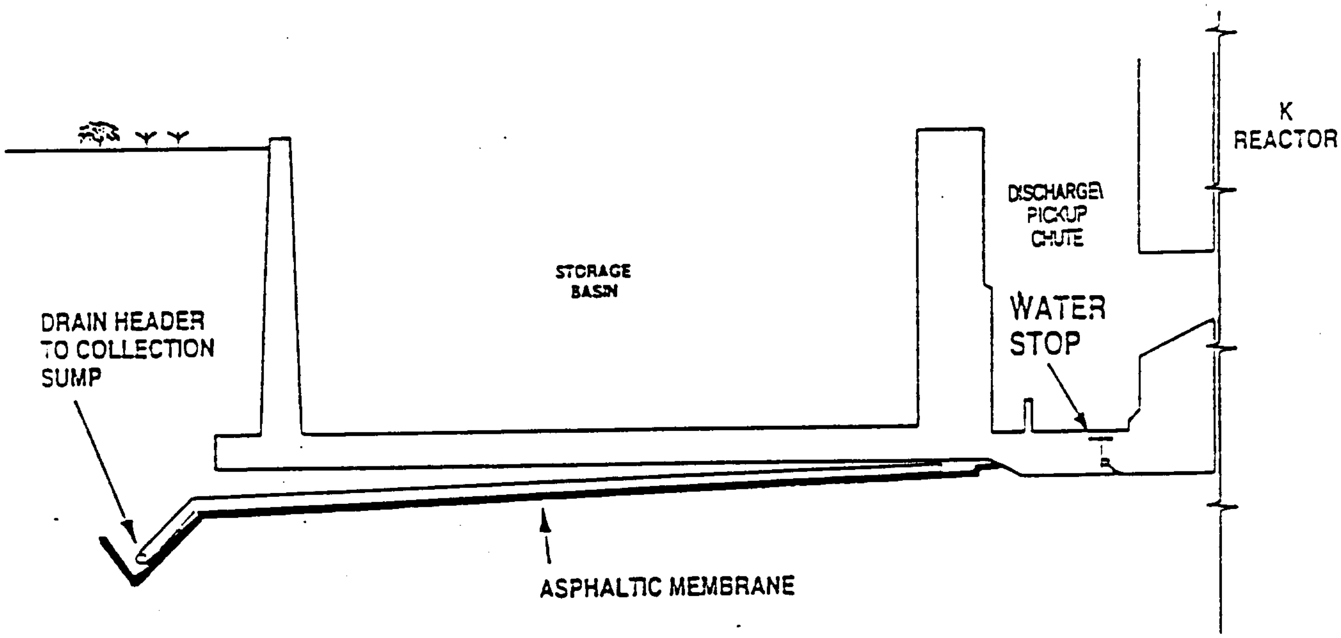


Figure A-5. Vertical section of the KE and KW Basins

membrane cast into the reactor building concrete below the outfall to the discharge chute. When the basins were constructed, the concrete floors were cast around the flexible membranes.

Two isolation barriers (Figure A-6) were recently installed between the basin proper and the reactor building. The barriers isolate the main part of the basin, where SNF is stored, from the reactor discharge chute, where the construction joint is located.

The walls and floor of the basin are the primary containment barrier. The bottom of each pool is approximately 6.1 m (20 ft) below grade; each bottom slab is 0.6 m (2 ft) thick. Unused or unnecessary drains have been plugged and sealed with concrete. Drains that might carry contaminated or potentially contaminated water have been intercepted and routed to a liquid effluent sump. As mentioned, an epoxy sealant lines the floor and walls of the KW Basin to further limit leakage. The discharge chute of the KE Basin was lined with epoxy after repair to a construction joint in 1980. The original underbasin leakage system (the asphalt membrane and a pipeline to a dispersion tile field) has been intercepted outside the facility. Contaminated effluents are now collected, routed to a sump, and pumped back to the

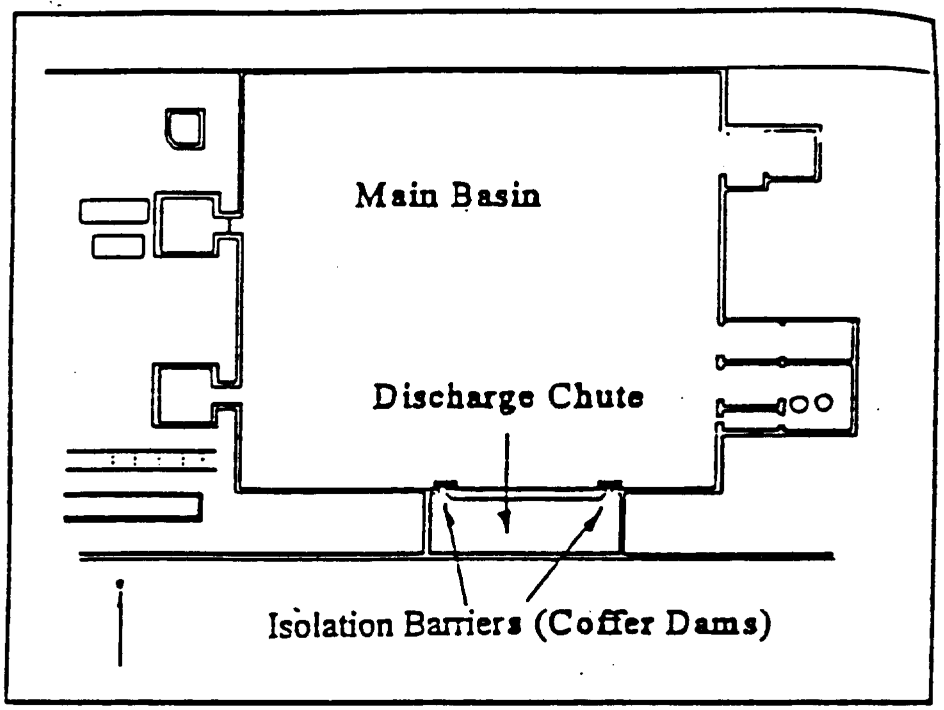


Figure A-6. Plan view of discharge chute with isolation dams installed

facility or to a radioactive waste holding tank. Two 303-L/min (80 gal/min) vertical, extended shaft, centrifugal sump pumps return the leakage water to the cooling basin. The pumps are equipped with electrical controls to alternate the pumping cycle between pumps and to operate both when the demand exceeds the capacity of one pump. The sump pumps are not Safety Class 1 equipment.

Each basin is equipped with a water-recirculating system that incorporates in-line filters, an ion-exchange system, a sand-filter system, mechanical chillers, and instruments to monitor radiation levels, heat-generation rate, and water level. The cooling and cleanup systems are manually controlled and can be shut down for maintenance or replacement of components. Each system has some redundant equipment (e.g., two cartridge filters, two primary pumps, two ion exchange systems); however, all electrical power is from a single source. During any power outage all normal fuel handling activity will cease, since normal instrumentation will be lost. Radiation levels, coolant temperature, and coolant level can be determined with portable instruments or by other means.

The fuel is stored in canisters in single-stacked storage racks at the bottom of each basin. The racks are steel frames that sit on the concrete floor. Although the racks are not anchored to the floors, they overlap along their long sides. The rack units extend to or nearly to the pool walls. The openings in the racks are so sized that they can hold only one fuel storage canister each. The canisters are approximately 74 cm (29 in.) high, have two cylindrical barrels approximately 23 cm (9 in.) in diameter, and normally contain 14 fuel elements. The racks and canisters together maintain geometric control of the stored fuel under normal handling operations and credible accidents to preclude criticality.

Hoists and separately attached lifting rods move canisters along an underwater path, which corresponds to the route of the interconnecting network of slots built into the floor grating. The canisters can be shifted to and from the storage basins into the abutting pits or pickup station for unloading, loading, reviewing, or inspection.

Water levels in the basins are maintained at a minimum of 4.72 m (15.5 ft) above the basin floor to cool the stored fuel and provide radiological shielding for personnel working in the facility. The filters and ion exchange systems maintain water clarity and remove radionuclides. Water temperature, pH, conductivity, and water level are continuously monitored; temperature is maintained around 10°C (50°F), pH is normally between 6 and 7 (range, 5.5 to 8), and average conductivity is 10 μmhos (range, 5 to 60 μmhos).

Four vents exhaust unfiltered air from the fuel storage area in the KE and KW buildings. Emission monitoring consists of an emission sampler for each vent. Each K Basin is a registered exhaust emission point that has been designated as a minor stack at the Hanford Site with the potential to contribute a dose of less than 0.1 mrem/year to the maximally exposed offsite individual.

In the KE building, two low-bay roof ventilators exhaust the fuel storage area, and two high-bay roof ventilators exhaust the water treatment area. The fuel-storage and water-treatment areas share the same air space inside the facility. All roof ventilators discharge their effluent horizontally, and each has four associated samplers.

Access to the K Basins is by rail. Only the transfer pit at the south side of each basin is functional. Cask handling capability is similar at both basins but is fairly restricted. Crane capacity is 27 MT. The cask-transfer pit is 2.1 m (6.8 ft) by 2.8 m (9.2 ft), but the loading pit internal framework restricts the free clearance to 1.5 m (4.9 ft) by 2.8 m (9.2 ft). Casks must be loaded under water and must be less than 2.6 m (8.5 ft) tall.

A.3 New Facilities Proposed on the Hanford Site

Several facilities are proposed for the Hanford Site in support of the defense fuel management decisions that will be made regarding the KE and KW Basins. All of the designs remain conceptual pending selection of an alternative in the record of decision. The final designs may be substantially improved.

A.3.1 Facilities Associated with the New Wet Storage

Two wet-storage modes have been suggested for the SNF:

- water-filled multicanister overpacks (MCOs) in a vault
- pool storage (MCOs in pool racks or vault tubes).

A.3.1.1 Water-Filled MCOs in a New Vault Storage Facility

The vault storage approach would use water-filled MCOs stacked two high in dry or water-filled storage tubes. The tubes would extend into below grade, concrete enclosed, shielding vaults, which would be cooled by recirculating refrigerated air. The vault storage tube material would be stainless steel, if the tubes were filled with water to minimize electrochemical corrosion mechanisms between the tubes and the stainless steel MCOs. If the tubes were dry, they would be made of carbon steel (Corten®).

If the partially constructed Canister Storage Building (CSB) site (see Section A.4) were selected, the vault facility would use the entire foundation. Three below-grade vaults would likely be constructed. The CSB design provides space for up to 880 MCOs, each containing 10 fuel canisters. Any excess vault capacity could be used for storage of other, compatible Hanford Site materials (i.e., cesium/strontium capsules, other Hanford SNF, vitrified waste), but their receipt and storage would require supplemental National Environmental Policy Act review.

If the reference site (see Section A.4) were selected, only two storage vaults would likely be built to meet the needs for only K Basins SNF storage. The information provided for the CSB site is, therefore, conservative and is used to develop generic impacts at both potential sites.

A conceptual layout of a vault storage facility is shown in Figure A-7. The facility would consist of seven main areas and six major systems. Arriving vehicles would be received and washed and the casks prepared and unloaded in the transport tunnel/cask unloading area. The unloading area would include the wash area, the cask unloading and storage area, the cask preparation pit, the cask unloading pool, and the cask loading pit.

This area would receive, handle, and prepare the incoming MCOs for placement in the storage tubes before stabilization. The wash area would be an airlock confinement area where the incoming rail cars or delivery truck/trailer would be washed before entering the cask unloading and storage area.

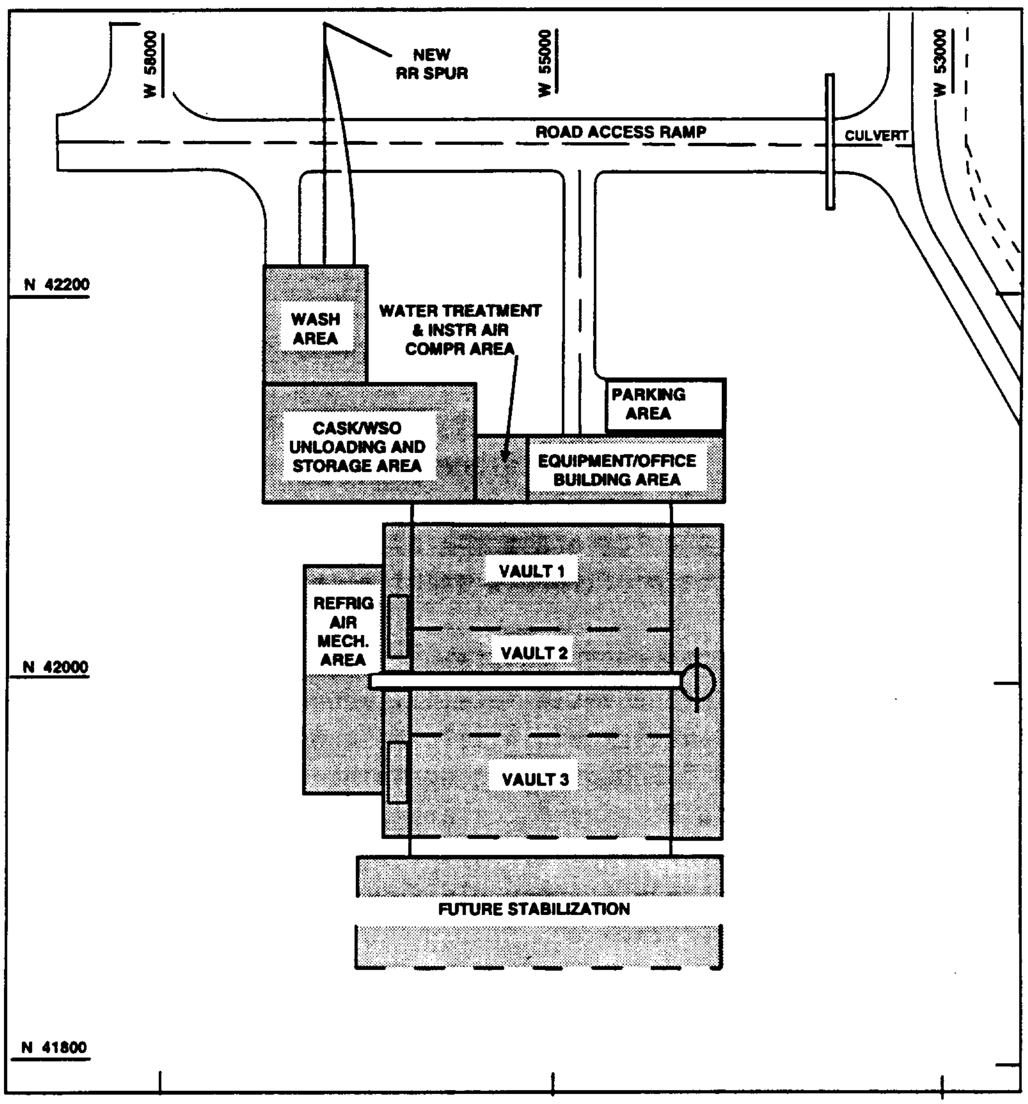


Figure A-7. New vault storage facility

The cask unloading and storage area would be designed for unloading and loading shipping casks and for handling and storage of empty MCOs. A 5-m (15-ft)-tall wall would partially isolate this area from the cask preparation pit, the unloading pool, and the loading pit but would allow passage of the overhead crane above it. The cask preparation pit, between the isolation wall and the end of the storage pool, would be dedicated to preparing shipping casks for unloading. A 54.4-MT (60-ton) overhead crane would be used to handle the cask. The cask unloading pool, adjacent to the cask preparation pit, would be dedicated to unloading MCOs from their casks, to MCO servicing, and to placing defective MCOs in overpacks. The pool would be lined with stainless steel to ensure water purity, to prevent water migration through the concrete pool structure, and to allow decontamination at the end of the facility life. The cask unloading area would have an underwater transfer canal to transfer MCOs to a receiving station in the operating area. The cask loading pit would be similar in construction to the preparation pit. The then ready-to-use cask would be transferred to a storage position or to an empty vehicle in the loading and storage area. Servicing four MCOs per day would require two servicing stations, each equipped with the necessary gas collection pit, filter, piping, and instruments.

The water in the cask unloading pool would provide shielding and cooling for the MCOs. The pool water treatment system would maintain pool temperature, clarity, and radioactive contamination at acceptable levels. Although no leakage would be expected from MCOs or system components, the pool and its water treatment system would be designed to minimize radiation exposure if an accident caused leakage.

The water-treatment system would have sufficient redundancy (or contingency backup capability in the available response time) so that a single failure of any active component (such as a pump, filter, or control) would not cause loss of system function.

The cask unloading pool water treatment system would consist of pool skimmers and flow distribution piping, recirculation pumps, high-efficiency filters, filter backwash equipment, deionization units, waste slurry holding, waste water holding, chemical unloading, water chillers, and water sterilizers. System drainage would go to the waste water holding tank to be neutralized and monitored before being picked up by a truck with a pump. Pool water filtrate slurry would go to the contaminated waste slurry holding tank to be monitored before being transferred into a shielded container on a truck. Separate curbed areas would be provided for truck loading and unloading and the tanks for waste water and contaminated waste slurry.

Structural Information

The operating floor superstructure over vaults 1, 2, and 3 would be a prefabricated steel frame building with crane rails and a girder for the overhead cask/crane system. This building would be approximately 14 m (46 ft) high.

On the west side of the storage vault would be the refrigerated air mechanical building, a 36.6-m (120-ft)-long, 12.2-m (40-ft)-wide, and 6.1-m (20-ft)-high prefabricated steel-frame building. West of that would be five air-cooled condensers, each supported on a 2.7-m (8-ft) by 5-m (15-ft) concrete pad. North of the storage vault would be four other support buildings:

- cask/MCO unloading and storage building
  [51.8 m (170 ft) long, 36.6 m (61 ft) wide, 10.1 m (33 ft) high]

- wash area building
  [19.5 m (64 ft) long, 15.2 m (50 ft) wide, 8.2 m (27 ft) high]

- water treatment and instrument air compressor building
  [10.7 m (35 ft) long, 9.1 m (30 ft) wide, 5.2 m (17 ft) high]

- equipment/office building
  [30.6 m (100 ft) long, 10.2 m (33 ft) wide, 5.2 m (17 ft) high].

All support buildings would be prefabricated steel frame type with metal siding and roof deck.

A heating, ventilating, and air conditioning duct would connect the exhaust stack and the refrigerated air mechanical area. This duct would be supported by the operating superstructure. Removable blinds in the air inlet ducts and exhaust stack would isolate the refrigerated air system from the environment.

Contamination Control in Closed Tube Storage

Gas vented from the MCOs would rise through 1.5 m (5 ft) or more of water in the storage tube to reach the operating area, which would normally be ventilated with enough fresh air [over 16,990 m^3/hr (10,000 ft^3/min)] to dilute the hydrogen and krypton-85 levels. Because the storage tubes would be enclosed spaces in which hydrogen could accumulate, provisions would be made to prevent the accumulation of explosive concentrations. In one concept for achieving this objective, each storage tube would have a sealed plug with an embedded vent line and two test lines. The test lines would have normally-closed valves, and the vent line would contain a high-efficiency particulate air filter. The tubes designed for the CSB could contain a pressure of almost 5 psig before the plug lifted from its sealed seat; the tube wall and bellows would be designed for higher pressures. A simple modification would be to add a relief device to each vent line so that the vent would be used only if the pressure in the tube rose to about 4 psig.

A local pressure indicator would be added to each tube plug, and a portable cart used to sample and purge each tube with nitrogen. If each tube was vented and purged with nitrogen before the pressure exceeded 0.8 psig, the hydrogen concentration would not exceed 6% by volume. A 6% mixture of hydrogen in nitrogen would be nonflammable when mixed with any proportion of air.

A.3.1.2 Pool Storage

In this option, a new storage pool would constructed. This water-filled open pool would hold 880 MCOs in underwater stainless steel racks. Each MCO would hold up to 10 fuel canisters. MCOs would be designed with grapples so that they could be transported underwater without the cask. Stainless steel storage racks in the pool would be modular and movable with the pool storage crane. MCOs would be stored vertically, under about 7.3 m (24 ft) of water. Approximately 18 spaces in the rack would be provided for storage of MCOs that had been overpacked because of detected or suspected leaks.

The pool water treatment system would maintain pool temperature, clarity, and radioactive contamination within acceptable levels. The stainless steel-lined pool would be equipped with a leak-detection system and a collection sump in the concrete structure. Water treatment would include filtration and ion exchange.

The pool would have three or four vaults, located below grade level. One vault would be used as a wet-staging pool. The others would be constructed as potential dry storage for MCOs returning from a future stabilization process, if such a process were selected for interim storage.

In the three-vault alternative, the dry storage vaults would be equipped with a total of 440 storage tubes, in which stabilized MCOs would be stacked two-deep. If the four-vault alternative is implemented, the dry storage vaults would contain a total of 660 storage tubes. Vaults would be constructed of concrete and enclosed by a steel-frame building.

A.3.2 Removal of SNF from the K Basins, Treatment, and up to 40 Years Dry Storage

Four different treatment options are under consideration, each with its own facilities: drying by vacuum and/or heating, passivation, calcination (oxide forms), and onsite processing.

A.3.2.1 Drying and Passivation (or Conditioning) Facility

Drying and passivation (or conditioning) as described in the ITAT (1994) report is a gradual process of drying the SNF from the K Basins in a safe and measured manner. The goal is to get the previously wet SNF to a dry, stable state, "conditioned" for dry storage.

Water-filled MCOs would be transferred from the storage facility to a new drying/passivation facility, which would be built adjacent to the storage facility and connected to it by a transfer corridor. The approximate overall building dimensions would be 25 m (82 ft) wide by 64 m (210 ft) long by 20 m (66 ft) high. The building would extend approximately 13 m (43 ft) above the ground. The building's construction is primarily "cast in place" concrete, but has some areas enclosed in metal sided structures. Roughly "L" shaped, the building would contain areas for MCO processing; wastewater collection and treatment; sludge collection and packaging; auxiliary power generation; heating, ventilating, and air conditioning and process off-gas handling; and other necessary functions. The proposed layout of the facility is shown in Figure A-8.

The SNF would be protected at all times in a shielded transfer cask or conditioning station. Additional equipment, such as the conditioning system isolation valves, would provide localized protection if warranted by an evaluation of probability versus mitigative actions provided in the system design.

A.3.2.2 New Facility for Onsite Calcination (Oxide Forms)

This option would require construction of a new facility adjacent to the storage facility and connected to it by a transfer corridor. The calcination facility would be a multilevel steel-reinforced, cast-in-place concrete structure like those typically used to process high-level radioactive materials. The process building would be appropriately hardened for ground motion. The hardened and highly shielded main canyon for this facility would have a width of 6 m (19.7 ft), a length of 70 m (230 ft), and a height of 26 m (85.3 ft).

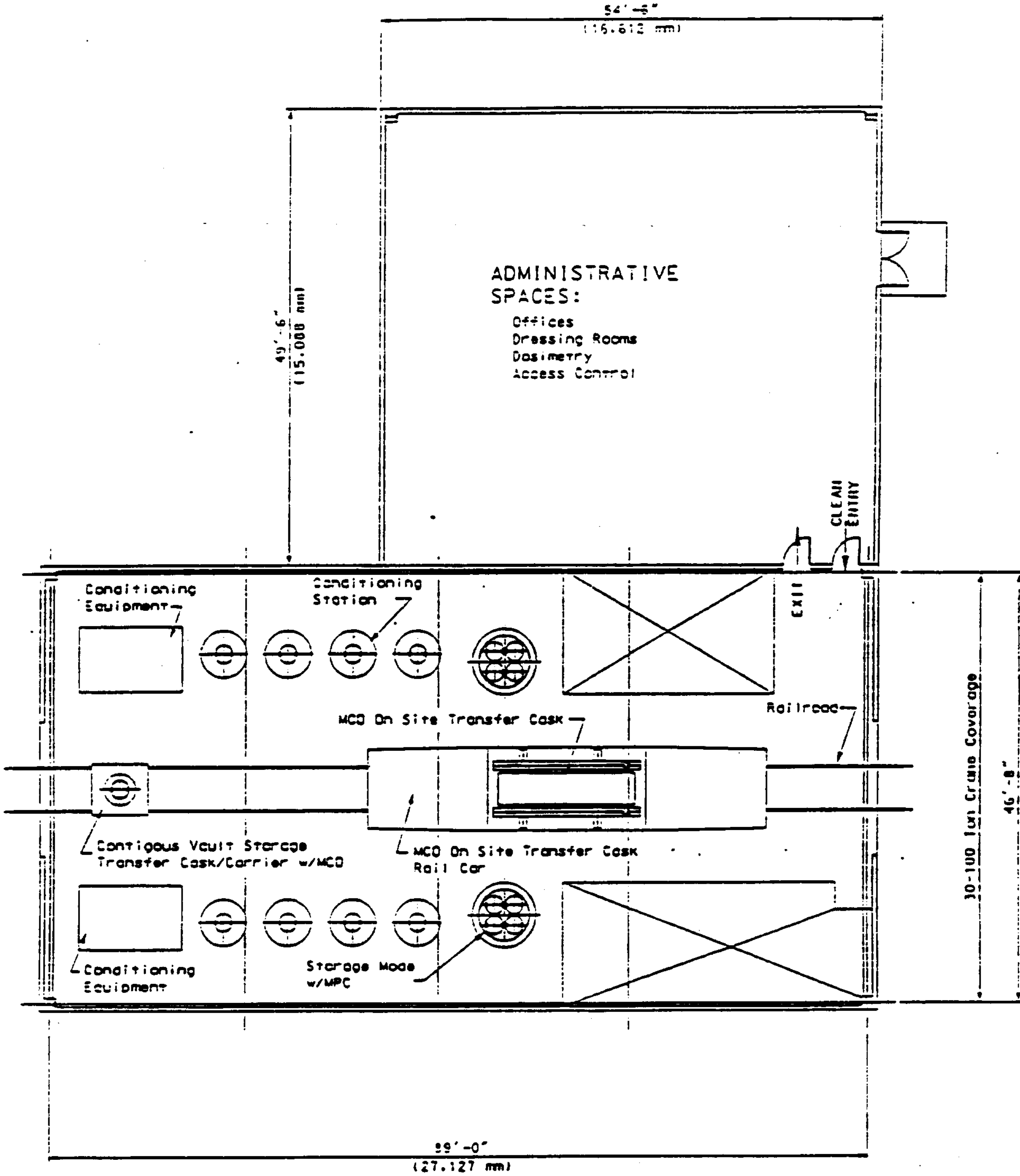


Figure A-8. Proposed conditioning facility conceptual layout (Bergsman et al. 1995)

The process building would be approximately 110 m (361 ft) long, 50 m (164 ft) wide, and 26 m (85.3 ft) tall; approximately 10 m (33 ft) of the facility height would be located below grade. Figure A-9 shows a layout of the proposed facility.

The calcination facility would be sized to finish stabilization of the 2100 MT (2000 tons) of fuel within 4 years. It is assumed that the facility would operate 24 hours per day, 7 days per week, during scheduled operating periods. It is further assumed that the facility would be scheduled for operation 280 days per year, with 85 days per year allowed for scheduled down time.

A.3.2.3 Dry Storage Facility

The fuel canisters would be delivered to the 200 Area dry storage facility packed in heavy stainless steel MCOs. It is anticipated that the canisters would come to the facility dry. The drying and passivation would have been completed, and the MCO would have been made inert with an appropriate storage atmosphere and sealed. The MCO would be the primary containment. The typical secondary containment would be a long steel tube mounted in a heavily shielded concrete modular vault or in a thick-walled concrete or steel storage cask.

Sludge disposition options that require no new facilities include:

- manage all canister sludge as SNF
- grout KW Basin floor sludge, if any, and transfer to low-level waste disposal site
- transfer KE Basin floor sludge to existing double-shell tanks
- dispose of sludge as low-level waste, mixed waste, or transuranic waste as determined by appropriate characterization.

Other commercially available dry storage systems are shown in Figure A-10. These indicate secondary fuel containment structures (e.g., tubes) and a thick wall of concrete. Air flow is designed into the structures to help with cooling.

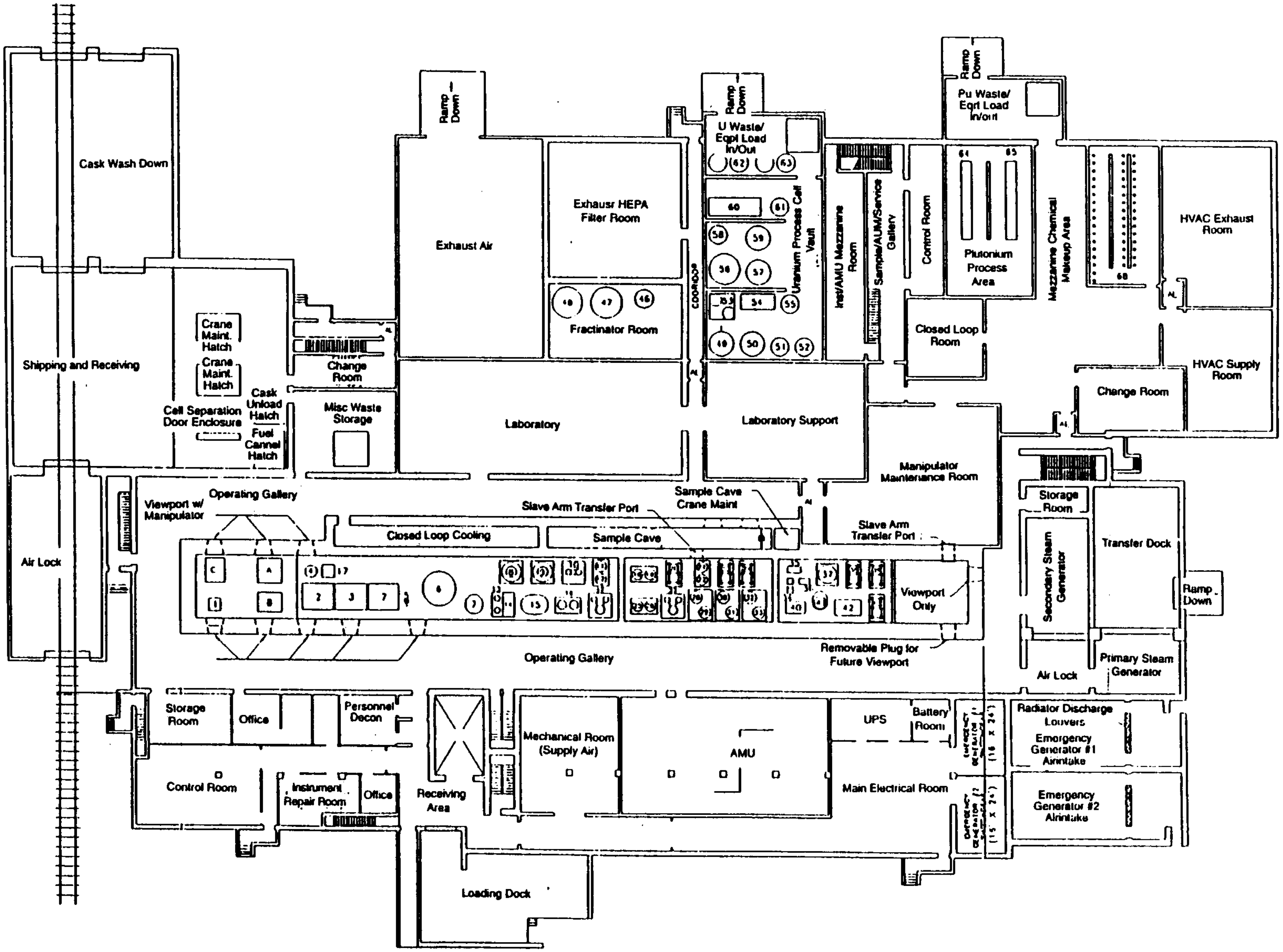


Figure A-9. Proposed calcination facility (Bergsman et al. 1995)

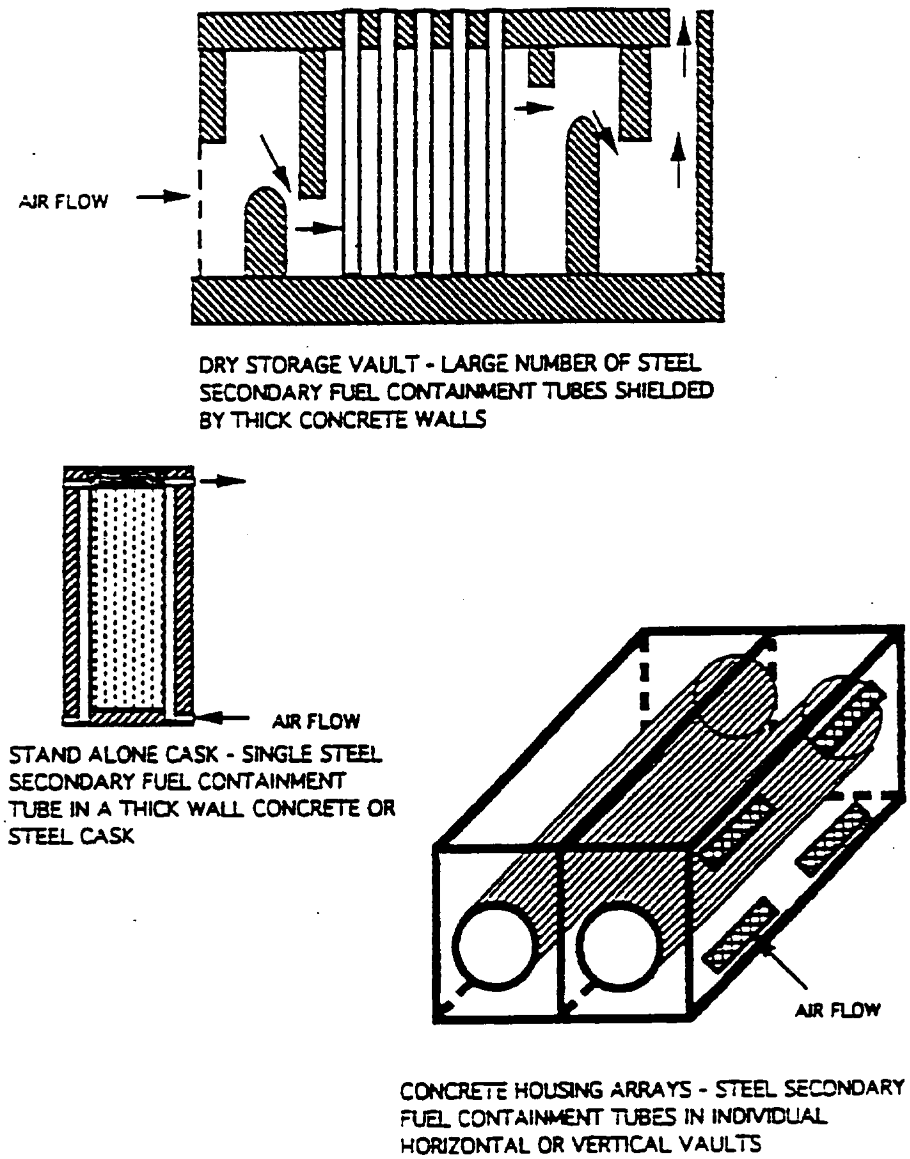


Figure A-10. Commercially available dry storage systems (ITAT 1994)

A.3.2.4 Dry Storage in Casks

Dry storage could be accomplished by storing the SNF in casks. To implement dry storage in casks, the conditioned K Basin SNF would be stored in casks designed for storage of commercial SNF, with horizontal storage chosen as the basis for details, consistent with DOE (1995). Each storage cask would be roughly 1.7 m (5.5 ft) in diameter, 4.9 m (16 ft) long, and would weigh over 1000,000 kg (100 tons). The concrete storage modules that would hold the cask in the system would have dimensions of approximately 3 m (10 ft) wide, 5.5 m (18 ft) deep, and 4.6 m (15 ft) high. On the order of 140 casks would be required and would be stored outside on a concrete pad.

The site would be the undisturbed 40.5-ha (100-acre) parcel described in Section A.4. A rough estimate of the land area occupied by the large casks would be approximately 3 acres.

A.3.3 Facilities Associated with Fuel Processing

Processing would require a new facility at the Hanford Site. Temporary SNF storage at a new wet facility would allow its removal from the K Basins while the processing facility was being built and operated. Processing would be scheduled to permit use of existing high-level waste tank systems.

A.3.3.1 Fuel Processing

A new facility would be required for onsite processing of K Basins SNF (Figure A-11). In this facility, metallic fuel would be sheared and then dissolved in nitric acid. Solvent extraction of uranium and plutonium from the fission products would be completed to yield uranium, plutonium, and fission product streams. The uranium nitrate product would be converted to UO_3 in a calciner and packaged for further use. The plutonium nitrate would be converted to PuO_2 and packaged for onsite storage. The high-level waste from solvent extraction would be concentrated, denitrated, neutralized, and transferred to underground storage until vitrification at a future Hanford facility. The removal of uranium and plutonium would result in the generation of a small amount of high-level waste, greatly reducing the amount of space required to dispose of the fuel. An acid absorber would recover nitric acid from the NO_x in the offgas, which would be filtered and treated as necessary to remove volatile fission products.

A.4 Proposed Sites for Construction of the Proposed Facilities

Two possible locations for the construction of the facilities associated with this project have been selected (see Figure A-1). One, called the reference site, is a 40.5-ha (100-acre) parcel just outside the northwest corner of the 200 East Area on undeveloped vacant land. It was set aside as the possible location of facilities associated with activities resulting from the alternative discussed in the *Programmatic SNF EIS* (DOE 1995).

The other site is located in the 200 East Area west of B Plant. A foundation and portions of the north and east walls of the proposed CSB for the discontinued Hanford Waste Vitrification Plant are present. The CSB was

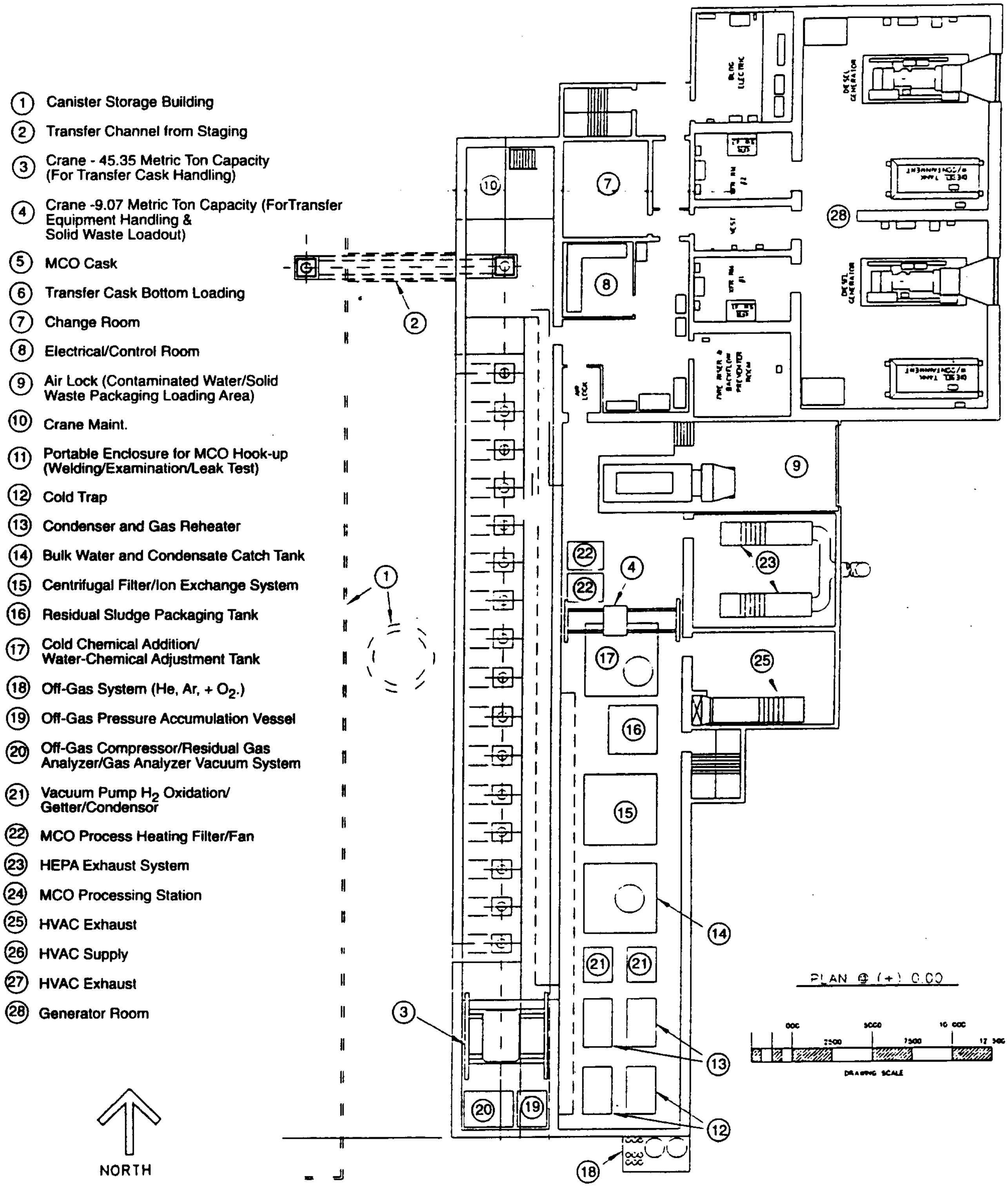


Figure A-11. Proposed onsite processing facility

designed to provide dry storage of the vitrified glass product from the Hanford Waste Vitrification Process. The CSB can be easily modified to store defense fuel from the K Basins.

A.5 Proposed Casks and Cask-Handling Equipment Associated With the Proposed Facilities

The proposed casks to be used in the transfer, processing, and storage of SNF and sludge from the K Basins would contain one MCO, but could hold more depending upon the final design chosen. One possible cask design is shown in Figure A-10. Each cask would accommodate one MCO.

Minor structural modifications and new equipment would be required in each of the K Basins to accommodate the equipment needed to prepare, load, and handle the MCOs in their casks. The modifications and new equipment recommended by the ITAT (1994) are the following:

- Remove the structural steel used to guide the existing N Reactor SNF transfer cask from the cask pit.

- Install the transfer cask support structure in the cask pit and attach MCO-decontamination spray nozzles. The MCO loading support frame would be placed on the floor of the cask pit and an auxiliary hoist would be attached to the existing overhead crane.

- Install the canister preparation station and canister water cleanup system.

A.5.1 Transport Tunnel/Cask Unloading Area

The rail tunnel/cask unloading area proposed for transporting the SNF to the storage area would occupy 930 m^2 (10,000 ft^2). The main functions of this area are to safely receive, handle, and prepare incoming MCOs for placement in the temporary storage pool storage racks (see Section A.3.2.1). The transport tunnel/cask unloading area would have capacity to handle transporters inside and outside the facility, and to store clean and contaminated shipping casks and new, empty MCOs and overpacks, which would be used if an MCO leaked. Included in this facility would be a wash area, a cask unloading and storage area, a cask preparation pit, and a cask loading pit. The wash area would be used to wash incoming rail cars and other vehicles. The cask unloading and storage area would be equipped with a crane and would be used to load and unload casks. The cask preparation pit would be used to prepare casks for unloading, including unbolting the cask cover.

The cask unloading pool would be used to unload the MCOs from their casks, service MCOs, and placing defective MCOs in an overpack. This work would all be done underwater. The unloading pool would be connected to the temporary storage pool so that the MCOs could be moved to storage racks.

A.6 References

Bergsman, K. H. 1993. *Hanford Irradiated Fuel Inventory Baseline*. WHD-SD-CP-TI-175, Westinghouse Hanford Company, Richland, Washington.

Bergsman, K. H., T. B. Bergman, D. W. Bergmann, G. E. Costley, M. T. Janskey, D. S. Leach, R. L. McCormack, M. J. Monthey, A. N. Praga, I. K. Ullah, W. L. Willis, and A. G. Hosler. 1995. *K Basin Environmental Impact Statement Technical Input*. WHC-SD-SNF-TI-013, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

DOE (U.S. Department of Energy). 1995. *Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement*. Vol. 1, Appendix A, Hanford Site Spent Nuclear Fuel Management Program. DOE/EIS-0203-F, U.S. Department of Energy, Washington, D.C.

Fluor Daniel, Inc. 1995. *Staging and Storage Facility Feasibility Study Final Report*. Fluor Daniel, Inc., Seattle, Washington.

Fulton, J. C. 1994. *Hanford Spent Nuclear Fuel Project, Recommended Path Forward*. WHC-EP-0830, Rev 0, Westinghouse Hanford Company, Richland, Washington.

ITAT (Independent Technical Assessment Team). 1994. *Dry Storage of N Reactor Fuel Independent Technical Assessment*. MAC Technical Services Co., Richland, Washington.

Pitner, A. L. 1995. *KE Basin Underwater Visual Fuel Survey*. WHC-SD-SNF-TI-012, Rev 0, Westinghouse Hanford Company, Richland, Washington.

APPENDIX B

TRANSPORTATION IMPACT ANALYSIS

APPENDIX B

TRANSPORTATION IMPACT ANALYSIS

This appendix evaluates the impacts associated with transporting spent nuclear fuel (SNF) and sludge wastes for the alternatives discussed in Chapter 3.0 of the environmental impact statement (EIS).

This appendix evaluates the impacts of both incident-free (routine) transport of radioactive materials in which the shipments reach their destinations without incident and the impacts of accidents involving the shipments. The consequences of the maximum credible transportation accident are also calculated. The approaches and data that were used to calculate these impacts are presented, as are the shipping scenarios and characteristics of the radioactive shipments that are important to determining the radiological impacts. Nonradiological impacts are also calculated.

The no action alternative was not evaluated in this analysis because there are no proposed shipments of SNF, sludge, or basin water associated with this alternative. The transportation impacts associated with new wet storage and dry storage are basically the same. The key differences result primarily from the assumed location of the storage and conditioning facilities and the options to transport the SNF and sludge wet or dry.

Further information on the transportation scenarios in support of the alternatives are provided in the next section. Descriptions of the approach and computer codes used in this analysis are presented in Section B.2. Section B.3 presents the results of the transportation impact calculations.

B.1 Shipping Scenarios and Shipment Characteristics

This section presents the shipping scenarios and shipment characteristics for each of the SNF management alternatives addressed in this EIS. The information presented includes container and shipment capacities, shipment inventories, numbers of shipments, and route information.

The radiological inventories used in the analyses are presented in Table B-1. The data in the table represent the bounding inventories of each radionuclide and were derived from Table A-2 and Bergsman et al. (1995). The bounding inventories were used in the analysis of both incident-free and accident impacts.

Table B-1. Bounding inventory[a]

Radionuclide	Mark IV Spent Fuel			Basin Sludge				Canister Sludge	
	Ci/MT	As Is Ci/MCO[b]	Re-packaged Ci/MCO[b]	Total Ci	Ci/HIC[c]	Ci/Over-pack[d]	Ci/MCO[b]	Ci/Over-pack[e]	Ci/MCO[b]
^{3}H	36.0	120	230					7.20	12.0
^{14}C	0.55	1.80	3.50					0.11	0.18
^{55}Fe	2.90	9.70	18.0					0.58	0.97
^{60}Co	120	400	760	220	2.20	1.10	3.10	24.0	40.0
^{59}Ni	0.032	0.11	0.2					0.0064	0.011
^{63}Ni	3.60	12.0	23.0					0.72	1.20
^{79}Se	0.063	0.21	0.4					0.013	0.021
^{85}Kr	540	1800	3400					110	180
^{90}Sr	7800	$2.60x10^{4}$	$5.00x10^{4}$	1300	13.0	5.90	19.0	1600	2600
^{90}Y	7800	$2.60x10^{4}$	$5.00x10^{4}$	1300	13.0	5.90	19.0	1600	2600
^{93}Zr	0.29	0.97	1.80					0.058	0.097
^{93m}Nb	0.16	0.53	1.00					0.032	0.053
^{99}Tc	0.0011	0.0037	0.007					$2.20x10^{-4}$	$3.70x10^{-4}$
^{106}Ru	$1.10x10^{-4}$	$3.70x10^{-4}$	$7.00x10^{-4}$					$2.20x10^{-5}$	$3.70x10^{-5}$
^{106}Rh	0.017	0.0570	0.11					0.0034	0.0057
^{107}Pd	$8.20x10^{-7}$	$2.70x10^{-6}$	$5.20x10^{-6}$					$1.60x10^{-7}$	$2.70x10^{-7}$
^{110m}Ag	$4.80x10^{-7}$	$1.60x10^{-6}$	$3.10x10^{-6}$					$9.60x10^{-8}$	$1.60x10^{-7}$
^{113m}Cd	0.0039	0.013	0.025					$7.80x10^{-4}$	0.0013
^{119m}Sn	$2.00x10^{-8}$	$6.70x10^{8}$	$1.30x10^{-7}$					$4.00x10^{-9}$	$6.70x10^{-9}$
^{121m}Sn	$7.10x10^{-5}$	$2.40x10^{-4}$	$4.50x10^{-4}$					$1.40x10^{-5}$	$2.40x10^{-5}$
^{126m}Sn	0.12	0.4	0.76					0.24	0.04
^{125}Sb	53.0	180	340					11.0	18.0
^{126}Sb	0.017	0.057	0.11					0.0034	0.0057

Table B-1. (contd)

Radionuclide	Mark IV Spent Fuel			Basin Sludge				Canister Sludge	
	Ci/MT	As Is Ci/MCO[b]	Re-packaged Ci/MCO[b]	Total Ci	Ci/HIC[c]	Ci/Over-pack[d]	Ci/MCO[b]	Ci/Over-pack[e]	Ci/MCO[b]
^{126m}Sb	0.12	0.4	0.76					0.024	0.04
^{125m}Te	13.0	43.0	83.0					2.60	4.30
^{129}I	0.0049	0.016	0.031					9.80×10^{-4}	0.0016
^{134}Cs	52.0	170	330					10.0	17.0
^{135}Cs	0.057	0.19	0.36					0.011	0.019
^{137}Cs	1.10×10^{4}	3.70×10^{4}	7.00×10^{4}	9700	97.0	44.0	140	2200	3700
^{137m}Ba	1.00×10^{4}	3.30×10^{4}	6.40×10^{4}	9200	92.0	42.0	130	2000	3300
^{144}Ce	0.2	0.67	1.30					0.04	0.067
^{144}Pr	0.2	0.67	1.30					0.04	0.067
^{144m}Pr	0.024	0.08	0.15					0.0048	0.008
^{147}Pm	550	1800	350					110	180
^{151}Sm	100	330	640					20.0	33.0
^{153}Gd	3.30×10^{-7}	1.10×10^{-6}	2.10×10^{-6}					6.60×10^{-8}	1.10×10^{-7}
^{154}Eu	180	600	1100	26.0	0.26	0.12	0.37	36.0	60.0
^{155}Eu	24.0	80.0	150	14.0	0.14	0.064	0.2	4.80	8.00
^{234}U	0.38	1.30	2.40					0.076	0.13
^{235}U	0.013	0.043	0.083					0.0026	0.0043
^{236}U	0.072	0.24	0.46					0.014	0.024
^{237}Np	0.57	1.90	3.60					0.11	0.19
^{238}U	0.33	1.10	2.10					0.066	0.11

Table B-1. (contd)

Radionuclide	Mark IV Spent Fuel			Basin Sludge				Canister Sludge	
	Ci/MT	As Is Ci/MCO[b]	Re-packaged Ci/MCO[b]	Total Ci	Ci/HIC[c]	Ci/Over-pack[d]	Ci/MCO[b]	Ci/Over-pack[e]	Ci/MCO[b]
^{238}Pu	170	570	1100	65.0	0.65	0.3	0.93	34.0	57.0
^{239}Pu	160	530	1000	260	2.60	1.20	3.70	32.0	53.0
^{240}Pu	130	430	830	140	1.40	0.64	2.00	26.0	43.0
^{241}Am	360	1200	2300	780	7.80	3.60	11.0	72.0	120
^{242}Am	0.83	2.80	5.30					0.17	0.28
^{241}Pu	9300	$3.10x10^4$	$5.90x10^4$	520	52.0	24.0	74.0	1900	3100
^{242}Pu	0.11	0.37	0.7	0.044	$4.40x10^{-4}$	$2.00x10^{-4}$	$6.30x10^{-4}$	0.022	0.037
^{242}Cm	0.69	2.30	4.40					0.14	0.23
^{242m}Am	0.84	2.80	5.30					0.17	0.28
^{243}Am	0.12	0.4	0.76					0.024	0.04
^{244}Cm	54.0	180	340					11.0	18.0
Total	$4.90x10^4$	$1.60x10^5$	$3.10x10^5$	$2.80x10^4$	280	13.0	0.4	9700	$1.60x10^4$

(a) Taken from Bergsman et al. (1995).
(b) MCO = multicanister overpack, 10 canister capacity.
(c) HIC = high integrity container.
(d) Overpack - Similar to an MCO, 19-canister capacity.
(e) Overpack - Similar to an MCO; total capacity is approximately one-third capacity of MCO.

The transportation routing information, by mode and waste form, is presented in Table B-2. These data were derived from Bergsman et al. (1995) and from detailed maps of the Hanford Site road and rail system. Additional alternative-specific information is presented in the rest of this section.

B.1.1 Enhanced K Basin Storage

This alternative involves upgrades to the KW Basin to extend basin operations for an additional 40 years and the waste management and SNF transfer activities necessary to consolidate and continue SNF storage in the KW Basin. Following upgrades to the KW Basin, SNF currently stored in the KE Basin would be transferred to KW Basin for wet storage. Sludge waste external to the SNF canisters (basin sludge) would be characterized. Based on the results of the waste characterization, the one of the following three options would be used for disposition of the basin sludge:

1. transfer to a Hanford double-shell tank (DST) farm,
2. package as SNF and transfer to the KW Basin, or
3. mix with grout, pour into container, and transfer to the solid waste burial ground (SWBG).

The SNF and the basin sludge, if characterized as SNF, will be transferred from the KE Basin to the KW Basin using the existing railroad line. The KE Basin sludge will be transferred to the Hanford DST tank farm or the SWBG by truck using existing roadways within the Hanford Site.

The transportation options assume that all SNF canisters within the KE Basin would be transferred to the KW Basin and the basin sludge would be removed from the basin, i.e., packaged and transported to a disposal site. The SNF would be loaded underwater into a canister, then placed into an overpack, which would then be placed inside a shipping cask and shipped by truck or rail approximately 500 m (1,700 ft) to the KW Basin for storage in the basin. A DOE-approved shipping cask would be used for this option.

The shipping cask would be capable of containing one multicanister overpack (MCO) or approximately 3.3 MTU per cask. A total of 750 MCOs would be required for all SNF in the K Basins. The fraction of the SNF inventory located at the KE Basin is about 50% of the total SNF inventory (or roughly 3,700 canisters), so it was estimated that 370 overpacks would be required to transfer the SNF from the KE to the KW Basin. The radiological inventory on a per-overpack basis (equivalent to the per-cask inventory) was shown in Table B-1.

Table B-2. Onsite transportation routing information

Option	Truck: Shipments Required[a]	Truck: One-Way-Distance[a][b] (km)	Truck: Total Distance[c] (km)	Rail: Shipments Required[a]	Rail: One-Way-Distance[a][b] (km)	Rail: Total Distance[c] (km)
No Action Alternative - Enhanced K Basin Storage						
SNF to KW	370	0.5	370	370	0.5	370
Basin sludge to KW	220	0.5	220	220	0.5	220
Basin sludge to DST	100	14	2,800	Truck Only		
Basin sludge to SWBG	100	22	4,400	Truck Only		
New Wet Storage						
SNF to reference site	750	12	18,000	750	14	21,000
SNF to Canister Storage Building	750	14	21,000	750	17	25,500
Basin sludge to reference site	70	12	1,680	70	14	1,960
Basin sludge to Canister Storage Building	70	14	1,960	70	17	2,380
Basin sludge to DST	100	14	2,800	Truck Only		
Basin sludge to SWBG	100	22	4,400	Truck Only		
Dry Storage						
SNF as is (Option is the same as wet storage)						
SNF-repackaged						
SNF to reference site	390	12	9,360	390	14	10,920
SNF to Canister Storage Building	390	14	10,920	390	17	13,300

Table B-2. (contd)

Option	Truck			Rail		
	Shipments Required[a]	One-Way-Distance[a][b] (km)	Total Distance[c] (km)	Shipments Required[a]	One-Way-Distance[a][b] (km)	Total Distance[c] (km)
Basin sludge to reference site	70	12	1,680	70	14	1,960
Basin sludge to Canister Storage Building	70	14	1,960	70	17	2,380
Canister sludge to reference site	60	12	1,440	60	14	1,680
Canister sludge to Canister Storage Building	60	14	1,680	60	17	2,040
Canister sludge to DST	100	14	2,800	Truck Only		
Basin sludge to DST	100	14	2,800	Truck Only		
Basin sludge to SWBG	100	22	4,400	Truck Only		

(a) Taken from Bergsman et al. (1995).
(b) Distances calculated using Hanford Site map.
(c) Round trip distance for entire campaign.

Based on the results of the basin sludge waste characterization, the basin sludge would be managed as SNF or solid or liquid waste; however, the preferred option is to transfer the basin sludge to a DST. For this assessment, it was assumed that the characteristics of the assumed solid and liquid waste packages (i.e., MTU per package and curies per package) and the required number of shipments would be the same. The basin sludge would be removed from the basin remotely and transferred to either a liquid waste high-integrity container (LWHIC), if the basin sludge meets the DST waste acceptance criteria, or grouted and containerized in a solid waste high-integrity container (SWHIC), if the basin sludge meets the SWBG waste acceptance criteria. The capacity of the LWHIC is approximately 6 m^3 (1,580 gal). It was assumed that up to 600,000 L (158,000 gal) of makeup water or an equivalent grout volume would be required to treat and remove the basin sludge.

The LWHIC would be shipped by truck approximately 14 km (8.7 mi) to the AW DST tank farm located in the 200 East Area. The SWHIC would also be shipped by truck approximately 22 km (13.7 mi) to the SWBG. The radiological inventory calculated for a LWHIC or SWHIC, shown in Table B-1, assumes that the basin sludge would be uniformly distributed throughout the 600,000 L (158,000 gal) of makeup water or grouted waste.

Should the basin sludge be designated SNF, the basin sludge would be loaded into a canister and placed into an overpack (10 canisters per overpack). The loaded MCO would then be placed into a rail shipping cask (one overpack per shipping cask). Approximately 220 overpacks would be required to transport the basin sludge from the KE to the KW Basin. The estimated inventory per overpack or shipping cask was shown in Table B-1.

B.1.2 New Wet Storage

This alternative assumes that a new wet storage facility is constructed away from the Columbia River. Two sites would be considered: the reference site is located to the northwest of the 200 East Area and the Canister Storage Building is located within the 200 East Area. All SNF currently stored in the K Basins would be transferred to the new facility. The basin sludge would be packaged and disposed of as discussed in the no action alternative. The SNF, as well as the basin sludge, would be transferred from the K Basins via rail or truck.

This alternative involves transferring all SNF at the basins to a new wet storage facility. The SNF shipping package, i.e., canisters, MCO, and shipping cask, with the exception of the MCO, are the same as those discussed in Section B.1.1. The KE Basin sludge waste packages, i.e., LWHICs and SWHICs, were also discussed previously in Section B.1.1.

The KE Basin SNF or basin sludge would be loaded underwater into an MCO and then placed into a shipping cask (one MCO per cask), as discussed previously, and transported via truck or rail. The rail shipping distances are approximately 13.5 km (8.4 mi) and 16.3 km (10 mi) from the KE Basin to the reference site and the Canister Storage Building, respectively. The truck shipping distances are approximately 12.0 km (7.4 mi) and 14.1 km (8.8 mi) to the reference site and the Canister Storage Building, respectively. The KW Basin SNF would be loaded underwater and shipped via rail approximately 14.0 km (8.7 mi) and 16.8 km (10.3 mi) from the KE Basin to the reference site and the Canister Storage Building, respectively, or via truck approximately 12.0 km (7.4 mi) and 14.0 km (8.8 mi) to the reference site and the Canister Storage Building, respectively. The estimated radiological inventory per MCO or shipping cask was shown in Table B-1.

The K Basins sludge would be recovered from the basin floor, packaged, and transported to the wet storage facility (if classified as SNF based on characterization data), AW tank farm (if classified as liquid waste), or SWBG (if classified as solid waste). The basin sludge would be transported via truck approximately 14.0 km (8.7 mi) to the AW tank farm in the 200 East Area or approximately 22.0 km (13.7 mi) to the SWBG. The estimated radiological inventory per LWHIC or SWHIC was shown in Table B-1.

B.1.3 Dry Storage

This alternative involves constructing a new dry storage facility at the reference site and the Canister Storage Building to accept and store all K Basins SNF or basin sludge characterized as SNF. As discussed previously, basin sludge meeting the DST waste acceptance criteria or the SWBG acceptance criteria would be shipped to the AW DST tank farm or the SWBG. However, there are four SNF and sludge handling options associated with this alternative.

The first dry storage option, with respect to transportation, is the same as the new wet storage alternative (Section B.1.2). That is, the shipping containers, shipping distances, and modes are the same. The differences between this alternative and the wet storage alternative result from SNF handling operations at the facility and are not related to transportation.

The second dry storage option is similar to the new wet storage option, except that the canisters would be perforated to allow for water drainage and gas flow; therefore, the SNF would be shipped in a damp or "dry" condition. The basin sludge would be packaged and shipped as discussed in Section B.1.2.

The third and fourth dry storage options involve mechanically removing the sludge from the canister, collecting the canister sludge, and packaging the canister sludge for disposition as SNF or liquid waste. That is, the canister sludge would be transferred remotely from the canister to a MCO. The fourth option involves removing the SNF from the canister and repackaging the SNF in baskets before loading the MCO. By repackaging the SNF in baskets, the capacity of the MCO would be increased from 10 canisters or 3.4 MTU to 19 canisters or 6.5 MTU. This would reduce the number of MCOs required and the number of shipments from 750 to 390. Repackaged SNF will only be shipped onsite and is not considered in the foreign processing alternative.

B.1.4 Foreign Processing

Potential shipping scenarios are described in this section for transporting irradiated N Reactor fuel from the Hanford Site to the U.K., and the return of separated plutonium, uranium, and HLW to Hanford. All scenarios assume stabilization and packaging, as necessary, of the SNF currently stored in the K Basins on the Hanford Site. From the K Basins, the SNF would be loaded for onsite or offsite transport as required for each scenario. Offsite transport would take place via either barge, truck, or rail to a port designated as a "facility of particular hazard" in accordance with 33 CFR 126, where the shipment would be loaded onto a ship for overseas transport. The overseas segment of the shipment was assumed to utilize purpose-built ships typical of those employed by the representative processing facility in the U.K. for shipping SNF (BNFL 1994). Such a system would likely be necessary if Hanford SNF were to be shipped without prior stabilization because alternative carriers would presumably not have either the equipment or expertise required for long-distance transport of metallic SNF in a wet overpack. If the SNF were stabilized before shipment, a variety of commercial or military shipping options might be available.

After processing of the SNF, the products and wastes are assumed to be returned to Hanford for interim storage via the same U.S. seaport at which the initial shipments exited the country. The three materials addressed in the analysis for the return shipments are plutonium, uranium, and HLW. It is assumed that the separated plutonium and uranium would be converted to oxide forms and shipped to the U.S. aboard a purpose-built ship similar to that used for transporting the irradiated fuel. Other transport options might also be available for these materials, including use of military or commercial ships or aircraft. HLW is assumed to be processed to a stable form (borosilicate glass encased in stainless steel canisters) before shipment. This section provides descriptions of the shipping scenarios, transportation and packaging systems, radiological characteristics of the shipments, transportation routes, and port facilities that were examined in this analysis.

B.1.4.1 Port Selection

Ports evaluated for the foreign processing option were chosen to minimize either the overland or ocean segments of the shipments and to provide a reasonable range of alternative transportation modes between the Hanford Site and the port (i.e., barge, truck, or rail). For this evaluation, two potential West Coast U.S. ports (Seattle/Tacoma, Washington, and Portland, Oregon) and one potential East Coast port (Norfolk, Virginia) were evaluated for the overland transportation analysis. Population densities along the routes to these ports are representative of those near many major U.S. seaports. In addition, the port of Newark, New Jersey, was included in the port accident analysis to estimate the consequences of an accident in a location with a very high surrounding population.

B.1.4.2 Overseas Transport

The routing for overseas transport from West Coast U.S. ports would include transit via the Columbia River or Puget Sound to the Pacific Ocean, a southerly route through the Panama Canal or around Cape Horn in South America, and then north to the U.K. The route around the cape is considered because it maximizes the distance that a shipment might be required to travel, and therefore provides an upper bound for risks associated with the ocean transport segment. However, a route via the Panama Canal would be preferable for West Coast shipments because it avoids potential risk associated with the added distance and adverse weather conditions that might be encountered during transport around the cape. Transport via an East Coast U.S. port would be directly across the Atlantic Ocean to the U.K. The total distance for ocean transport via the West Coast is approximately 7,000 nautical miles via the Panama Canal or 17,000 nautical miles via Cape Horn; that for the East Coast is approximately 3,000 nautical miles.

B.1.4.3 Transport Scenarios

Overland transport between the Hanford Site and overseas shipping ports was evaluated for three different scenarios, as described in the following sections.

Barge to the Port of Portland, Transoceanic Shipment to the U.K. This scenario begins with cask loading operations at the Hanford Site K Basins. The shipping casks would be loaded with SNF and prepared for truck transport to the Port of Benton barge slip near the 300 Area of the Hanford Site. After arrival at the barge slip, the shipping casks would be transloaded onto the barge via crane and then secured to the deck of the barge. After a full load of casks was secured, the barge would depart for the Port of Portland, Oregon, traveling down the Columbia River through routinely navigated shipping channels. At the Port of Portland, the shipping casks would be lifted off the barge and placed aboard a ship for the overseas segment of the journey. The shipping casks would then be secured, and the ship would depart for the U.K. After processing of the SNF, the HLW shipments are assumed to return via Portland, where the material would be transloaded onto a rail car and transported to Hanford for interim storage. Shipments of uranium trioxide and plutonium dioxide would be returned to Hanford by truck.

Truck/Rail to the Port of Seattle, Transoceanic Shipment to the U.K. The first leg of this scenario is different from the barge-to-Portland scenario in that the shipping casks would be loaded at the K Basins and shipped directly to the Port of Seattle, Washington, for transloading onto the ocean-going vessel. The overland leg would consist of either truck or rail shipments. The assumption was made that one shipping cask would be transported per truck shipment or two casks per rail shipment. After arrival at the Port of Seattle, the shipping casks would be transloaded onto the ocean-going vessel, and when a shipload of casks had been loaded, the ship would sail through Puget Sound and the Strait of Juan de Fuca to the Pacific Ocean, travel south via either the Panama Canal or Cape Horn, and then north to the U.K. After processing, the uranium trioxide, plutonium dioxide, and vitrified HLW would be returned to the U.S. by ship via Seattle and finally to Hanford by truck or rail.

Truck/Rail to the Port of Norfolk, Virginia, Transoceanic Shipment to the U.K. This scenario would be similar to the truck/rail to Seattle scenario except the intermediate port would be Norfolk, Virginia. Similar to the Port of Seattle scenario, the shipping casks would be loaded aboard the ocean-going vessel and shipped to the U.K. This shipping scenario maximizes the overland transport leg and minimizes the ocean travel distance. As with the other two shipping scenarios, the vitrified HLW, plutonium dioxide, and uranium trioxide materials were assumed to be returned to Hanford via Norfolk.

B.1.4.4 Shipping System Descriptions

This section presents descriptions of the shipping cask and truck, rail, and barge shipping systems that are used in the three potential shipping scenarios. The information presented focuses on the parameters important to the impact calculations, namely the cargo capacities and radionuclide inventories.

The shipping cask assumed to be used for the SNF shipments from Hanford to the U.K. is a standard design routinely used for commercial SNF transport (BNFL 1994). The cask could transport approximately 5.5 MT (5 tons) of intact fuel (with a smaller capacity for damaged fuel). The loaded cask weight is about 51 MT (46 tons), so it was assumed that one cask could be transported per highway shipment and two per rail shipment. The capacities of the barge and ship are assumed to be 24 casks each. A total of 17 transoceanic shipments would be required to accommodate the 408 caskloads that would be necessary to ship all Hanford SNF. The actual number of shipments required would depend on the number of casks available, or on procurement of a sufficient number of new casks to provide for efficient shipment of Hanford SNF on a reasonable schedule.

The radionuclide inventories for the SNF shipments were determined using the information on N Reactor fuel inventories presented in Bergsman (1994). The resulting radionuclide inventories for the three types of shipments (truck, rail, and barge/ship) are presented in Table B-3.

The return shipments of HLW and plutonium and uranium oxides were assumed to be shipped via the same routes used for overseas shipment of Hanford SNF. For the barge-to-Portland option, these materials were assumed to be returned to the U.S. by ship to the Port of Portland, where HLW shipping casks would be transloaded onto a barge and uranium and plutonium onto trucks for transport to Hanford. Similarly for the other options, the materials would be transported by ships to the ports of Norfolk or Seattle, transloaded onto truck or rail shipping systems, and transported to Hanford.

The number of shipments of solidified HLW was estimated using assumed shipping cask capacities for HLW. It is estimated that a total of 500 containers of vitrified HLW, each weighing about 500 kg (1100 lb), would result from processing the N Reactor SNF (BNFL 1994). The U.K. processing facility has designed a new 121 MT (110-ton) shipping cask for vitrified HLW that would be capable of carrying 21 HLW containers per shipment. Therefore, about 24 caskloads would be required to return the HLW to the U.S. This material was assumed to be transported to a U.S. port facility in one shipment and then transloaded onto a rail car for the overland shipment segment (the HLW cask is

Table B-3. Facility and transport mode radionuclide inventory development for foreign processing alternative[a]

			Ci/Shipment[b]			Ci/Shipping Cask[c]		
Radionuclide	Ci/MTU	Total Curies in SNF	Truck	Rail	Barge	HLW[d]	Plutonium Dioxide[e]	Uranium Trioxide[e]
Shipments			408	204	17	24/1	186	236
Duration			5 yr	5 yr	5 yr	7 mo	2.3 yr	2.9 yr
^{3}H	45.9	$9.64x10^{4}$	236	473	5670	4020		
^{55}Fe	12.2	$2.56x10^{4}$	62.8	126	1510	1070		
^{60}Co	8.78	$1.84x10^{4}$	45.2	90.4	1080	768		
^{85}Kr	807	$1.69x10^{6}$	4150	8310	$9.97x10^{4}$	$7.06x10^{4}$		
^{90}Sr	9320	$1.96x10^{7}$	$4.80x10^{4}$	$9.59x10^{4}$	$1.15x10^{6}$	$8.16x10^{5}$		
^{90}Y	9320	$1.96x10^{7}$	$4.80x10^{4}$	$9.59x10^{4}$	$1.15x10^{6}$	$8.16x10^{5}$		
^{106}Rh	85.2	$1.79x10^{5}$	439	877	$1.05x10^{4}$	7460		
^{106}Ru	85.2	$1.79x10^{5}$	439	877	$1.05x10^{4}$	7460		
^{125}Sb	202	$4.24x10^{5}$	1040	2080	$2.50x10^{4}$	$1.77x10^{4}$		
^{125}Te	49.4	$1.04x10^{5}$	254	509	6100	4320		
^{134}Cs	301	$6.32x10^{5}$	1550	3100	$3.72x10^{4}$	$2.63x10^{4}$		
^{137}Cs	$1.20x10^{4}$	$2.52x10^{7}$	$6.18x10^{4}$	$1.24x10^{5}$	$1.48x10^{6}$	$1.05x10^{6}$		
^{137m}Ba	$1.14x10^{4}$	$2.39x10^{7}$	$5.87x10^{4}$	$1.17x10^{5}$	$1.41x10^{6}$	$9.98x10^{5}$		
^{144}Ce	39.7	$8.34x10^{4}$	204	409	4900	3470		
^{144}Pr	39.7	$8.34x10^{4}$	204	409	4900	3470		
^{144m}Pr	0.477	1000	2.46	4.91	58.9	41.7		
^{147}Pm	2720	$5.71x10^{6}$	$1.40x10^{4}$	$2.80x10^{4}$	$3.36x10^{5}$	$2.38x10^{5}$		

Table B-3. (contd)

Radionuclide	Ci/MTU	Total Curies in SNF	Ci/Shipment[b] Truck	Ci/Shipment[b] Rail	Ci/Shipment[b] Barge	Ci/Shipping Cask[c] HLW[d]	Ci/Shipping Cask[c] Plutonium Oxide[e]	Ci/Shipping Cask[c] Uranium Oxide[e]
^{151}Sm	110	$2.31x10^5$	566	1130	$1.36x10^4$	9630		
^{154}Eu	217	$4.56x10^5$	1120	2230	$2.68x10^4$	$1.90x10^4$		
^{155}Eu	51.4	$1.08x10^5$	265	529	6350	4500		
^{234}U	0.434	911	2.23	4.47	53.6			3.73
^{235}U	0.016	33.5	0.0822	0.164	1.97			0.137
^{236}U	0.0763	160	0.393	0.786	9.43			0.657
^{237}Np	0.0475	99.8	0.245	0.489	5.87	4.16		
^{238}U	0.331	694	1.70	3.40	40.8			2.85
^{238}Pu	122	$2.56x10^5$	628	1260	$1.51x10^4$		1330	
^{239}Pu	136	$2.86x10^5$	702	1400	$1.68x10^4$		1480	
^{240}Pu	99.4	$2.09x10^5$	512	1020	$1.23x10^4$		1080	
^{241}Am	184	$3.86x10^5$	947	1890	$2.27x10^4$	$1.61x10^4$		
^{241}Pu	8710	$1.83x10^7$	$4.49x10^4$	$8.97x10^4$	$1.08x10^6$		$9.48x10^4$	
^{242}Pu	0.0645	135	0.332	0.663	7.96		0.701	
^{244}Cm	26.2	$5.50x10^4$	135	270	3240	2290		

(a) Radionuclide inventory taken from Bergsman (1994) and represents 10-year cooled Mark IA fuel, in which plutonium-240 constitutes of 16% of the total plutonium.
(b) Ci/shipment inventories assume 1 cask per truck shipment, 2 truck casks per rail, and 24 truck casks per barge shipment.
(c) Ci/cask inventories are based on one cask per truck and/or rail shipment.
(d) HLW = solidified HLW; inventory assumes 100% removal of plutonium and uranium. HLW to be shipped only by barge (24 casks per barge) or rail (1 cask per rail car).
(e) Plutonium and uranium oxide inventories assume 100% removal, and the number of shipments has been adjusted to reflect conversion from metal to oxide. Plutonium and uranium oxide to be shipped by barge and truck only.

too large to be transported by regular truck service). The actual number of shipments required would depend on the number of HLW casks available or on procurement of a sufficient number of new casks to provide for efficient return shipment of HLW on a reasonable schedule.

The radionuclide inventories for the vitrified HLW shipments are presented in Table B-3. These inventories were calculated by dividing the total quantity of each radionuclide shipped to the U.K. (exclusive of uranium and plutonium) by the number of HLW casks (24) to be returned to the U.S.

The number of shipments of uranium trioxide and plutonium dioxide were estimated using standard U.S. shipping equipment for uranium trioxide and plutonium dioxide. The estimated quantities to be shipped include 2,600 MT (2,360 tons) of purified uranium trioxide and 7 MT (6.5 tons) of plutonium dioxide generated from processing the K Basins SNF. For this analysis, it was assumed that the plutonium dioxide would be transported by truck in a Type B package with a capacity of 35 kg/shipment (71 lb/shipment). This results in a total of 186 caskloads of plutonium dioxide. The vehicle for transport of plutonium dioxide was assumed to be a Safe-Secure Trailer/Armored Tractor specifically designed for shipment of special nuclear materials within the U.S. The uranium trioxide was assumed to be transported by truck in shipping systems with a capacity of 10,000 kg/shipment (22,000 lb/shipment). This would require a total of 236 caskloads of uranium trioxide. One caskload per truck shipment for overland segments was assumed. One sea shipment of uranium trioxide and one of plutonium dioxide were assumed to be required.

The radionuclide inventories for the plutonium dioxide and uranium trioxide shipments are presented in Table B-3. The inventories were determined by dividing the total quantities of uranium trioxide and plutonium dioxide to be shipped to the U.K. by the respective numbers of caskloads presented above.

B.2 Routine and Accident Impact Analysis Methods and Models

This section describes the methods used to estimate consequences of normal and accidental exposure of individuals or populations to radioactive materials. The RADTRAN 4 (Neuhauser and Kanipe 1992) computer codes were used to calculate the transportation impacts, and the GENII software package (Napier et al. 1988) was used to estimate the consequences to the maximally exposed individuals. Nonradiological impacts from both incident-free transport and accidents were also evaluated.

The output from computer codes, as total effective dose equivalent (TEDE or dose) to the affected receptors, was then used to express the consequences in terms of potential latent cancer fatalities (LCFs). Radiological exposures were used to convert dose as TEDE to LCF using recommendations of the International Commission on Radiological Protection (ICRP 1991). The conversion factor applied to adult workers was 4×10^{-4} LCF/rem TEDE; for the general population, the conversion factor was 5×10^{-4} LCF/rem TEDE. The general population was assumed to have a higher rate of cancer induction for a given radiation dose than healthy adult workers because of the presence of more sensitive individuals (e.g., children) in the general population.

The estimated LCF for potential accidents was multiplied by the expected accident frequency per year, per shipment, or for the entire duration of the operation, to provide a point estimate of risk consistent with risks reported in the remainder of this EIS. Incident-free transportation or normal facility operations were assumed to occur; therefore, the cumulative risks associated with normal operations would be identical to the predicted number of LCFs for the duration of the operation.

Nonradiological incident-free and accident impacts were also evaluated. Nonradiological incident-free impacts consist of fatalities from pollutants emitted from the vehicles. Nonradiological accident impacts are the fatalities resulting from potential vehicular accidents involving the shipments. Neither of these two categories of impacts are related to the radiological characteristics of the cargo. Hand calculations were performed using unit-risk factors (fatalities per kilometers of travel) to derive estimates of the nonradiological impacts. The nonradiological impacts were calculated by multiplying the unit risk factors by the total shipping distances for all of the shipments in each shipping option. Nonradiological unit risk factors for incident-free transport were taken from Rao et al. (1982), and for vehicular accidents were taken from Bergsman et al. (1995) and Cashwell et al. (1986).

B.2.1 RADTRAN 4 Computer Code

The RADTRAN 4 computer code (Neuhauser and Kanipe 1992) was used to perform the analyses of the radiological impacts of routine transport and the population dose of accidents during transport of the waste. RADTRAN was developed by Sandia National Laboratories (SNL) to calculate the risks associated with the transportation of radioactive materials. The original code was written by SNL in 1977 in association with the preparation of NUREG-0170, *Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes* (NRC 1977). The code has since been refined and expanded and is currently maintained by SNL under contract with DOE.

The RADTRAN 4 computer code is organized into the following seven models (Neuhauser and Kanipe 1992):

- material model
- transportation model
- population distribution model
- health effects model
- accident severity and package release model
- meteorological dispersion model
- economic model.

The code uses the first three models to calculate the potential population dose from normal, incident-free transportation and the first six models to calculate the risk to the population from user-defined accident scenarios. The economic model was not used in this study.

The material model defines the source as either a point source or as a line source. For exposure distances of less than twice the package dimension, the source is conservatively assumed to be a line source. For all other cases, the source is modeled as a point source that emits radiation equally in all directions.

The material model also contains a library of 59 isotopes, each of which has 11 defining parameters that are used in the calculation of dose. The user can add isotopes not in the RADTRAN library by creating a data table in the input file, consisting of 11 parameters.

The transportation model allows the user to input descriptions of the transportation route. A transportation route may be divided into links or segments of the journey with information for each link on population density, mode of travel (e.g., trailer truck or ship), accident rate, vehicle speed, road type, vehicle density, and link length. Alternatively, the transportation route also can be described by aggregate route data for rural, urban, and suburban areas. For this analysis, the aggregate route method was used for each potential origin-destination combination.

The health effects model in RADTRAN 4 is outdated and was replaced by hand calculations for this EIS. The health effects were determined by multiplying the population dose (person-rem) supplied by RADTRAN 4 by a conversion factor.

Accident analysis in RADTRAN 4 is performed using the accident severity and package release model. The user can define up to 20 severity categories for three population densities (urban, suburban, and rural), each increasing in magnitude. Eight severity categories for SNF containers that are related to fire, puncture, crush, and immersion environments are defined in NUREG-0170 (NRC 1977). Various other studies also have been performed for small packages (Clarke et al. 1976) and large packages (Dennis et al. 1978) that also can be used to generate severity categories. The accident scenarios are further defined by allowing the user to input release fractions and aerosol and respirable fractions for each severity category. These fractions are also a function of the physical-chemical properties of the materials being transported.

RADTRAN 4 allows the user to choose two different methods for modeling the atmospheric transport of radionuclides after a potential accident. The user can either input Pasquill atmospheric-stability category data or averaged time-integrated concentrations. In this analysis, the dispersion of radionuclides after a potential accident was modeled by the use of time-integrated concentration values in downwind areas compiled from national averages by SNL.

B.2.1.1 Incident-Free Transport

The models described above are used by RADTRAN 4 to determine dose from incident-free transportation or risk from potential accidents. The public and worker doses calculated by RADTRAN 4 for incident-free transportation are dependent on the type of material being transported and the transportation index of the package or packages. The transportation index is defined in 49 CFR 173.403(bb) as the highest package dose rate in mrem/hr at a distance of 1 m (3.3 ft) from the external surface of the package. Dose consequences are also dependent on the size of the package that, as indicated in the material model description, will determine whether the package is modeled as a point source or line source for close-proximity exposures.

B.2.1.2 Analysis of Potential Accidents

The accident analysis performed in RADTRAN 4 calculates population doses for each accident severity category using six exposure pathway models. They include inhalation, resuspension, groundshine, cloudshine, ingestion, and direct exposure. This RADTRAN 4 analysis assumes that any contaminated area is either mitigated or public-access-controlled so the dose via the ingestion pathway equals zero. The consequences calculated for each severity category are multiplied by the appropriate frequencies for accidents in each category and summed to give a total point estimate of risk for a radiological accident.

B.2.2 GENII Description

GENII (Napier et al. 1988), which is also referred to as the Hanford Environmental Dosimetry Software System, was developed and written by the Pacific Northwest Laboratory to analyze radiological releases to the environment. GENII is composed of seven linked computer programs and their associated data libraries. This includes user interface programs, internal and external dose factor generators, and the environmental dosimetry programs.

GENII is capable of calculating

- doses resulting from acute or chronic releases, including options for annual dose, committed dose, and accumulated dose
- doses from various exposure pathways evaluated including direct exposure via water, soil, and air as well as inhalation and ingestion pathways
- acute and chronic elevated and ground level releases to air
- acute and chronic releases to water
- initial contamination of soil or surfaces
- radionuclide decay.

The pathways considered in this analysis include inhalation, submersion, and external exposures caused by ground contamination.

B.3 Results of Incident-Free Transportation Impact Analysis

This section discusses the radiological and nonradiological impacts to the transportation crew and the public during incident-free or routine transportation activities for each of the SNF management alternatives and shipping options. The key input parameters for the RADTRAN 4 computer code that were used to perform the incident-free transportation impact calculations for the onsite alternatives are provided in Table B-4. The key input parameters for the foreign processing alternatives are discussed later in this section. Following that discussion, separate subsections are provided below for the results of the radiological and nonradiological impact calculations.

Table B-4. Input parameters for incident-free and accident analyses (onsite alternatives)[a]

Parameter	Value
Fraction of travel time, rural population zone[b]	0.971
Fraction of travel time, suburban population zone[b]	0.029
Fraction of travel time, urban population zone[b]	0
Dose rate at 1 m (3.3 ft) from package (mrem/hr)	10[c] 0.5[d]
Length of package (m)	4
Speed (km/hr)	56.3
Number of crewmen--truck	2
Number of crewmen--rail	3
Distance from source to crew	10
Number of people per vehicle	2
Rural population density (people/km^2)[b]	2.4
Suburban population density (people/km^2)[b]	89.8
Urban population density (people/km^2)[b]	0.0
Traffic count--rural (one-way vehicles/hr)	470
Traffic count--suburban (one-way vehicles/hr)	780
Traffic count--urban (one-way vehicles/hr)	2,800

(a) Unless otherwise indicated, values have been taken from Neuhauser and Kanipe (1992).
(b) Values taken from Daling and Harris (1994). Suburban population characteristics are used to model Hanford Site onsite personnel.
(c) Maximum allowable, 10 CFR 71.
(d) Basin water dose rate taken from Green (1995).

B.3.1 Transportation Route Information

The overland transportation routes assumed for the analysis of the foreign processing alternative are described in the following section. The descriptive information includes the shipping distances and population density data. These data were developed using the HIGHWAY (Johnson et al. 1993a) and INTERLINE (Johnson et al. 1993b) computer codes for truck and rail shipments, respectively, and are used to calculate transportation impacts. These data are summarized below for each transport segment. No population data are presented for the ocean segments because once at sea, the exposed population becomes essentially zero.

Hanford to Seattle, Washington. The truck and rail shipping distances from Hanford to Seattle were determined to be 277 km (172 mi) and 716 km

(445 mi), respectively. The large difference in shipping distance arises from the fact that the rail route is not a direct link to Seattle, but travels fromHanford to Vancouver, Washington, and then to Seattle. For the highway route, the shipment travels through 88.1% rural areas (weighted population density 4.5 persons/km^2), 10% in suburban areas (359 persons/km^2) and 1.9% in urban population zones (1,870 persons/km^2). The rail route travels through 74.1% rural areas (9.8 persons/km^2), 19% in suburban zones (415.5 persons/km^2), and 6.9% in urban areas (2,226 persons/km^2).

Hanford to Norfolk, Virginia. The truck and rail shipping distances from Hanford to Norfolk were determined to be 4,585 km (2,849 mi) and 4,984 km (3,097 mi), respectively. For the highway route, the shipment travels through 84.5% rural areas (7.3 persons/km^2), 13.4% in suburban areas (365 persons/km^2), and 2.1% in urban population zones (2,299 persons/km^2). The rail route travels through 83% rural areas (7.8 persons/km^2), 14.5% in suburban zones (360.4 persons/km^2), and 2.4% in urban areas (2,149 persons/km^2).

Hanford to Portland, Oregon. The only option evaluated for using the Port of Portland was to barge the SNF to Portland, where it would be transloaded onto the ship. The distance and population density information for this shipment was approximated using INTERLINE (Johnson et al. 1993b), which evaluates potential rail routes, because the rail lines closely follow the Columbia River in which the barge would be operating. Consequently, the route data for a barge shipment would be similar to that for a rail shipment. The rail data are thought to be more conservative than actual barge data because the rail lines pass closer to the city centers along the river than would a barge does.

Dose rates emitted by the shipping casks are important input parameters. RADTRAN 4 uses the dose rate at 1 m or 3.3 ft (referred to as the transportation index) in calculating dose to the public and worker. All of the SNF and HLW shipments in this analysis were assumed to be at the regulatory maximum dose rate, which is 10 mrem/hr at a distance of 2 m (6.6 ft) from the cask surface. This would be equivalent to a transportation index of 13 (or a dose rate of 13 mrem/hr at 1 m or 3.3 ft from the surface). Although it is likely that many of these shipments will have significantly smaller transportation index values, the use of the regulatory maximum value is bounding because it cannot be exceeded.

Because shipments of plutonium dioxide and uranium trioxide would have much smaller dose rates than SNF or HLW, preliminary shielding calculations were performed to derive more realistic values. The computer code MICROSHIELD (Grove Engineering 1988) was used to perform these calculations. Both types of shipments were modeled as cylindrical sources with cylindrical shields. The parameters used in these calculations are shown as follows:

- Plutonium dioxide: The plutonium source was assumed to be 12.7 cm (5 in.) in diameter and 127 cm (50 in.) in length. Shielding was assumed to be provided by a 1-cm-thick (0.4-in.-thick) steel shield and an 8-cm (3-in.) thickness of solid hydrogenous material. The source inventory was the same as that shown in Table B-3.
- Uranium trioxide: The uranium source was modeled as a single large container although the shipment will most likely be composed of several smaller containers. The source dimensions were assumed to be 114 cm (45 in.) in diameter and 370 cm (146 in.) in length. The source was assumed to be surrounded by a 1-cm-thick (0.4-in.-thick) steel cylinder and a 3-cm-thick (1.2-in.-thick) shield of solid hydrogenous material. The source inventory was shown in Table B-3.

The dose rate at 1 m (3.3 ft) from the surface of the plutonium dioxide shipment was calculated to be 0.019 mrem/hr. Because this was increased by a factor of five to provide a bounding estimate, the transportation index value for these shipments was set to 0.1 mrem/hr. The dose rate for the uranium trioxide shipments was calculated to be 0.0049 mrem/hr. This was also increased by a factor of five to 0.025 mrem/hr for conservatism.

Table B-5 is a list of input parameters that are used by RADTRAN 4 in the calculation of population dose for incident-free transportation. Many of the parameters are default values in the RADTRAN 4 code. Those that are not default values are identified and their sources are provided in footnotes to the table.

The potential receptors include workers and the general public. Worker doses include those received by the truck, rail, or barge crew and package handlers aboard the barge. Although RADTRAN models package handlers as persons who handle packages during intermediate stops, the routine doses to this group were assumed to apply to personnel who inspect the shipping containers aboard the barge. The equations used to calculate these doses assume that a five-person team spends approximately 0.5 hr per handling operation (or per inspection tour of the shipping casks). Although not exact, this is believed to be a reasonable approximation.

Public doses include doses to persons on the highway or railway (this category is not applicable to barge shipments as indicated in the RADTRAN documentation); doses to persons who reside near the highway, railway, or river; and doses at stops (for barge transport, this was assumed to include

Table B-5. Input parameters for analysis of incident-free impacts for the foreign processing alternative[a]

Parameter	Rail	Barge	Truck
Dose rate 1 m (3.3 ft) from vehicle/package (mrem/hr)[b]	13.1	13.1	13.1
Length of package (m)	3.0	3.0	3.0
Exclusive use	No	Yes	Yes
Velocity in rural population zone (km/hr)[c]	64.4	16.09	88.6
Velocity in suburban population zone (km/hr)[b]	40.3	8.06	40.3
Velocity in urban population zone (km/hr)[c]	24.2	3.20	24.2
Number of crew	5	2	2
Distance from source to crew (m)	152	45.70	10.0
Stop time per km (hr/km)[c]	0.033	0.01	0.011
Persons exposed while stopped[c]	100	50	50
Average exposure distance while stopped (m)[c]	20.0	50.0	20.0
Number of people per vehicle on link[c]	3	0	2
Traffic count passing a specific point-rural zone, one-way[c]	1.0	0	470
Traffic count passing a specific point-suburban zone, one-way[c]	5.0	0	780
Traffic count passing a specific point-urban zone, one-way[c]	5.0	0	2,800

(a) Values shown are shipment-specific unless otherwise noted.
(b) These values were used for SNF and HLW shipments. See text for the derivation of transportation index values for plutonium dioxide (0.1 mrem/hr) and uranium trioxide shipments (0.025 mrem/hr).
(c) Default values from RADTRAN (Neuhauser and Kanipe 1992; Madsen et al. 1983).

stops at navigation locks in dams). For all three shipping modes, the doses to passengers were assumed to be zero because there would be no passengers traveling with the shipments. In addition, there were assumed to be no intermediate storage needs for the shipments, and the doses to in-transit storage personnel were set equal to zero.

B.3.2 Radiological Impacts from Incident-Free Transportation Activities

The radiological doses to the truck crew, onsite worker, and the public resulting from transportation activities were calculated using RADTRAN 4 (see

Section B.2). The calculated dose to the rail crew and truck crews and the public were calculated on a per-shipment basis and for the entire campaign. For this analysis, a shipping campaign is defined as the total number of shipments required to ship all radiological materials from its origin to its destination facility. Because all shipping would occur within the Hanford Site (i.e., away from public population zones and public access), the incident-free exposures to the offsite population are essentially zero. Consequently, the term "public" in this instance refers to Hanford Site workers who are not directly involved in the SNF management activities at the various facilities.

The following subsections provide a discussion of each of the alternatives and options and presents the results of the impact analysis.

B.3.2.1 Enhanced K Basins Storage Alternative

Table B-6 presents the incident-free radiological impacts of the enhanced K Basin storage alternative. As shown, the total dose to the workers (i.e., truck or rail crew members) would be 8.4×10^{-6} person-rem for truck

Table B-6. Transportation radiological impacts of the enhanced K Basins storage alternative[a]

	Radiological Impacts		Health Effects
Option	Truck Crew (person-rem)	Onsite (person-rem)	Onsite (LCF)
SNF and Basin Sludge to KW Basin			
Truck	0.049	0.0018	7.2×10^{-7}
Rail	0.048	0.0018	7.2×10^{-7}
SNF to KW Basin; Basin Sludge to DST			
Truck	5.4	0.022	8.8×10^{-6}
Rail	5.4	0.022	8.8×10^{-6}
SNF to KW Basin; Basin Sludge to SWBG			
Truck	13.0	0.05	2.0×10^{-5}
Rail	13.0	0.05	2.0×10^{-5}

(a) Potential health effects or latent cancer fatalities (LCFs) calculated using the methodology described in DOE (1995a).

shipments and 3.6 x 10^{-6} person-rem for rail shipments, assuming the basin sludge were designated SNF. The total dose to the workers, assuming the basin sludge were shipped to the AW DST farm would be 0.0019 person-rem and 0.0019 person-rem, for truck and rail shipments, respectively. The total dose to the workers, assuming the basin sludge were shipped to the SWBG, would be 0.0030 person-rem for truck shipments and rail shipments. The total dose, truck crew plus onsite individuals, would be 8.4 x 10^{-6} person-rem if the basin sludge were designated SNF; 0.0019 person-rem if the basin sludge were shipped to the AW DST farm; and 0.0030 person-rem if the sludge were shipped to the SWBG. The total dose, rail crew plus onsite individuals, would be 3.6 x 10^{-6} person-rem, 0.0019 person-rem, and 0.0030 person-rem, for these options, respectively.

The potential health effects or LCFs were calculated using the methodology described in ICRP (1991), i.e., 4.0 x 10^{-4} LCFs/person-rem each to the onsite workers and truck crew. The health effects for truck crews were estimated to be 3.4 x 10^{-9} (sludge as SNF), 7.6 x 10^{-7} (sludge to DST), and 1.2 x 10^{-6} (sludge to SWBG). The annual health effects for onsite workers were estimated to be less than 6.0 x 10^{-9}, or essentially zero.

B.3.2.2 New Wet Storage

As shown in Table B-7, the total dose (reference site dose estimates are shown first followed by the Canister Storage Building dose estimates in parentheses) to the workers in the new wet storage alternative (i.e., truck or rail crew members) would be 1.7 x 10^{-4} (2.0 x 10^{-4}) person-rem for truck shipments and 9.7 x 10^{-6} (7.0 x 10^{-5}) person-rem for rail shipments, assuming the basin sludge were designated SNF. The total dose to the workers, assuming the basin sludge were shipped to the AW DST farm, would be 0.0020 (0.0020) person-rem and 0.0019 (0.0020) person-rem for truck and rail shipments, respectively. The total dose to the workers, assuming the basin sludge were shipped to the SWBG, would be 0.0031 (0.0031) person-rem for truck shipments and 0.0030 (0.0031) person-rem for rail shipments. The total dose, truck crew plus onsite individuals, would be 1.7 x 10^{-4} (2.0 x 10^{-4}) person-rem if the sludge were SNF, 0.0020 (0.0020) person-rem if the sludge went to a DST, and 0.0031 (0.0031) person-rem if the sludge went to the SWBG. The total dose, rail crew plus onsite individuals, would be 1.0 x 10^{-5} (7.1 x 10^{-5}) person-rem, 0.0019 (0.0020) person-rem, and 0.0030 (0.0031) person-rem, for these options, respectively.

The potential health effects or LCFs were calculated for truck crews to be 6.7 x 10^{-8} (8.0 x 10^{-8}) LCFs (sludge as SNF), 8.0 x 10^{-7} (8.1 x 10^{-7}) LCFs

Table B-7. Transportation radiological impacts of the new wet storage alternative[a]

Option[b]	Radiological Impacts: Truck Crew (person-rem)	Radiological Impacts: Onsite (person-rem)	Health Effects: Onsite (LCF)
SNF and Basin Sludge to Reference Site			
Truck	2.1	0.011	$4.4x10^{-6}$
Rail	1.1	0.011	$4.4x10^{-6}$
SNF to Reference Site; Basin Sludge to DST			
Truck	7.2	0.031	$1.2x10^{-5}$
Rail	6.3	0.031	$1.2x10^{-5}$
SNF to Reference Site; Basin Sludge to SWBG			
Truck	15.0	0.057	$2.3x10^{-5}$
Rail	14.0	0.059	$2.4x10^{-5}$
SNF and Basin Sludge to Canister Storage Building			
Truck	2.8	0.015	$6.0x10^{-6}$
Rail	1.5	0.014	$5.6x10^{-6}$
SNF to Canister Storage Building; Basin Sludge to DST			
Truck	7.9	0.034	$1.4x10^{-5}$
Rail	6.7	0.033	$1.3x10^{-5}$
SNF to Canister Storage Building; Basin Sludge to SWBG			
Truck	16.0	0.062	$2.5x10^{-5}$
Rail	15.0	0.061	$2.4x10^{-5}$

(a) Potential health effects or latent cancer fatalities (LCFs) calculated using the methodology described in the DOE SNF PEIS.
(b) Values taken from Daling and Harris (1994). Suburban population characteristics are used to model Hanford Site (onsite) personnel.

(sludge to DST) and 1.2 x 10^{-6} (1.2 x 10^{-6}) LCFs (sludge to SWBG). The health effects for the onsite worker were estimated to be less than 6.0 x 10^{-9} LCFs, or essentially zero.

B.3.2.3 New Dry Storage

The results and input parameters associated with this alternative have been separated into two categories. The first category, "spent nuclear fuel - as is," is similar to wet storage; thus, the radiological impacts are the same as discussed in Section B.3, under "New Wet Storage." The second category, "spent nuclear fuel - repackaged," as discussed in Sections B.1.3, is significantly different. The results for the second category of impacts are discussed in this section.

As can be seen in Table B-8, the total dose (reference site dose estimates are shown first followed by the Canister Storage Building dose estimates in parenthesis) to the workers (i.e., truck or rail crew members) for the repackaged SNF would be 2.4 x 10^{-4} (2.8 x 10^{-4}) person-rem for truck shipments and 5.9 x 10^{-5} (7.9 x 10^{-5}) person-rem for rail, assuming the repackaged SNF, canister sludge, and basin sludge are transported to the reference site (or Canister Storage Building). The dose to crew members would be 0.0021 and 0.0020 person-rem for truck and rail shipments, respectively, assuming the basin sludge were shipped to the AW DST farm for each of the repackaged SNF destinations (reference site or Canister Storage Building). The total dose to the workers for each of the SNF destinations, assuming the basin sludge were shipped to the SWBG, would be 0.0032 person-rem for truck shipments and 0.0031 person-rem for rail shipments.

The worst case potential health effects or LCFs calculated for truck and rail crews were estimated to be 1.3 x 10^{-6} LCFs (sludge to DST), and 1.2 x 10^{-6} (sludge to SWBG), respectively. The annual health effects for the onsite worker were estimated to be less than 6.0 x 10^{-9} LCFs and thus are considered zero.

B.3.2.4 Foreign Processing

The following sections describe expected radiological consequences to workers and the public during transportation in the support of the foreign processing alternative.

Table B-8. Transportation radiological impacts of the new dry storage alternative[a]

Option[b]	Radiological Impacts: Truck Crew (person-rem)	Radiological Impacts: Onsite (person-rem)	Health Effects: Onsite (LCF)
SNF packaged with canister sludge (wet shipments); 3 basin sludge options.			
Impacts same as those for wet storage alternative (reference site and Canister Storage Building)			
SNF packaged with canister sludge (dry shipments); 3 basin sludge options.			
Impacts same as those for wet storage alternative (reference site and Canister Storage Building)			
SNF, canister sludge, basin sludge packaged separately; all to reference site			
Truck	2.2	0.012	4.8×10^{-6}
Rail	1.1	0.011	4.4×10^{-6}
SNF, canister sludge packaged separately (reference site); basin sludge to DST			
Truck	7.4	0.031	1.2×10^{-5}
Rail	6.4	0.031	1.2×10^{-5}
SNF, canister sludge packaged separately (reference site); basin sludge to SWBG			
Truck	15.0	0.059	2.4×10^{-5}
Rail	14.0	0.059	2.4×10^{-5}
SNF, canister sludge, basin sludge packaged separately; all to Canister Storage Building			
Truck	3.1	0.015	6.0×10^{-6}
Rail	1.6	0.015	6.0×10^{-6}
SNF, canister sludge packaged separately (Canister Storage Building); basin sludge to DST			
Truck	8.1	0.035	1.4×10^{-5}
Rail	6.8	0.034	1.4×10^{-5}
SNF, canister sludge packaged separately (Canister Storage Building); basin sludge to SWBG			
Truck	16.0	0.063	2.5×10^{-5}
Rail	15.0	0.062	2.5×10^{-5}

Table B-8. (contd)

Option[b]	Radiological Impacts: Truck Crew (person-rem)	Radiological Impacts: Onsite (person-rem)	Health Effects: Onsite (LCF)
SNF repackaged; SNF, canister sludge, and basin sludge packaged separately and shipped to reference site			
Truck	1.3	0.0083	3.3×10^{-6}
Rail	0.65	0.0077	3.1×10^{-6}
SNF repackaged; canister sludge packaged separately (reference site); basin sludge packaged separately and shipped to DST			
Truck	6.5	0.028	1.1×10^{-5}
Rail	5.9	0.028	1.1×10^{-5}
SNF repackaged; canister sludge packaged separately (reference site); basin sludge packaged separately and shipped to SWBG			
Truck	14.0	0.056	2.2×10^{-5}
Rail	14.0	0.056	2.2×10^{-5}
SNF repackaged; SNF, canister sludge, and basin sludge packaged separately and shipped to Canister Storage Building			
Truck	1.8	0.01	4.0×10^{-6}
Rail	0.98	0.1	4.0×10^{-6}
SNF repackaged; canister sludge packaged separately (Canister Storage Building); basin sludge packaged separately and shipped to DST			
Truck	6.9	0.03	1.2×10^{-5}
Rail	6.2	0.03	1.2×10^{-5}
SNF repackaged; canister sludge packaged separately (Canister Storage Building); basin sludge packaged separately and shipped to SWBG			
Truck	15.0	0.058	2.3×10^{-5}
Rail	14.0	0.058	2.3×10^{-5}

(a) Potential health effects or latent cancer fatalities (LCFs) calculated using the methodology described in DOE (1995a).
(b) Values taken from Daling and Harris (1994). Suburban population characteristics are used to model Hanford Site (onsite) personnel.

Worker Doses

The results of the incident-free impact calculations for transportation from Hanford to U.S. ports are presented in Table B-9. The radiological impacts are presented in terms of the population dose (person-rem) received by exposed workers and the projected health effects calculated to occur in the

Table B-9. Results of incident-free transportation impact calculations for shipments from Hanford to U.S. ports

Option and Material	Radiation Doses (person-rem)	Latent Cancer Fatalities
Barge to Portland		
SNF	3.0	0.0012
HLW	0.18	7.0×10^{-5}
Plutonium	0.077	3.1×10^{-5}
Uranium	0.053	2.1×10^{-5}
Total	3.3	0.0013
Truck to Seattle		
SNF	6.0	0.0024
HLW (Rail)	0.38	1.5×10^{-4}
Plutonium (Truck)	0.045	1.8×10^{-5}
Uranium (Truck)	0.034	1.3×10^{-5}
Total	6.5	0.0026
Rail to Seattle		
SNF	3.2	0.0013
HLW (Rail)	0.38	1.5×10^{-4}
Plutonium (Truck)	0.045	1.8×10^{-5}
Uranium (Truck)	0.034	1.3×10^{-5}
Total	3.7	0.0015
Truck to Norfolk		
SNF	100	0.042
HLW (Rail)	1.5	5.9×10^{-4}
Plutonium (Truck)	0.77	3.1×10^{-4}
Uranium (Truck)	0.58	2.3×10^{-4}
Total	110	0.043
Rail to Norfolk		
SNF	13	0.005
HLW (Rail)	1.5	5.9×10^{-4}
Plutonium (Truck)	0.77	3.1×10^{-4}
Uranium (Truck)	0.58	2.3×10^{-4}
Total	15	0.0061

exposed population. As shown, no LCFs were calculated to result from any of the five transportation options considered in this study.

As shown in Table B-9, the transportation option to U.S. ports that results in the lowest worker population doses is that involving barge shipments to the Port of Portland. This option is closely followed by the option of shipping by rail to the Port of Seattle. The option involving truck transport to the Port of Seattle is the third lowest option. The option of shipping by rail to the Port of Norfolk is next, followed by the option of shipping by truck to the Port of Norfolk.

In general, the shipments of N Reactor SNF to the U.K. would produce the highest doses of all the materials. This is attributed primarily to the higher number of N Reactor SNF shipments than the other materials. Also, it can be seen that rail shipments generally result in lower worker doses than truck shipments. This is because the exposure distances between the source and crew are much longer for rail shipments than for truck shipments. Similarly, the crew doses for rail and barge shipments are approximately comparable.

Maximum individual doses to workers from incident-free transport were calculated using the RISKIND computer code. The maximally exposed workers for truck shipments were found to be the truck drivers (two-person crew), who were assumed to drive shipments for up to 2,000 hr/year. The maximally exposed worker for rail shipments was a transportation worker in a rail yard who spent a time- and distance-weighted average of 0.16 hr inspecting, classifying, and repairing railcars and was assumed to be present for all of the radioactive shipments.

The maximum incident-free exposure calculations for workers were performed for each shipping option. The results are 1.46 person-rem for the barge-to-Portland option, 2.0 person-rem for the option of shipping to Seattle by truck, 1.03 person-rem for the option of shipping to Seattle by rail, 35.3 person-rem for the option of shipping to Norfolk by truck, and 17.9 person-rem for the option of shipping to Norfolk by rail.

Consequences to workers during handling and loading activities in ports are based on commercial experience during the last three quarters of 1994. Over this period, workers handled two shipments consisting of 16 loaded casks, and 1 shipment consisting of 5 empty casks. The collective dose to the 30 workers involved was 0.024 person-rem, with the maximum individual receiving 0.016 rem. Assuming that handling of the empty casks did not contribute measurably to that total, the expected collective dose from handling a single loaded cask is estimated to be on the order of 0.001 rem to the maximally exposed worker and 0.0015 person-rem total to all workers. The consequences for loading and unloading of 408 casks during shipment from the U.S. to the U.K. would therefore be approximately 1.2 person-rem to all workers over the expected 5-year campaign. Accounting for an additional two handling activities per cask at the Hanford Site and at the U.K. process facility would roughly double that estimate, resulting in a collective dose of 2.4 person-rem and a potential for 9.8×10^{-4} LCF for all shipments. The maximum dose to an individual worker, assuming that worker were involved in handling all 408 casks at one point in the shipping sequence, would be on the order of 0.4 rem over 5 years.

The primary impact of routine marine transport of SNF is potential radiological exposure to crew members of the ships used to carry the casks. Members of the general public and marine life would not receive any measurable dose from the SNF during incident-free marine transport of the casks. While at sea, the crew dose would be limited to those individuals who might enter the ship's hold during transit and receive external radiation near the packaged SNF. At all other times, the crew would be shielded from the casks by the decking and other structures of the vessel. The number of entries and inspections would be a function of the transit time from the port of loading to the port of off-loading.

External radiation from an intact shipping package must be less than specified limits that control the exposure of the handling personnel and general public. These limits are established in 49 CFR 173. The limit of interest is a 10-mrem/hr dose rate at any point 2 m (6.6 ft) from the outer surfaces of the transport cask. This limit applies to exclusive-use shipments, i.e., a shipment in which no other cargo is loaded on the platform used for the transportation casks, not that the ship is an exclusive-use vessel, although this would not be a limitation for the commercial special-purpose ships assumed for this analysis.

The external dose rates at the outside of the transport casks are anticipated to be much less than the regulatory limits. It was estimated that the N Reactor SNF considered in this analysis would fall within the design envelope of the internationally licensed casks routinely used by the U.K. facility for SNF transport (BNFL 1994). However, estimates of dose during normal transportation have been made assuming dose rates at the regulatory limits, using analyses performed for transport of foreign research reactor SNF as a basis (DOE 1995b). These analyses may be used to develop an upper bound of the doses anticipated to be received by ships crews during transport of the N Reactor SNF. Actual doses would be expected to be lower than these estimates.

Bounding Dose Calculations. Calculations performed to estimate bounding radiation doses during routine cask inspections aboard ship (DOE 1995b) provided information from which an inspection dose factor (IDF) could be determined of 6×10^{-5} rem/min/cask/day/person, based on an average distance of 5.5 m (18 ft). Because the ship crews are highly trained and the ships are designed for SNF transport, it was assumed that inspection of each of the eight holds on the ship (each containing three casks) would take no longer than 15 min, or an average of 5 min per cask for the total 24 casks. The total inspection time per day would be 2 hr. If an inspection crew were assumed to consist of two members of the ship's crew, the bounding dose per daily inspection would be

$$6 \times 10^{-5} \text{ (IDF)} \times 5 \text{ min} \times 24 \text{ casks} = 0.007 \text{ rem/person/day} \qquad (1)$$

Assuming a travel time from an eastern U.S. port of 10 days, the estimated maximum dose received by each member of a two-person inspection crew would be 0.07 rem. This value would not exceed the 0.1-rem dose limit for a member of the general public. The transit time for a shipment originating on the West Coast of the U.S. could be up to five times longer, resulting in a dose per shipment of 0.35 rem. This value would exceed the 0.1-rem dose limit for a member of the general public. However, because the ship's crews are trained and issued dosimeters, it is presumed that they would be considered radiation workers. Although it is not clear at this time if radiation exposure of the ship's crew would fall under the jurisdiction of the U.K. or U.S. radiation protection standards, these standards are identical for both countries (5 rem/year, with an administrative control level of 2 rem/year). Therefore, the maximum possible dose received by individual workers during ocean transit would be well within the limits of the U.S. and U.K. radiation protection standards for workers.

Complete transport of the SNF to the U.K. for processing would require 17 shipments of 24 casks. The collective dose to crew members responsible for conducting inspections on the transport ships during fuel transport from the U.S. East Coast would be

$$\begin{aligned}(0.007 \text{ rem/person/day}) \times 2 \text{ persons} \times \\ (10 \text{ days/trip}) \times 17 \text{ trips} = 2.4 \text{ person-rem}\end{aligned} \qquad (2)$$

Based on this bounding estimate of the collective dose to the ship's crew for transportation of the SNF, an upper limit of approximately 0.001 LCF would be expected among the ship's crew from exposure to external radiation from the SNF transport casks. If all shipments originated at a western U.S. port, the collective dose could be up to 12 person-rem with a corresponding consequence of 0.005 LCF.

As a bounding estimate, the same number of return shipments and similar external dose rates, at the regulatory limit, were assumed for high level waste, plutonium dioxide and uranium trioxide. Under those circumstances, an upper limit of 0.01 LCF would be expected among the ships' crews from exposure to the external radiation during all shipments.

Commercial Fuel Transport Experience. Information on radiation doses to ships' crews during transport of commercial fuel, gathered from actual crew dosimeters, supports the statements above that actual doses to the crew would be lower than the calculated bounding doses. The average individual dose during one voyage was 0.001 rem, with a maximum individual dose of 0.022 mrem. The collective dose to the ship's crew for one voyage was about 0.038 person-rem. On that basis, the crew's collective dose for 17 SNF shipments would be 0.65 person-rem. A comparison of bounding dose estimates and commercial transport experience is shown in Table B-10. Based on these results, less than 0.0003 LCF would be expected among ships' crews from radiation exposure during SNF transport, and approximately 0.0005 LCF would be expected from radiation exposure during transport of SNF and the subsequent return of processing products and waste.

Return of HLW to the U.S. is assumed to result in cumulative worker doses that are bounded by those incurred in the initial SNF shipments to the U.K. However, the distribution of dose among individual workers may differ because of the different configuration and radionuclide content of the HLW canisters. As noted in Section B.3, the dose rates associated with plutonium and uranium shipments are substantially below the regulatory maximum that was assumed for the SNF and HLW shipments.

Public Doses. The following section describes expected routine exposures to the public from various activities involved in transporting N Reactor SNF to the U.K. The following paragraphs address the routine public doses from transportation activities. The results of the public dose calculations were developed using the RADTRAN 4 computer code and the input parameters described in Table B-11.

Table B-10. Comparison of bounding and typical ship crew's doses

	Bounding Dose Calculations	Commercial Fuel Transport Experience
Individual dose, rem	0.07 - 0.35	0.001 typical 0.022 maximum
Collective dose, person-rem		
- 17 SNF shipments	2.4 - 12	0.65
- ≤ 17 round trips	≤ 24	≤ 1.3

Table B-11. Results of public incident-free exposure calculations

Option and Material	Radiation Doses (person-rem)	Latent Cancer Fatalities
Barge to Portland		
SNF	0.34	1.7×10^{-4}
HLW	0.0067	3.4×10^{-6}
Plutonium	0.037	1.9×10^{-5}
Uranium	0.029	1.4×10^{-5}
Total	0.41	2.1×10^{-4}
Truck to Seattle		
SNF	15	0.0076
HLW (rail)	0.19	9.6×10^{-5}
Plutonium (truck)	0.025	1.2×10^{-5}
Uranium (truck)	0.019	9.3×10^{-6}
Total	15	0.0077
Rail to Seattle		
SNF	1.6	8.1×10^{-4}
HLW (rail)	0.19	9.6×10^{-5}
Plutonium (truck)	0.025	1.2×10^{-5}
Uranium (truck)	0.019	9.3×10^{-6}
Total	1.9	9.3×10^{-4}
Truck to Norfolk		
SNF	250	0.13
HLW (rail)	0.7	3.5×10^{-4}
Plutonium (truck)	0.41	2.1×10^{-4}
Uranium (truck)	0.31	1.6×10^{-4}
Total	250	0.13
Rail to Norfolk		
SNF	5.9	0.003
HLW (rail)	0.7	3.5×10^{-4}
Plutonium (truck)	0.41	2.1×10^{-4}
Uranium (truck)	0.31	1.6×10^{-4}
Total	7.3	0.0037

From a domestic transportation perspective, the lowest-impact option is one that includes rail shipments of SNF from Hanford to the Port of Seattle. This option is followed closely by the option of moving SNF from Hanford to the Port of Portland by barge. The third lowest domestic transportation option is that involving SNF shipments to Seattle by truck. The highest impact options are those involving shipments from Hanford to the Port of Norfolk. Obviously, the lowest impact domestic transportation option would be that involving the shortest shipping distances (i.e., Hanford to Seattle or Portland). Some of the impacts of the long domestic transportation links would be offset by subsequent reductions in the lengths of the ocean shipment segments. Consequently, the rankings of the options presented in Table B-11 do not necessarily represent the rankings that would result if the ocean segments of the shipments were included. However, public routine doses are not significant for ocean voyages because the separation distance between the ship and the nearest exposed population is greater, resulting in extremely low radiation dose rates.

The results in Table B-11 demonstrate that barge shipments of SNF (and HLW) would produce lower public routine doses than truck or rail shipments. This is attributed primarily to the lower traffic volumes on waterways relative to railroads and highways, generally greater separation distances between barges and the public relative to the separation distances between highways/railroads and the public, as well as the increased per-shipment capacities of barges relative to truck and rail shipments (resulting in fewer shipments).

Table B-11 also demonstrates that rail shipments would produce lower public routine doses than equivalent truck shipments. This can be seen by comparing the SNF shipment impacts for truck shipments to Seattle (15 person-rem) and rail shipments to Seattle (1.6 person-rem). Even though the rail shipping route from Hanford to Seattle is much longer than the truck route (277 km and 716 km), the total public routine doses are smaller. As with barge shipments, this is attributed to lower traffic volumes, larger separation distances, and increased shipment capacity for rail shipments.

This analysis expects no dose to members of the public resulting from incident-free ocean transport of N Reactor SNF to the U.K. The ships carrying the fuel are owned and operated by the commercial vendor, and its shipboard crews are assumed to be classified as radiation workers for the purposes of this analysis.

B.3.3 Nonradiological Impacts from Incident-Free Transportation Activities

Impacts to the public from nonradiological causes were also evaluated. This included potential fatalities resulting from pollutants emitted from the vehicles during normal transportation. Based on the information contained in Rao et al. (1982), the types of pollutants that are present and can impact the public are sulfur oxides (SO_x), particulates, nitrogen oxides (NO_x), carbon monoxide (CO), hydrocarbons (HC), and photochemical oxidants (O_x). Of these pollutants, Rao et al. (1982) determined that the majority of the health effects are from SO_x and the particulates. Unit risk factors (fatalities per kilometer) for truck shipments were developed by Rao et al. (1982) for travel

Table B-12. Summary of transportation nonradiological impacts for all onsite alternatives

Option[a][b]	Onsite Fatalities
Enhanced K Basin storage alternative	
SNF and basin sludge to KW Basin	
Truck	$3.9x10^{-5}$
Rail	$3.9x10^{-5}$
SNF to KW Basin; basin sludge to DST	
Truck	$4.7x10^{-5}$
Rail	$4.7x10^{-5}$
SNF to KW Basin; basin sludge to SWBG	
Truck	$5.1x10^{-5}$
Rail	$5.2x10^{-5}$
New wet storage alternative	
SNF and basin sludge to reference site	
Truck	$1.2x10^{-4}$
Rail	$1.4x10^{-4}$
SNF to reference site; basin sludge to DST	
Truck	$1.2x10^{-4}$
Rail	$1.4x10^{-4}$
SNF to reference site; basin sludge to SWBG	
Truck	$1.3x10^{-4}$
Rail	$1.5x10^{-4}$
SNF and basin sludge to Canister Storage Building	
Truck	$1.3x10^{-4}$
Rail	$1.5x10^{-4}$
SNF to Canister Storage Building; basin sludge to DST	
Truck	$1.3x10^{-4}$
Rail	$1.5x10^{-4}$
SNF to Canister Storage Building; basin sludge to SWBG	
Truck	$1.4x10^{-4}$
Rail	$1.6x10^{-4}$

Table B-12. (contd)

Option[a][b]	Onsite Fatalities
Dry storage alternative	
SNF packaged with canister sludge (wet shipments); 3 basin sludge options	
Impacts same as those for new wet storage (reference site and Canister Storage Building)	
SNF packaged with canister sludge (dry shipments); 3 basin sludge options	
Impacts same as those for new wet storage (reference site and Canister Storage Building)	
SNF, canister sludge, basin sludge packaged separately; all to reference site	
Truck	$1.2x10^{-4}$
Rail	$1.4x10^{-4}$
SNF, canister sludge packaged separately (reference site); basin sludge to DST	
Truck	$1.3x10^{-4}$
Rail	$1.4x10^{-4}$
SNF, canister sludge packaged separately (reference site); basin sludge to SWBG	
Truck	$1.3x10^{-4}$
Rail	$1.5x10^{-4}$
SNF, canister sludge, basin sludge packaged separately; all to Canister Storage Building	
Truck	$1.3x10^{-4}$
Rail	$1.6x10^{-4}$
SNF, canister sludge packaged separately (Canister Storage Building); basin sludge to DST	
Truck	$1.4x10^{-4}$
Rail	$1.6x10^{-4}$
SNF, canister sludge packaged separately (Canister Storage Building); basin sludge to SWBG	
Truck	$1.4x10^{-4}$
Rail	$1.6x10^{-4}$

Table B-12. (contd)

Option[a][b]	Onsite Fatalities
SNF repackaged; SNF, canister sludge, and basin sludge packaged separately and shipped to reference site	
Truck	1.0×10^{-4}
Rail	1.1×10^{-4}
SNF repackaged; canister sludge packaged separately (reference site); basin sludge packaged separately and shipped to DST	
Truck	1.0×10^{-4}
Rail	1.1×10^{-4}
SNF repackaged; canister sludge packaged separately (reference site); basin sludge packaged separately and shipped to SWBG	
Truck	1.1×10^{-4}
Rail	1.2×10^{-4}
SNF repackaged; SNF, canister sludge, and basin sludge packaged separately and shipped to the Canister Storage Building	
Truck	1.1×10^{-4}
Rail	1.2×10^{-4}
SNF repackaged; canister sludge packaged separately (Canister Storage Building); basin sludge packaged separately and shipped to DST	
Truck	1.1×10^{-4}
Rail	1.2×10^{-4}
SNF repackaged; canister sludge packaged separately (Canister Storage Building); basin sludge packaged separately and shipped to SWBG	
Truck	1.1×10^{-4}
Rail	1.2×10^{-4}

(a) Values taken from Daling and Harris (1994). Suburban population characteristics are used to model Hanford Site (onsite) personnel.
(b) Basin debris included.

in urban population zones. The unit risk factors are 1.0×10^{-7} fatalities/km for truck and 1.3×10^{-7} fatalities/km for rail. Although this unit risk factor is for urban population zones, it was combined with the total shipping distance in suburban population zones that was used to model occupied facilities onsite (2.9% of the total distance from Table B-2) to calculate the nonradiological incident-free impacts to the public or Hanford Site workers.

The nonradiological incident-free impacts were calculated based on the travel distances given in Tables B-3 and B-4. The results for all alternative options are shown in Table B-12. The estimated number of fatalities would be less than 2.0 x 10^{-4} for all truck and rail shipping options for the onsite alternatives. Results are not presented in Table B-12 for the foreign processing alternative. The foreign processing alternative involves offsite transport so the public impacts will outweigh the onsite impacts. The results for the foreign processing alternative are presented later.

B.4 Analysis of Transportation Accidents

This section discusses the potential radiological and nonradiological impacts from transportation accidents for each alternative discussed in Section B.1. Radiological accident impacts to the collective population (public) were calculated using the RADTRAN 4 computer code (Neuhauser and Kanipe 1992). The radiological impacts to a maximally exposed individual, and the maximally exposed onsite and offsite individual, were calculated using the GENII code (Napier et al. 1988).

B.4.1 Radiological Impacts to the Public from Transportation Accidents

The transportation impacts are expressed as maximum individual doses and as population doses. The population doses were determined by multiplying the expected consequences of an accident by the accident frequency, summed over all possible accidents, and then integrated over the entire shipping campaign. The potential impacts or consequences to the population from transportation accidents were expressed in terms of radiological dose and LCFs.

Accident impacts can result from breaches in the shipping cask or damage to the cask shielding; however, the frequencies of occurrence of transportation accidents that would release significant quantities of radioactive material are relatively small. The shipping casks are designed to withstand specified transportation accident conditions (i.e., the shipping casks for all the materials shipped in this analysis were assumed to meet the type B packaging requirements specified in 49 CFR 173 and 10 CFR 71); therefore, only a relatively small fraction of accidents involve conditions that would be severe enough to result in a release of radioactive materials.

Once the material is released to the environment in an accident, it would be dispersed and diluted by atmospheric conditions and a small amount would be deposited on the ground from plume depletion at the receptor location. Access to the area adjacent to the transportation accident would be controlled by emergency response personnel until the area could be remediated and the radiation monitoring personnel have declared the area safe.

The RADTRAN 4 computer code was used to calculate the radiological risk of transportation accidents involving radioactive material shipments. The RADTRAN 4 methodology was summarized previously. For further details, refer to the discussions in *RADTRAN III* (Madsen et al. 1986) and *RADTRAN 4: Volume 3--User's Guide* (Neuhauser and Kanipe 1992).

There are five major categories of input data needed to calculate potential accident transportation risk impacts using the RADTRAN 4 computer code. These are 1) accident frequency, 2) release quantities, 3) atmospheric dispersion parameters, 4) population distribution parameters, and 5) human uptake and dosimetry models. Accident frequency and release quantities are discussed below. The remaining parameters were discussed in Section B.2.1.

The frequency of a severe accident is calculated by multiplying an overall accident rate (accidents per truck-km or per rail-km) by the conditional probability that an accident would involve mechanical and/or thermal conditions that are severe enough to result in container failure and subsequent release of radioactive material.

For this analysis, the six shipment-specific severity categories and conditional probabilities identified in DOE (1995a) were used to model cask failure. The conditional probability for a given severity category is defined as the fraction of accidents that would fall into that severity category if an accident were to occur. Severity category 1 was defined as encompassing all accidents that are within the type B package envelope that would not be severe enough to result in failure of the shipping cask (i.e., accidents with zero release). The higher categories (2 through 6) were defined to include more severe accidents, and thus may lead to a release of radioactive material. The conditional probabilities of the various severity categories that were used in the onsite analysis are shown in Table B-13.

Release fractions are used to determine the quantity of radioactive material released to the environment as a result of an accident. The quantity of material released is a function of the severity of the accident (i.e., thermal and mechanical conditions produced in the accident), the response of the shipping container to these conditions, and the physical and chemical properties of the material being shipped. The release fractions used in this analysis were taken from DOE (1995a) and are shown in Table B-14.

Table B-13. Accident severity categories and conditional probabilities for onsite and foreign processing alternatives[a]

Mode	Conditional Probability by Severity Category 1	2	3	4	5	6
Truck	0.9943	$4.03x10^{-5}$	0.00382	$1.55x10^{-5}$	0.0018	$9.84x10^{-6}$
Truck[b]	0.511	0.574	0.175	0.256	NA	NA
Rail	0.994	0.00202	0.00272	$6.14x10^{-4}$	$8.55x10^{-4}$	$1.25x10^{-4}$
Barge[c]	0.953	0.00202	0.0402	$6.41x10^{-4}$	0.00401	$1.34x10^{-4}$
Ship[d]	0.603	0.395	0.00202	$4.0x10^{-4}$	$4.0x10^{-4}$	$4.0x10^{-4}$

(a) Taken from DOE (1995a).
(b) Used for analysis of releases from basin water transport cask. Values taken from Green (1995).
(c) Pippen et al. (1995).
(d) DOE (1994).
NA = not applicable.

Table B-14. Release fractions used for assessment of accident impacts[a][b]

Material	Release fraction by severity category 1	2	3	4	5	6
SNF[a]						
Gases	0.0	0.0099	0.033	0.39	0.33	0.63
Cesium	0.0	$3.0x10^{-8}$	$1.0x10^{-7}$	$1.0x10^{-6}$	$1.0x10^{-6}$	$1.0x10^{-5}$
Ruthenium	0.0	$4.1x10^{-9}$	$1.4x10^{-8}$	$2.4x10^{-7}$	$1.4x10^{-7}$	$2.4x10^{-6}$
Particles	0.0	$3.0x10^{-10}$	$1.0x10^{-9}$	$1.0x10^{-8}$	$1.0x10^{-8}$	$1.0x10^{-7}$
HLW[a]	HLW release fractions are the same as those for SNF					
Plutonium Dioxide Particles	0.0	$1.0x10^{-6}$	$1.0x10^{-5}$	$1.0x10^{-4}$	0.0010	0.010
Uranium Trioxide Particles	0.0	$1.0x10^{-6}$	$1.0x10^{-5}$	$1.0x10^{-4}$	0.0010	0.010
Liquids[c]	0.0	0.01	0.5	1.0	NA	NA

(a) Taken from DOE (1995a).
(b) These release fractions were applied to truck and rail shipments of SNF and HLW. Release fractions for barge shipments were multiplied by 1/24, 1/12, 1/6, 1/3, and 1 for severity categories 2 through 6, respectively, to reflect the number of shipping casks that are damaged in each category.
(c) Used for analysis of releases from basin water transport cask. Values were taken from Green (1995).
NA = not applicable.

The input data used to calculate the radiological dose to the public (i.e., population densities, travel times, and distances) were the same as the inputs used to calculate the incident-free dose to the population and are shown in Tables B-3 and B-4. The radiological inventories used in the accident analysis were shown in Tables B-1 and B-2. The initial accident data (or rates expressed as accidents/km) used in this analysis were taken from Bergsman et al. (1995) and are recommended for the Hanford Site. The accident rate used for truck shipments is 8.86 x 10^{-8} accident/km (5.50 x 10^{-8} accident/mi); and for rail, it is 2.40 x 10^{-8} accident/km (1.49 x 10^{-8} accident/mi).

B.4.1.1 Enhanced K Basin Storage

For this analysis, the release fractions identified in Table B-14 for SNF were also used to model releases of radiological materials from shipping casks containing basin or canister sludge and SWHIC containing basin sludge. The dispersibility and respirability parameters in RADTRAN 4 were used to reflect the differences in waste forms. The assumed dispersibility factor for SNF is 1.0 and sludge is 0.050. These values were taken from Neuhauser and Kanipe (1992) for SNF and large powders, respectively. The category of large powders was considered appropriate for sludge based on its chemical and physical form (i.e., sludge will not be dried) and thus will not contain small, dry particles before packaging. It was also assumed that 100% of the liquid contained in LWHIC would be released from a transportation accident. Assuming a resuspension rate of 1 x 10^{-10}/s (Sutter 1982), for a 6,000-L (1,580-gal) release, 0.0043 L (0.0011 gal) would be aerosolized in a 2-hr period.

Using the accident modelling data contained in DOE (1995a) and the default values contained in Neuhauser and Kanipe (1992), it was assumed that 5% of the SNF (including basin sludge designated SNF and the grouted basin sludge released) and 100% of the liquid aerosolized would be respirable. The results of the analysis are shown in Table B-15.

B.4.1.2 New Wet Storage

For this analysis, the release fractions, accident rates, and dispersibility/respirability parameters presented above for the no action alternative were also used for this alternative. The results of the analysis are shown in Table B-16.

Table B-15. Transportation accident radiological impacts for the enhanced K Basin storage alternative

Option	Radiological Impacts[a] Onsite	Health Effects[b] Onsite
SNF and Basin Sludge to KW Basin		
Truck	$8.0x10^{-4}$	$3.2x10^{-7}$
Rail	$5.0x10^{-4}$	$2.0x10^{-7}$
SNF to KW Basin; Basin Sludge to DST		
Truck	2.1	$8.4x10^{-4}$
Rail	2.1	$8.4x10^{-4}$
SNF to KW Basin; Basin Sludge to SWBG		
Truck	1.2	$4.8x10^{-4}$
Rail	1.2	$4.8x10^{-4}$

(a) Radiological impacts expressed as person-rem.
(b) Health effects expressed as latent cancer fatalities (LCFs), using ICRP 60 methodology.

Table B-16. Transportation accident radiological impacts for the new wet storage alternative

Option[a]	Radiological Impacts (person-rem) Onsite	Health Effects[b] (LCFs) Onsite
SNF and basin sludge to reference site		
Truck	0.49	$2.0x10^{-4}$
Rail	0.15	$6.0x10^{-5}$
SNF to reference site; basin sludge to DST		
Truck	2.6	0.001
Rail	2.3	$9.2x10^{-4}$
SNF to reference site; basin sludge to SWBG		
Truck	1.7	$6.8x10^{-4}$
Rail	1.3	$5.2x10^{-4}$
SNF and basin sludge to Canister Storage Building		
Truck	0.68	$2.7x10^{-4}$
Rail	0.21	0.0084
SNF to Canister Storage Building; basin sludge to DST		
Truck	2.8	0.0011
Rail	2.3	$9.2x10^{-4}$
SNF to Canister Storage Building; basin sludge to SWBG		
Truck	1.9	$7.6x10^{-4}$
Rail	1.4	$5.6x10^{-4}$

(a) Values taken from Daling and Harris (1994). Suburban population characteristics are used to model Hanford Site (onsite) personnel.
(b) Health effects expressed as latent cancer fatalities (LCFs), using ICRP (1991) methodology.
DST equals double-shell tank.
LCF equals latent cancer fatality.
SWBG equals solid waste burial ground.

B.4.1.3 Dry Storage

As discussed in Section B.1.3, two options were analyzed to assess potential radiological accident impacts to the public. The first option, remove the SNF as is, involves the same transportation assumptions as the new wet storage alternative. Therefore, the results of the analysis are the same shown for new wet storage in Table B-16.

The second option assumes that the canister sludge is removed from the canister and packaged for disposition as SNF or liquid waste, and the SNF is repackaged, increasing the fuel loading per SNF cask. The basin sludge may be shipped as SNF, solid waste, or liquid waste; therefore, the impacts to the public, with respect to the basin sludge would be the same as the new wet storage alternative. The analysis assumptions discussed above for the enhanced K Basin alternative were also used in this analysis. The results of the analysis are shown in Table B-17.

B.4.1.4 Foreign Processing

The results of the integrated population risk assessment for the foreign processing alternative are presented in Table B-18. The lowest impact option is that in which SNF is shipped from Hanford to the Port of Seattle by rail. The Port of Seattle by truck option is the next highest followed in order by the rail option to Norfolk, truck to Norfolk, and then barge to Portland. The impacts for all of the options are dominated by the SNF shipments to the U.K. and plutonium dioxide return shipments to Hanford, primarily because the quantities and forms of these materials are more vulnerable to accidental releases and represent higher radiotoxicities than do vitrified HLW and uranium trioxide. Shipments of vitrified HLW were determined to present the lowest impacts of all the materials because of the reasons given plus the immobilized form of the material relative to the other materials.

Shipments by barge are shown in Table B-18 to result in relatively higher accident impacts than shipments by rail or truck. This is because the inventories of radioactive materials transported by barge, and the resulting potential accident releases, are at least an order of magnitude greater than for truck and rail shipments. Because the accident rates for the three modes are comparable, this results in a higher per shipment (or per-km) accident risk for barge than the other modes. This higher per-shipment risk more than offsets the risk reduction attributable to fewer barge shipments so, overall, barge accident risks appear to be higher than truck or rail transport risks. However, in comparing the magnitudes of the accident risks to the public routine exposures, it can be seen that the accident risks are lower than the

Table B-17. Transportation accident radiological impacts for the new dry storage alternative

Option[a]	Radiological Impacts (person-rem) Onsite	Health Effects[b] Onsite
SNF packaged with canister sludge (wet shipments); 3 basin sludge options.		
Impacts same as those for the wet storage alternative (reference site and Canister Storage Building)		
SNF packaged with canister sludge (dry shipments); 3 basin sludge options.		
Impacts same as those for the wet storage alternative (reference site and Canister Storage Building)		
SNF, canister sludge, basin sludge packaged separately; all to reference site		
Truck	0.49	2.0×10^{-4}
Rail	0.16	6.4×10^{-5}
SNF, canister sludge packaged separately (reference site); basin sludge to DST		
Truck	2.6	0.001
Rail	2.3	9.2×10^{-4}
SNF, canister sludge packaged separately (reference site); basin sludge to SWBG		
Truck	1.7	6.8×10^{-4}
Rail	1.3	5.2×10^{-4}
SNF, canister sludge, basin sludge packaged separately; all to Canister Storage Building		
Truck	0.68	2.7×10^{-4}
Rail	0.21	8.4×10^{-5}
SNF, canister sludge packaged separately (Canister Storage Building); basin sludge to DST		
Truck	2.8	0.0011
Rail	2.3	9.2×10^{-4}
SNF, canister sludge packaged separately (Canister Storage Building); basin sludge to SWBG		
Truck	1.9	7.6×10^{-4}
Rail	1.4	5.6×10^{-4}
SNF repackaged; SNF, canister sludge, and basin sludge packaged separately and shipped to reference site		
Truck	0.49	2.0×10^{-4}
Rail	0.13	5.2×10^{-5}
SNF repackaged; canister sludge packaged separately (reference site); basin sludge packaged separately and shipped to DST		
Truck	2.6	0.001
Rail	2.2	8.8×10^{-4}
SNF repackaged; canister sludge packaged separately (reference site); basin sludge packaged separately and shipped to SWBG		
Truck	1.7	6.8×10^{-4}
Rail	1.3	5.2×10^{-4}

Table B-17. (contd)

Option[a]	Radiological Impacts (person-rem) Onsite	Health Effects[b] Onsite
SNF repackaged; SNF, canister sludge, and basin sludge packaged separately and shipped to Canister Storage Building		
Truck	0.67	2.7×10^{-4}
Rail	0.22	8.8×10^{-5}
SNF repackaged; canister sludge packaged separately (Canister Storage Building); basin sludge packaged separately and shipped to DST		
Truck	2.8	0.0011
Rail	2.3	9.2×10^{-4}
SNF repackaged; canister sludge packaged separately (Canister Storage Building); basin sludge packaged separately and shipped to SWBG		
Truck	1.8	7.2×10^{-4}
Rail	1.4	5.6×10^{-4}

(a) Values taken from Daling and Harris (1994). Suburban population characteristics are used to model Hanford Site (onsite) personnel.
(b) Health effects expressed as latent cancer fatalities (LCFs), using ICRP (1991) methodology.

routine public exposures. Consequently, it may be concluded that transportation accident risk impacts are insignificant contributors to the total impacts of the transportation options.

B.4.2 Radiological Impacts to Maximally Exposed Individuals from Transportation Accidents

Radiological doses were calculated for maximally exposed individuals for each of the alternatives. This includes a hypothetical maximally exposed individual located 100 m (328 ft) from the release, a maximally exposed individual located onsite at the nearest occupied facility, and a maximally exposed individual located offsite at the Site boundary.

For the analysis of the impacts of onsite alternatives, it was assumed that all of the maximally exposed individuals were located to the east-southeast of the release, which, in general, is the direction in which maximum consequences are obtained. The maximally exposed offsite individual was assumed to be located 1.4 km (0.87 mi) from the release (Daling and Harris 1994). The location of the maximally exposed onsite worker was determined by reviewing the Hanford Site drawings and selecting a representative distance. For this analysis, it was assumed that this individual is located 0.75 km (0.47 mi) from the release. All releases have been modeled as ground level releases.

Table B-18. Results of transportation accident risk assessment for the foreign processing alternative[(a)]

Option and Material	Accident Impacts (person-rem)	Latent Cancer Fatalities
Barge to Portland		
SNF	0.018	9.0×10^{-6}
HLW	1.5×10^{-8}	7.5×10^{-12}
Plutonium	0.0093	4.7×10^{-6}
Uranium	2.7×10^{-6}	1.4×10^{-9}
Total	0.027	1.4×10^{-5}
Truck to Seattle		
SNF	9.3×10^{-5}	4.7×10^{-8}
HLW (Rail)	1.6×10^{-10}	8.0×10^{-14}
Plutonium (Truck)	0.0036	1.8×10^{-6}
Uranium (Truck)	1.1×10^{-6}	5.5×10^{-10}
Total	0.0037	1.9×10^{-6}
Rail to Seattle		
SNF	6.3×10^{-5}	3.2×10^{-8}
HLW (Rail)	1.6×10^{-10}	8.0×10^{-14}
Plutonium (Truck)	0.0036	1.8×10^{-6}
Uranium (Truck)	1.1×10^{-6}	5.5×10^{-10}
Total	0.0037	1.8×10^{-6}
Truck to Norfolk		
SNF	0.0021	1.1×10^{-6}
HLW (Rail)	9.3×10^{-10}	4.7×10^{-13}
Plutonium (Truck)	0.083	4.1×10^{-5}
Uranium (Truck)	2.4×10^{-5}	1.2×10^{-8}
Total	0.085	4.2×10^{-5}
Rail to Norfolk		
SNF	7.4×10^{-4}	3.7×10^{-7}
HLW (Rail)	9.3×10^{-10}	4.7×10^{-13}
Plutonium (Truck)	0.083	4.1×10^{-5}
Uranium (Truck)	2.4×10^{-5}	1.2×10^{-8}
Total	0.083	4.2×10^{-5}

(a) Reported values are point estimates of risk (i.e., the accident frequency multiplied by the consequences that would be expected if an accident occurred).

Radiological accident impacts to the maximally exposed offsite and onsite individuals and the maximally exposed individual were calculated using GENII (Napier et al. 1988). The results of the radiological dose calculations for these individuals are presented in Table B-19 for onsite SNF management alternatives and in Tables B-20 to B-23 for the foreign processing alternative.

Table B-19. Radiological impacts to maximally exposed individuals for onsite alternatives

	Radiological Dose (person-rem)		
Destination Mode	Maximally Exposed Individual	Maximally Exposed Onsite Individual	Maximally Exposed Offsite Individual
SNF[a]	2.8	0.91	0.33
SNF-repackage	5.8	1.9	0.68
Sludge[b]			
LWHIC	0.026	$8.5x10^{-4}$	$3.0x10^{-4}$
SWHIC	0.026	$8.5x10^{-4}$	$3.0x10^{-4}$

(a) Worst-case receptor dose for SNF or sludge designated as SNF.
(b) Worst-case receptor dose for basin sludge.

Table B-20. Calculated maximally exposed individual doses for accidents involving SNF for the foreign processing alternative

Transportation Route	TEDE (rem)
Hanford, Washington, to Portland, Oregon	0.26
Hanford, Washington, to Seattle, Washington	0.118
Hanford, Washington, to Norfolk, Virginia	0.26
Hanford, Washington, to Portland, Oregon	0.98
Hanford, Washington, to Seattle, Washington	1.27
Hanford, Washington, to Norfolk, Virginia	1.27

TEDE = 50-yr total effective dose equivalent.

Table B-21. Calculated maximally exposed individual doses for accidents involving plutonium dioxide shipments for the foreign processing alternative

Transportation Route	TEDE[a] (rem)
Portland, Oregon, to Hanford, Washington	0.123
Seattle, Washington, to Hanford, Washington	0.0123
Norfolk, Virginia, to Hanford, Washington	0.123

(a) Assumes one cask per truck shipment.
TEDE = 50-year total effective dose equivalent.

Table B-22. Calculated maximally exposed individual doses for accidents involving uranium trioxide shipments for the foreign processing alternative

Transportation Route	TEDE (rem)
Portland, Oregon, to Hanford, Washington	2.36×10^{-5}
Seattle, Washington, to Hanford, Washington	2.36×10^{-5}
Norfolk, Virginia, to Hanford, Washington	2.36×10^{-5}

TEDE = 50-year total effective dose equivalent.

Table B-23. Calculated maximally exposed individual doses for accidents involving solidified high-level waste shipments for the foreign processing alternative

Transportation Route	TEDE (rem)
Portland, Oregon, to Hanford, Washington	0.839
Seattle, Washington, to Hanford, Washington	0.839
Norfolk, Virginia, to Hanford, Washington	0.839

TEDE = 50-year total effective dose equivalent.

The consequences of accidents during port transit were estimated using the same assumptions described for worker consequences in Section B.2.4. Collective point estimates of risk to the population within 80 km (50 mi) of each location were calculated for an accident at the dock and on the approach to the port. The point estimate of risk to an individual at 1,600 m (1 mi) was also estimated for applicable exposure pathways. Consequences for populations and individuals are reported, both with and without the risk from ingestion of locally grown foods because protective action guidelines would require mitigative actions if the projected dose exceeded specified levels. Individual consequences assume 95% atmospheric dispersion, whereas consequences to populations are estimated for both 50% and 95% atmospheric dispersion.

The consequences of port accidents were estimated in a manner similar to that used for overland transportation impacts. The contents of one shipping cask were assumed to be involved in an accident (see Table B-2), with radionuclide releases according to the release fractions reported in Table B-14. The dose and resulting LCF were calculated for each of the six accident severity categories. The point estimates of risk included the consequences as LCF for accidents of each severity category multiplied by the frequency with which an accident of that severity would occur. The accident frequencies for each severity category were assumed to be the overall accident rate per port transit (3.2×10^{-4}) multiplied by the conditional probability for accidents in each severity category listed in Table B-13 (DOE 1994). The total accident risk for an individual or population was then estimated as the sum of risks for all accident severity categories. Risks for accidents evaluated at 95% (stable) atmospheric dispersion were assumed to be 10% lower than those at 50% (neutral) dispersion.

The results for accidents at the four representative ports are shown in Table B-24, with estimated risks for populations within 80 km (50 mi). Collective point estimates of risk to the population within 80 km (50 mi) of Portland, Oregon, were 5.2×10^{-9} to 4.9×10^{-6} LCF assuming 50% atmospheric dispersion conditions and 1.0×10^{-8} to 8.3×10^{-6} LCF for 95% atmospheric dispersion. Corresponding results for the population near Newark are 2.3×10^{-8} to 4.9×10^{-5} LCF assuming 50% atmospheric dispersion and 1.5×10^{-8} to 8.4×10^{-5} LCF for 95% atmospheric dispersion. Consequences for the collective populations of Seattle-Tacoma and Norfolk fell between the estimates for the other two ports.

The maximum reasonably foreseeable accident was a category 6 accident, which has a frequency of 1.3×10^{-7} per port transit, and which was evaluated for either neutral or stable atmospheric conditions resulting in a cumulative frequency of 2.2×10^{-6} or 2.2×10^{-7}, respectively for 17 SNF shipments. Dose and risk estimates for the maximum reasonably foreseeable accident are presented in Table B-25. The dose to the resident member of the public ranged from an estimated 0.02 to somewhat over 1 rem for all ports, depending on whether locally grown food was considered as an exposure pathway. The collective consequences to the populations within 80 km (50 mi) of the ports ranged from 0.0020 to 380 LCF assuming the accident occurs, depending on the location of the accident (port or harbor approach) and the exposure pathways considered. The corresponding point estimates of risk for latent fatal cancers amounted to 4.4×10^{-9} to 8.2×10^{-5}.

The effects of losing a cask at sea are estimated to be comparable to those evaluated for shipment of foreign research reactor SNF to the U.S. (DOE 1994), based on similar shipping inventories of long-lived radionuclides per cask. The maximum dose to an individual for a cask lost in coastal waters was expected to be 11 mrem/year if the cask were left in place until all its contents dispersed. The corresponding consequences to marine biota were 0.24 mrad/year for fish, 0.32 mrad/year for crustaceans, and 13 mrad/year for mollusks. The consequences resulting from loss of a cask in the deep ocean would be many orders of magnitude lower than estimates for coastal waters.

Table B-24. Point estimate of risk[a] of latent cancer fatalities from port accidents

	Portland, Oregon		Seattle, Washington		Norfolk, Virginia	
	All Pathways	Inhalation + External	All Pathways	Inhalation + External	All Pathways	Inhalation + External
Population within 80 km (50 mi) of dock--50% (neutral) atmospheric conditions						
1 Shipment	2.9×10^{-7}	6.6×10^{-9}	1.9×10^{-7}	4.3×10^{-9}	1.2×10^{-7}	2.7×10^{-9}
17 Shipments	4.9×10^{-6}	1.1×10^{-7}	3.2×10^{-6}	7.2×10^{-8}	2.0×10^{-6}	4.6×10^{-8}
Population within 80 km (50 mi) of harbor approach--50% (neutral) atmospheric conditions						
1 Shipment	2.4×10^{-7}	5.2×10^{-9}	6.0×10^{-8}	1.4×10^{-9}	1.1×10^{-7}	2.5×10^{-9}
17 Shipments	4.0×10^{-6}	8.9×10^{-8}	1.0×10^{-6}	2.3×10^{-8}	1.9×10^{-6}	4.3×10^{-8}
Population within 80 km (50 mi) of dock--95% (stable) atmospheric conditions						
1 Shipment	4.5×10^{-7}	1.0×10^{-8}	2.3×10^{-7}	5.1×10^{-9}	3.3×10^{-7}	7.4×10^{-9}
17 Shipments	7.6×10^{-6}	1.8×10^{-7}	3.9×10^{-6}	8.8×10^{-8}	5.6×10^{-6}	1.3×10^{-7}
Population within 80 km (50 mi) of harbor approach--95% (stable) atmospheric conditions						
1 Shipment	4.9×10^{-7}	1.0×10^{-8}	1.2×10^{-7}	2.8×10^{-9}	2.5×10^{-7}	5.8×10^{-9}
17 Shipments	8.3×10^{-6}	1.7×10^{-7}	2.0×10^{-6}	4.7×10^{-8}	4.3×10^{-6}	9.8×10^{-8}

(a) Point estimate of risk is defined as the consequences to the population (as LCF) of an accident of a given severity category (assuming the accident occurs), multiplied by the frequency per shipment with which an accident of that severity would occur. The risks for accidents of all severity categories are then summed to obtain the total risk per shipment.

Table B-25. Consequences and risk to the public surrounding port facilities from maximum reasonably foreseeable accidents involving SNF shipments at or near the ports

	Portland, Oregon		Seattle, Washington		Norfolk, Virginia	
	All Pathways	Inhalation + External	All Pathways	Inhalation + External	All Pathways	Inhalation + External
Resident at 1600 m (523 ft)						
Dose (rem)	1.3	0.023	0.99	0.018	1.3	0.023
Population within 80 km (50 mi) of dock--50% (neutral) atmospheric dispersion						
Dose (person-rem)	870	19	550	12	350	7.7
LCF	0.44	0.0097	0.28	0.0060	0.18	0.0039
LCF risk	9.5×10^{-7}	2.1×10^{-8}	6.0×10^{-7}	1.3×10^{-8}	3.8×10^{-7}	8.4×10^{-9}
Population within 80 km (50 mi) of harbor approach--50% (neutral) atmospheric dispersion						
Dose (person-rem)	690	15	180	4.0	330	7.3
LCF	0.35	0.0075	0.090	0.0020	0.17	0.0037
LCF risk	7.5×10^{-7}	1.6×10^{-8}	2.0×10^{-7}	4.4×10^{-9}	3.6×10^{-7}	7.9×10^{-9}
Population within 80 km (50 mi) of dock--95% (stable) atmospheric dispersion						
Dose (person-rem)	1.3×10^{4}	290	6900	150	9800	210
LCF	6.5	0.14	3.5	0.075	4.9	0.11
LCF risk	1.4×10^{-6}	3.1×10^{-8}	7.5×10^{-7}	1.6×10^{-8}	1.1×10^{-6}	2.3×10^{-8}
Population within 80 km (50 mi) of harbor approach--95% (stable) atmospheric dispersion						
Dose (person-rem)	1.4×10^{4}	310	3600	78	7500	160
LCF	7.0	0.16	1.8	0.039	3.8	0.080
LCF risk	1.5×10^{-6}	3.4×10^{-8}	3.9×10^{-7}	8.5×10^{-9}	8.2×10^{-7}	1.7×10^{-8}

The probability of accident on the open ocean was estimated to be 4.6×10^{-5} per shipment for an average duration voyage of about 20 days in transporting SNF from foreign research reactors to the U.S. (DOE 1995b). The frequency of accidents for overseas shipment of SNF and process materials via special-purpose ships would likely be within a factor of two or three of this estimate. However, that frequency applies to commercial freight shipping experience, and it is possible that the use of special-purpose ships could result in a different accident rate. Using the commercial freight accident rate given above, the probability of an accident on the open ocean involving transport of SNF (17 ocean shipments), HLW (1 shipment), uranium trioxide (1 shipment), and plutonium dioxide (1 shipment) was calculated to be about 9.2×10^{-4}, integrated over all the shipments.

B.4.3 Nonradiological Impacts from Transportation Accidents

This section describes the analyses performed to assess nonradiological impacts to the public and the maximally exposed individuals.

The nonradiological impacts associated with the transportation of SNF and basin sludge were assumed to be comparable to the impacts associated with general transportation activities in the United States. To calculate non-radiological impacts or fatalities, a unit risk factor (i.e., fatalities per km or fatalities per mi) developed for specific population zones or density was multiplied by the total shipment distance (i.e., total distance per campaign). The fatalities would occur as the result of vehicular impacts with solid objects, rollovers, or collisions. Therefore, unit risk factors are required for crew members and the public (i.e., individuals on or immediately adjacent to roadways or rail lines).

As discussed in Daling and Harris (1994), the Hanford Site can be characterized as a rural population zone. The following unit risk factors (Cashwell et al. 1986) were used in this analysis:

Truck:

1.5×10^{-8} fatalities/km for crew members
5.3×10^{-8} fatalities/km for the public

Rail:

1.8×10^{-9} fatalities/km for crew members
2.6×10^{-8} fatalities/km for the public

Results were obtained for each alternative by multiplying the unit risk factors by the appropriate total shipping distances for each alternative.

The results of this analysis are shown in Table B-26 for all SNF management alternatives. A dominant contributor for nonradiological impacts is the shipments of basin water to the ETF. This is because of the number of shipments and travel distance required to transport the liquids (i.e., 9,000 km or 5,600 mi for the enhanced K Basins storage alternative and 18,000 km or 11,200 mi for all other alternatives).

Table B-26. Summary of nonradiological transportation accident impacts for all onsite alternatives (does not include foreign processing)

	Health Effects (Fatalities)	
Option[a][b]	Crew	Onsite
Enhanced K Basin storage alternative		
SNF and basin sludge to KW Basin		
Truck	$2.0x10^{-4}$	$7.2x10^{-4}$
Rail	$2.0x10^{-4}$	$7.1x10^{-4}$
SNF to KW Basin; basin sludge to DST		
Truck	$2.4x10^{-4}$	$8.5x10^{-4}$
Rail	$2.4x10^{-4}$	$8.4x10^{-4}$
SNF to KW Basin; basin sludge to SWBG		
Truck	$2.7x10^{-4}$	$9.4x10^{-4}$
Rail	$2.6x10^{-4}$	$9.3x10^{-4}$
New wet storage alternative		
SNF and basin sludge to reference site		
Truck	$6.2x10^{-4}$	0.0022
Rail	$3.6x10^{-4}$	0.0017
SNF to reference site; basin sludge to DST		
Truck	$6.4x10^{-4}$	0.0023
Rail	$4.0x10^{-4}$	0.0018
SNF to reference site; basin sludge to SWBG		
Truck	$6.6x10^{-4}$	0.0023
Rail	$4.3x10^{-4}$	0.0018
SNF and basin sludge to Canister Storage Building		
Truck	$6.7x10^{-4}$	0.0024
Rail	$3.7x10^{-4}$	0.0018

Table B-26. (contd)

Option[(a)(b)]	Health Effects (Fatalities) Crew	Onsite
SNF to Canister Storage Building; basin sludge to DST		
Truck	6.9×10^{-4}	0.0024
Rail	4.1×10^{-4}	0.0019
SNF to Canister Storage Building; basin sludge to SWBG		
Truck	7.1×10^{-4}	0.0025
Rail	4.3×10^{-4}	0.0019
Dry storage alternative		
SNF packaged with canister sludge (wet shipments); 3 basin sludge options		
Impacts same as those for new wet storage (reference site and Canister Storage Building)		
SNF packaged with canister sludge (dry shipments); 3 basin sludge options		
Impacts same as those for new wet storage (reference site and Canister Storage Building)		
SNF, canister sludge, basin sludge packaged separately; all to reference site		
Truck	6.5×10^{-4}	0.0023
Rail	3.7×10^{-4}	0.0017
SNF, canister sludge packaged separately (reference site); basin sludge to DST		
Truck	6.6×10^{-4}	0.0023
Rail	4.1×10^{-4}	0.0018
SNF, canister sludge packaged separately (reference site); basin sludge to SWBG		
Truck	6.9×10^{-4}	0.0024
Rail	4.3×10^{-4}	0.0019
SNF, canister sludge, basin sludge packaged separately; all to Canister Storage Building		
Truck	6.9×10^{-4}	0.0024
Rail	3.7×10^{-4}	0.0018

Table B-26. (contd)

Option[a][b]	Health Effects (Fatalities)	
	Crew	Onsite
SNF, canister sludge packaged separately (Canister Storage Building); basin sludge to DST		
Truck	$7.1x10^{-4}$	0.0025
Rail	$4.1x10^{-4}$	0.0019
SNF, canister sludge packaged separately (Canister Storage Building); basin sludge to SWBG		
Truck	$7.3x10^{-4}$	0.0026
Rail	$4.4x10^{-4}$	0.002
SNF repackaged; SNF, canister sludge, and basin sludge packaged separately and shipped to reference site		
Truck	$5.2x10^{-4}$	0.0018
Rail	$3.5x10^{-4}$	0.0015
SNF repackaged; canister sludge packaged separately (reference site); basin sludge packaged separately and shipped to DST		
Truck	$5.3x10^{-4}$	0.0019
Rail	$3.9x10^{-4}$	0.0016
SNF repackaged; canister sludge packaged separately (reference site); basin sludge packaged separately and shipped to SWBG		
Truck	$5.6x10^{-4}$	0.002
Rail	$4.1x10^{-4}$	0.0017
SNF repackaged; SNF, canister sludge, and basin sludge packaged separately and shipped to Canister Storage Building		
Truck	$5.5x10^{-4}$	0.0019
Rail	$3.5x10^{-4}$	0.0015
SNF repackaged; canister sludge packaged separately (Canister Storage Building); basin sludge packaged separately and shipped to DST		
Truck	$5.6x10^{-4}$	0.002
Rail	$3.9x10^{-4}$	0.0016
SNF repackaged; canister sludge packaged separately (Canister Storage Building); basin sludge packaged separately and shipped to SWBG		
Truck	$5.8x10^{-4}$	0.0021
Rail	$4.2x10^{-4}$	0.0017

(a) Values taken from Daling and Harris (1994). Suburban population characteristics are used to model Hanford Site (onsite) personnel.
(b) Basin debris included.

B.5 References

Bergsman, K. H. 1994. *Hanford Irradiated Fuel Inventory Baseline*, WHC-SD-SNF-TI-001, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Bergsman, K. E, T. B Bergman, D. W. Bergmann, G. E. Costley, M. T. Jansky, D. S. Leach, R. L. McCormack, M. J. Monthey, A. N. Praga, I. K. Ullah, W. L. Willis, and A. G. Hosler. 1995. *K Basin Environmental Impact Statement Technical Input*. WHC-SD-SNF-TI-013, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

BNFL (British Nuclear Fuels Limited). 1994. "UK-Based Processing as a Spent Fuel Management Option for US DOE." British Nuclear Fuels, Inc., Washington, D.C.

Cashwell, J. W., K. S. Neuhauser, P. C. Reardon, and G. W. McNair. 1986. *Transportation Impacts of the Commercial Radioactive Waste Management Program*. SAND85-2715, Sandia National Laboratory, Albuquerque, New Mexico.

Clarke, R. K., J. T. Foley, W. F. Hartman, and D. W. Larson. 1976. *Severities of Transportation Accidents, Volume 1 - Summary*. SLA-74-001, Sandia National Laboratories, Albuquerque, New Mexico.

Daling, P. M., and M. S. Harris. 1994. *Transportation Impact Analysis for Shipment of Irradiated N-Reactor Fuel and Associated Materials*. PNL-10249, Pacific Northwest Laboratory, Richland, Washington.

Dennis, A. W., J. T. Foley, W. F. Hartman, and D. W. Larson. 1978. *Severities of Transportation Accidents Involving Large Packages*. SAND77-0001, Sandia National Laboratories, Albuquerque, New Mexico.

DOE (U.S. Department of Energy). 1994. *Environmental Assessment of Urgent-Relief Acceptance of Foreign Research Reactor Spent Nuclear Fuel*, DOE/EA-0912, U.S. Department of Energy, Washington, D.C.

DOE (U.S. Department of Energy). 1995a. *Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement*. The Programmatic EIS includes Vol. 1, Appendix A, Hanford Site Spent Nuclear Fuel Management Program. DOE/EIS-0203-F, U.S. Department of Energy, Washington, D.C.

DOE (U.S. Department of Energy). 1995b. *Draft Environment Impact Statement on a Proposed Policy for the Acceptance of Foreign Research Reactor Spent Nuclear Fuel*, DOE/EIS-0218-D, U.S. Department of Energy, Washington, D.C.

Green, J. R. 1995. *Transportation Impact Analysis for Shipment of Low Specific Activity Nitric Acid.* WHC-SD-TP-RPT-015, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

Grove Engineering, Inc. 1988. *MICROSHIELD, Version 3.* Rockville, Maryland.

ICRP (International Commission on Radiological Protection). 1991. *1990 Recommendations of the International Commission on Radiological Protection.* ICRP Publication 60, Pergamon Press, Oxford.

Johnson, D. E., D. S. Joy, D. B. Clarke, and J. M. Jacobi. 1993a. *HIGHWAY 3.1 - An Enhanced Highway Routing Model: Program Description, Methodology, and Revised User's Manual.* ORNL/TM-12124, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Johnson, P. E., D. S. Joy, D. B. Clarke, and J. M. Jacobi. 1993b. *INTERLINE 5.0 - An Expanded Railroad Routing Model: Program Description, Methodology, and Revised User's Manual.* ORNL/TM-12090, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Madsen, M. M., E. L. Wilmot, and J. M. Taylor. 1983. *RADTRAN II User's Guide.* SAND82-2681, Sandia National Laboratories, Albuquerque, New Mexico.

Madsen, M. M., J. M. Taylor, R. M. Ostmeyer, and P. C. Reardon. 1986. *RADTRAN III.* SAND84-0036, Sandia National Laboratories, Albuquerque, New Mexico.

Napier, B. A., D. L. Strenge, R. A. Peloquin, and J. V. Ramsdell. 1988. *GENII -The Hanford Environmental Radiation Dosimetry Software System.* PNL-6584, Vols. 1 and 3, Pacific Northwest Laboratory, Richland, Washington.

Neuhauser, K. S., and F. L. Kanipe. 1992. *RADTRAN 4: Volume 3--User's Guide.* SAND89-2370, Sandia National Laboratories, Albuquerque, New Mexico.

NRC (U.S. Nuclear Regulatory Commission). 1977. *Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes.* NUREG-0170, U.S. Nuclear Regulatory Commission, Washington, D.C.

Pippin, H. K., M. Hall, and T. Wierman. 1995. *Scoping Evaluation for the Option of Transporting Spent Nuclear Fuel by Barge*. SAIC Engineering Design File No. EIS-TRANS-39, Science Applications International Corp., Idaho Falls, Idaho.

Rao, R. K., E. L. Wilmot, and R. E. Luna. 1982. *Non-Radiological Impacts of Transporting Radioactive Material*. SAND81-1703, Sandia National Laboratories, Albuquerque, New Mexico.

Sutter, S. L. 1982. *Accident Generated Particulate Materials and Their Characteristics--A Review of Background Information*. PNL-4514, Pacific Northwest Laboratory, Richland, Washington.

APPENDIX C

NOISE ANALYSIS

APPENDIX C

NOISE ANALYSIS

The purpose of this appendix is to provide documentation of noise analysis for this environmental impact statement (EIS). Construction and operational noise impacts have been assessed for several major projects at Hanford, including the new production reactor (DOE 1991), and were not considered significant. Construction of facilities associated with the alternatives in this EIS is smaller in scope and duration than that for these other major projects. Additionally, there is no blasting associated with the alternatives. Consequently, the construction noise impacts of alternatives have a low potential for adverse impact and are not evaluated further.

The remainder of this appendix addresses the estimation of traffic noise associated with the alternatives in this EIS.

C.1 Estimation of Traffic Noise

A regression equation was developed from modeled data of traffic volume (vehicles/hr) and estimated noise levels (1-hr equivalent sound level; Leq in dB[A]). The Leq is the equivalent steady sound that, if continuous during a specified time period, would contain the same total energy as the actual time-varying sound over the monitored or modeled time period. The modeled data were developed to assess traffic noise associated with the New Production Reactor Environmental Impact Statement (DOE 1991). The regression equation was:

$$Y = 48.35549 + 7.25929X$$

where Y is the predicted noise level in 1-hr Leq (dB[A]) and X is the log of the hourly traffic volume.

For the analysis, four baseline levels of traffic volume were used: 10, 100, 1000, and 4000 vehicles/hr. The 10-vehicle/hr limit might approximate early morning traffic. The 4000-vehicle/hr value is a conservative estimate of maximum rush hour traffic volume. The larger the baseline traffic volume, the lower the potential impact resulting from K Basin associated traffic noise in the community. Incremental increases of traffic for each of these baseline traffic volumes were adjusted by the estimated change in staff associated with each alternative by year. Each increase in staff corresponds with an additional vehicle on the road. Carpooling or commuter buses would reduce the noise estimates as fewer vehicles would be involved; consequently, this approach provides a worst-case assessment. All traffic was modeled as passing one location. Noise estimates were estimated at 5 m (15 ft) from the side of the road. Noise impacts associated with construction and operation were estimated by year for the period of 1995 through 2009, and 2010 through 2035 as a single period of time (Table C-1). The impact was then related to the no action alternative to define incremental impacts as increases or decreases in the 1-hr Leq (Table C-2).

Incremental increases in traffic noise for wet storage, passivation with dry storage, calcination with dry storage, and onsite processing show minor increases in traffic noise from 1995 through 2002. Depending on the alternative, decreases in noise levels would start in 2002 through 2005 and continue through 2035 because of reduced staff requirements (see Table C-1). The greatest incremental increases were associated with onsite processing. This was an increase of 4.2 dB(A) at the baseline of 10 vehicles/hr for the period of 2006 through 2009. Baseline rush hour traffic volumes would exceed 1000 vehicles/hr; therefore, the potential for adverse impacts is lower under more realistic traffic flow conditions. These incremental increases would not be expected to cause public complaint as they would occur during times of normally high traffic flow (6:30 to 8:00 a.m. and 3:30 to 5:30 p.m.) and existing baseline traffic noise levels would be relatively high.

C.2 Reference

DOE (U.S. Department of Energy). 1991. *Draft Environmental Impact Statement for the Siting, Construction and Operation of New Production Reactor Capacity.* Vol. 4, Appendices D-R, DOE/EIS-0144D, U.S. Department of Energy, Washington, D.C.

Table C-1. Labor projections and traffic noise estimates (dB[A]); 1-hr Leq by alternative

Analysis Variable	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008 to 2009	2010 to 2013	2014 to 2035
No action																
Labor (FTE)	280.0	280.0	280.0	280.0	280.0	280.0	280.0	280.0	280.0	280.0	280.0	280.0	280.0	280.0	280.0	280.0
10 veh/hr	66.2	66.2	66.2	66.2	66.2	66.2	66.2	66.2	66.2	66.2	66.2	66.2	66.2	66.2	66.2	66.2
100 veh/hr	67.1	67.1	67.1	67.1	67.1	67.1	67.1	67.1	67.1	67.1	67.1	67.1	67.1	67.1	67.1	67.1
1000 veh/hr	70.9	70.9	70.9	70.9	70.9	70.9	70.9	70.9	70.9	70.9	70.9	70.9	70.9	70.9	70.9	70.9
4000 veh/hr	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7
Enhanced K Basin storage																
Labor (FTE)	280.0	280.0	280.0	280.0	280.0	280.0	280.0	280.0	249.0	249.0	249.0	187.0	187.0	187.0	187.0	187.0
10 veh/hr	66.2	66.2	66.2	66.2	66.2	66.2	66.2	66.2	65.9	65.9	65.9	65.0	65.0	65.0	65.0	65.0
100 veh/hr	67.1	67.1	67.1	67.1	67.1	67.1	67.1	67.1	66.8	66.8	66.8	66.2	66.2	66.2	66.2	66.2
1000 veh/hr	70.9	70.9	70.9	70.9	70.9	70.9	70.9	70.9	70.8	70.8	70.8	70.7	70.7	70.7	70.7	70.7
4000 veh/hr	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.6	74.6	74.6	74.6	74.6
New wet storage																
Labor (FTE)	280.0	373.0	503.0	409.0	409.0	403.0	355.0	202.0	202.0	202.0	77.0	77.0	77.0	77.0	77.0	77.0
10 veh/hr	66.2	67.1	68.0	67.4	67.4	67.3	67.0	65.2	65.2	65.2	62.4	62.4	62.4	62.4	62.4	62.4
100 veh/hr	67.1	67.8	68.5	68.0	68.0	68.0	67.7	66.4	66.4	66.4	64.7	64.7	64.7	64.7	64.7	64.7
1000 veh/hr	70.9	71.1	71.4	71.2	71.2	71.2	71.1	70.7	70.7	70.7	70.4	70.4	70.4	70.4	70.4	70.4
4000 veh/hr	74.7	74.8	74.9	74.8	74.8	74.8	74.8	74.7	74.7	74.7	74.6	74.6	74.6	74.6	74.6	74.6
Passivation with dry storage																
Labor (FTE)	280.0	460.0	688.0	571.0	539.0	473.0	483.0	264.0	264.0	264.0	22.0	22.0	22.0	22.0	22.0	22.0
10 veh/hr	66.2	67.8	69.0	68.4	68.2	67.8	67.9	66.1	66.1	66.1	59.3	59.3	59.3	59.3	59.3	59.3
100 veh/hr	67.1	68.3	69.4	68.9	68.7	68.4	68.4	66.9	66.9	66.9	63.5	63.5	63.5	63.5	63.5	63.5
1000 veh/hr	70.9	71.3	71.8	71.6	71.5	71.4	71.4	70.9	70.9	70.9	70.2	70.2	70.2	70.2	70.2	70.2
4000 veh/hr	74.7	74.8	75.0	74.9	74.9	74.9	74.9	74.7	74.7	74.7	74.5	74.5	74.5	74.5	74.5	74.5
Calcination with dry storage																
Labor (FTE)	280.0	373.0	503.0	409.0	409.0	720.0	850.0	697.0	848.0	697.0	717.0	747.0	747.0	747.0	622.0	22.0
10 veh/hr	66.2	67.1	68.0	67.4	67.4	69.1	69.7	69.0	69.7	69.0	69.1	69.3	69.3	69.3	68.7	59.3
100 veh/hr	67.1	67.8	68.5	68.0	68.0	69.5	70.0	69.4	70.0	69.4	69.5	69.6	69.6	69.6	69.1	63.5
1000 veh/hr	70.9	71.1	71.4	71.2	71.2	71.8	72.1	71.8	72.1	71.8	71.8	71.9	71.9	71.9	71.7	70.2
4000 veh/hr	74.7	74.8	74.9	74.8	74.8	75.0	75.1	75.0	75.1	75.0	75.0	75.0	75.0	75.0	75.0	74.5
Onsite processing																
Labor (FTE)	280.0	373.0	503.0	409.0	409.0	792.0	744.0	1128.0	1074.0	850.0	728.0	1172.0	1172.0	1172.0	1321.0	15.0
10 veh/hr	66.2	67.1	68.0	67.4	67.4	69.4	69.2	70.5	70.4	69.7	69.2	70.7	70.7	70.7	71.0	58.5
100 veh/hr	67.1	67.8	68.5	68.0	68.0	69.8	69.6	70.8	70.6	70.0	69.5	70.9	70.9	70.9	71.2	63.3
1000 veh/hr	70.9	71.1	71.4	71.2	71.2	72.0	71.9	72.5	72.4	72.1	71.9	72.6	72.6	72.6	72.8	70.2
4000 veh/hr	74.7	74.8	74.9	74.8	74.8	75.1	75.0	75.3	75.3	75.1	75.0	75.3	75.3	75.3	75.4	74.5
Foreign processing																
Labor (FTE)	280.0	280.0	287.0	295.0	304.0	298.0	298.0	298.0	298.0	298.0	300.0	307.0	307.0	198.0	5.0	5.0
10 veh/hr	66.2	66.2	66.3	66.4	66.5	66.4	66.4	66.4	66.4	66.4	66.4	66.5	66.5	65.2	56.9	56.9
100 veh/hr	67.1	67.1	67.1	67.2	67.3	67.2	67.2	67.2	67.2	67.2	67.2	67.3	67.3	66.3	63.0	63.0
1000 veh/hr	70.9	70.9	70.9	70.9	71.0	71.0	71.0	71.0	71.0	71.0	71.0	71.0	71.0	70.7	70.1	70.1
4000 veh/hr	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.7	74.5	74.5

Table C-2. Incremental changes (dB[A]; 1-hr Leq) in noise levels (alternative compared to no action) resulting from increases or decreases in traffic noise at four levels of traffic volume

Traffic Volume	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008 to 2009	2010 to 2013	2014 to 2035
Enhanced K Basin storage																
10 veh/hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.4	-0.4	-0.4	-1.2	-1.2	-1.2	-1.2	-1.2
100 veh/hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.3	-0.3	-0.3	-0.9	-0.9	-0.9	-0.9	-0.9
1000 veh/hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2
4000 veh/hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1
New wet storage																
10 veh/hr	0.0	0.9	1.8	1.2	1.2	1.1	0.7	-1.0	-1.0	-1.0	-3.8	-3.8	-3.8	-3.8	-3.8	-3.8
100 veh/hr	0.0	0.7	1.5	0.9	0.9	0.9	0.6	-0.7	-0.7	-0.7	-2.4	-2.4	-2.4	-2.4	-2.4	-2.4
1000 veh/hr	0.0	0.2	0.5	0.3	0.3	0.3	0.2	-0.2	-0.2	-0.2	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5
4000 veh/hr	0.0	0.1	0.2	0.1	0.1	0.1	0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2
Passivation with dry storage																
10 veh/hr	0.0	1.5	2.8	2.2	2.0	1.6	1.7	-0.2	-0.2	-0.2	-6.9	-6.9	-6.9	-6.9	-6.9	-6.9
100 veh/hr	0.0	1.2	2.3	1.8	1.6	1.3	1.3	-0.1	-0.1	-0.1	-3.6	-3.6	-3.6	-3.6	-3.6	-3.6
1000 veh/hr	0.0	0.4	0.9	0.6	0.6	0.4	0.5	0.0	0.0	0.0	-0.7	-0.7	-0.7	-0.7	-0.7	-0.7
4000 veh/hr	0.0	0.1	0.3	0.2	0.2	0.1	0.1	0.0	0.0	0.0	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2
Calcination with dry storage																
10 veh/hr	0.0	0.9	1.8	1.2	1.2	2.9	3.4	2.8	3.4	2.8	2.9	3.0	3.0	3.0	2.5	-6.9
100 veh/hr	0.0	0.7	1.5	0.9	0.9	2.4	2.9	2.3	2.9	2.3	2.4	2.5	2.5	2.5	2.0	-3.6
1000 veh/hr	0.0	0.2	0.5	0.3	0.3	0.9	1.2	0.9	1.2	0.9	0.9	1.0	1.0	1.0	0.7	-0.7
4000 veh/hr	0.0	0.1	0.2	0.1	0.1	0.3	0.4	0.3	0.4	0.3	0.3	0.3	0.3	0.3	0.2	-0.2
Onsite processing																
10 veh/hr	0.0	0.9	1.8	1.2	1.2	3.2	3.0	4.3	4.2	3.4	2.9	4.4	4.4	4.4	4.8	-7.7
100 veh/hr	0.0	0.7	1.5	0.9	0.9	2.7	2.5	3.7	3.6	2.9	2.5	3.8	3.8	3.8	4.2	-3.8
1000 veh/hr	0.0	0.2	0.5	0.3	0.3	1.1	1.0	1.6	1.5	1.2	0.9	1.7	1.7	1.7	1.9	-0.7
4000 veh/hr	0.0	0.1	0.2	0.1	0.1	0.4	0.3	0.6	0.5	0.4	0.3	0.6	0.6	0.6	0.7	-0.2
Foreign processing																
10 veh/hr	0.0	0.0	0.1	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	-1.0	-9.3	-9.3
100 veh/hr	0.0	0.0	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	-0.8	-4.1	-4.1
1000 veh/hr	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	-0.2	-0.8	-0.8
4000 veh/hr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.2	-0.2

INDEX

Subjects are indexed by section