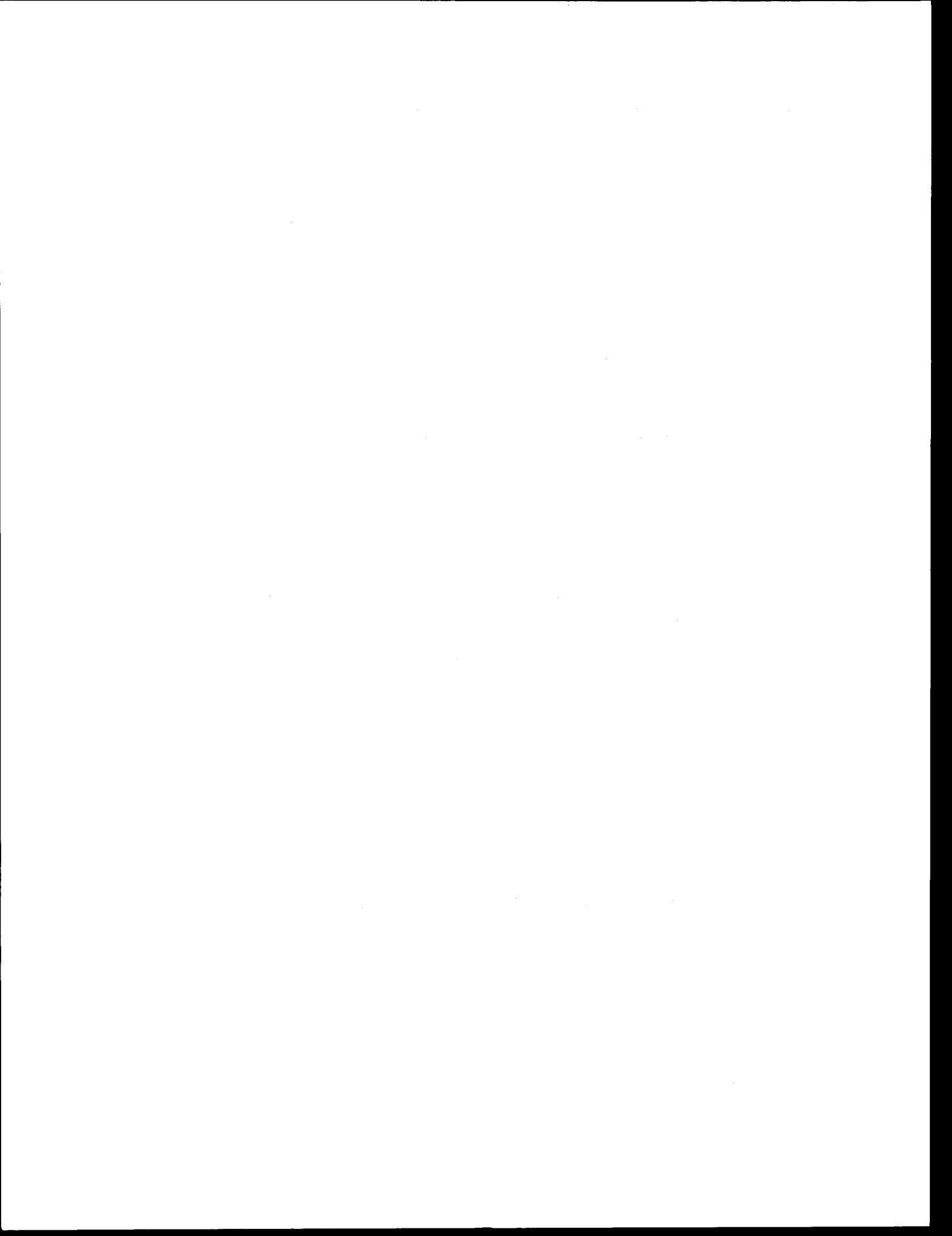


U.S. DEPARTMENT OF ENERGY
Office of New Production Reactors
Washington, DC 20585

**Draft
Environmental Impact Statement
for the Siting, Construction,
and Operation of
New Production Reactor Capacity**

**Volume 3: Sections 7-12
Appendices A-C**

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GENERAL PUBLIC AND NEWS MEDIA

One-hundred-and-nineteen copies of the DEIS were sent to individuals in or affected by the project in the regions of the alternative sites. Twenty-seven copies of the DEIS were sent to the news media (including newspapers and radio and television stations) in the regions of the alternative sites. A complete distribution list is available through the U.S. Department of Energy, Freedom of Information Room, Washington, DC 20585.

10 ACRONYMS, ABBREVIATIONS, AND UNITS OF MEASURE

AADT	annual average daily traffic
AAQS	Ambient Air Quality Standards
ACGIH	American Conference of Governmental Industrial Hygienists
ACHP	Advisory Council on Historic Preservation
AEC	Atomic Energy Commission
AIRFA	American Indian Religious Freedom Act
ALARA	as low as reasonably achievable
ALE	arid land ecology
ANL	Argonne National Laboratory
ANL-W	Argonne National Laboratory - West
ANSI	American National Standards Institute
AQCR	Air Quality Control Region
ARTS	Augusta Regional Transportation Study
BACT	best available control technology
BAT	best available technology
BEIR	biological effects of ionizing radiation (see glossary)
B.P.	before present
BPA	Bonneville Power Administration
°C	degrees Celsius
CAA	Clean Air Act
CCDF	complementary cumulative distribution function
CEDE	committed effective dose equivalent
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
C ₃ H ₆ O	acetone
Ci	curie (see glossary)
Ci/L	curies per liter
μCi/L	microcuries per liter
Ci/m ³	curies per cubic meter
μCi/mL	microcuries per milliliter
Ci/yr	curies per year
CNR	composite noise rating
cm	centimeters
CO	carbon monoxide
CO ₂	carbon dioxide
COE	Corps of Engineers
CP	construction permit
CSDT	California State Department of Transportation
CWA	Clean Water Act
d	day
D&D	decontamination and decommissioning
dB	decibel (see glossary)
dBA	decibel, A weighted (see glossary)
DBA	design-basis accident
DBE	design-basis earthquake
DECON	see glossary

DEIS	Draft Environmental Impact Statement
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOE-RL	Department of Energy, Richland Operations Office
DOE-SR	Department of Energy, Savannah River Operations Office
DOT	U.S. Department of Transportation
EAB	exclusion area boundary
EBR	Experimental Breeder Reactor
EDE	effective dose equivalent
EDNA	environmental designation for noise abatement
EEI	Edison Electrical Institute
EG&G	EG&G Idaho, Inc.
EIS	Environmental Impact Statement
ENM	Environmental Noise Model
ENTOMB	see glossary
EPA	U.S. Environmental Protection Agency
ERAB	Energy Research Advisory Board
ERDA	Energy Research and Development Administration
ERPG	Emergency Response Planning Guideline
°F	degrees fahrenheit
FEIS	Final Environmental Impact Statement
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FR	Federal Register
Freon-113	trichlorotrifluoroethane
ft	foot
FWS	U.S. Fish and Wildlife Service
FY	fiscal year
g	grams, gravity
µg/m ³	micrograms per cubic liter
gal	gallon
GAO	General Accounting Office
h	hour
ha	hectare
HEPA	high-efficiency particulate air filters
HLLW	high-level liquid waste
HLW	high-level waste
HMS	Hanford Meteorological Station
HNO ₃	nitric acid
hp	horsepower
HWPF	hazardous waste processing facility
HWR	heavy-water reactor
Hz	hertz
I	Interstate
IAEA	International Atomic Energy Agency
IAP	individual annoyance prediction
ICRP	International Commission on Radiation Protection
IDHW	Idaho Department of Health and Welfare
INEL	Idaho National Engineering Laboratory

ISCST	Industrial Source Complex Short Term Model
ISU	Idaho State University
kg	kilogram
kg/d	kilograms per day
kg/h	kilograms per hour
kg/km ²	kilograms per square kilometer
kJ/m ²	kilojoules per square meter
km	kilometer
km ²	square kilometer
kV	kilovolt
kW	kilowatt
kWe	kilowatt electric
kWh	kilowatt-hour
L/d	liters per day
L/s	liters per second
LANL	Los Alamos National Laboratory
lb	pound
L _{dn}	day-night-weighted equivalent sound level
L _{eq}	equivalent sound level (see glossary)
LLNL	Lawrence Livermore National Laboratory
LLW	low-level waste
LMR	liquid-metal reactor
LOCA	loss-of-coolant accident
LWR	light-water reactor
m	meter
m ³	cubic meter
m ³ /d	cubic meters per day
m ³ /h	cubic meters per hour
m ³ /s	cubic meters per second
m ³ /yr	cubic meters per year
MACCS	MELCOR Accident Consequence Code System
mg	microgram
mg/L	milligrams per liter
mg/m ³	milligrams per cubic meter
μmhos/cm	micromhos per centimeter
MHTGR	modular high-temperature gas-cooled reactor
mi	mile
min	minute
mm	millimeter
MMI	Modified Mercalli Intensity
mo	month
MPa	megapascals (million pascals)
mR/h	milliroentgens per hour
mrem	millirem
mrem/h	millirem/hour
MSL	mean sea level
MW	megawatt
MWe	megawatt electric
MWh	megawatt-hour
MWt	megawatt thermal

NAAQS	National Ambient Air Quality Standards
NAS	National Academy of Science
nCi/L	nanocuries per liter
NCRP	National Council on Radiation Protection and Measurements
NEPA	National Environmental Policy Act
NEIC	National Earthquake Information Center
NERC	North American Electric Reliability Council
NERPS	National Environmental Research Parks
NESHAP	National Emission Standards for Hazardous Air Pollutants
NH ₃	ammonia
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
NOC	Notice of Construction
NOI	Notice of Intent
NO ₂	nitric oxide
NO _x	nitrogen oxides
NP	Office of New Production Reactors (DOE)
NPDES	National Pollutant Discharge Elimination System
NPR	New Production Reactor
NRC	Nuclear Regulatory Commission
NRHP	National Register of Historic Places
NTS	Nevada Test Site
NUS	NUS Corporation
NWS	National Weather Service
O ₃	ozone
ORNL	Oak Ridge National Laboratory
OSHA	Occupational Health and Safety Administration
Pa	Pascal
PAG	Protective Action Guide
Pb	lead
PCB	polychlorinated biphenyls
pCi/L	picocuries per liter
PCS	primary coolant system
PEL	permissible exposure level
PL	Public Law
PLO	Public Land Order
PM	particulate matter
PM ₁₀	particulate matter with a diameter of less than or equal to 10 μm.
PNA	probabilistic noise audibility
PNL	Pacific Northwest Laboratory
ppb	parts per billion
ppm	parts per million
PRA	probabilistic risk assessment
PSD	Prevention of Significant Deterioration
PUREX	Plutonium-Uranium Extraction Plant
QA	quality assurance
rad	radiation dose absorbed
RCRA	Resource Conservation and Recovery Act
REDOX	Reduction Oxidation Plant
rem	roentgen equivalent man

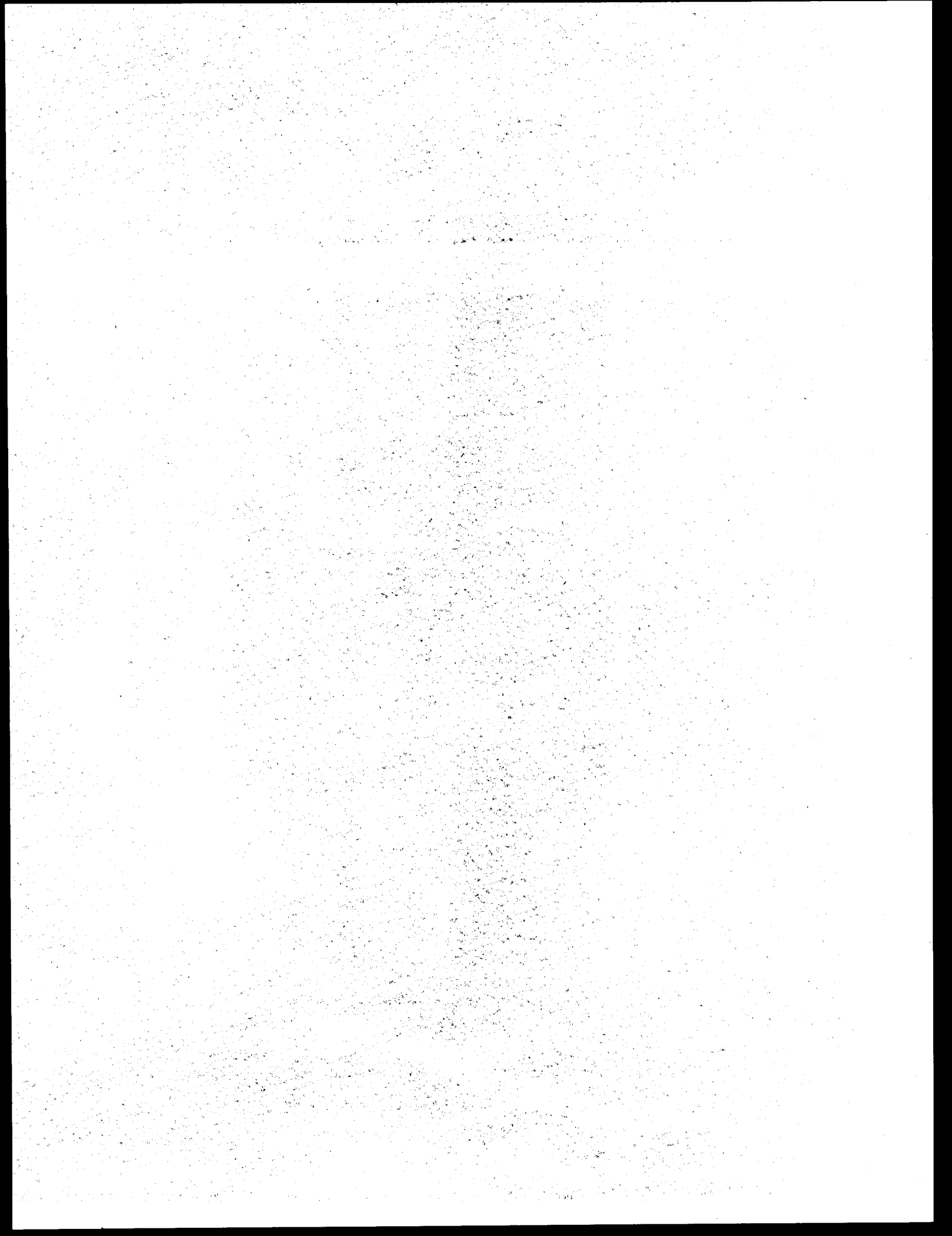
RFP	Rocky Flats Plant
RI/FS	reports of investigation/feasibility studies
ROD	Record of Decision
ROI	region of influence
s	second
SACTI	Seasonal/Annual Cooling Tower Impacts (computer code)
SAFSTOR	see glossary
SAIC	Science Applications International Corporation
SARA	Superfund Amendments and Reauthorization Act
SCDHEC	South Carolina Department of Health and Environmental Control
SCE&G	South Carolina Electric and Gas Company
SDWA	Safe Drinking Water Act
SIC	Standard Industrial Code
SET	Site Evaluation Team
sft ³	standard cubic feet
SHPO	State Historic Preservation Officer
SLAEM	Single Layer Analytical Element Model
SMSA	standard metropolitan statistical area
SNL	Sandia National Laboratories
SO ₂	sulfur dioxide
SPL	sound pressure level
SR	State Route
SRS	Savannah River Site
SSE	safe shutdown earthquake
t	metric ton
TCA	1, 1, 1-trichloroethane
TCE	trichloroethylene
TDS	total dissolved solids
TRU	transuranic, a classification of wastes
TSP	total suspended particulates
UO ₃	uranium oxide
USC	United States Code
USFWS	U.S. Fish and Wildlife Service
USGS	United States Geological Survey
VMT	vehicle miles traveled
VOC	volatile organic compounds
WAC	Washington Administrative Codes
WDOE	Washington Department of Ecology
WHC	Westinghouse Hanford Company
WIPP	Waste Isolation Pilot Plant
WINCO	Westinghouse Idaho Nuclear Company, Inc.
WNP-1	Washington Nuclear Plant No. 1
WNP-2	Washington Nuclear Plant No. 2
WPPSS	Washington Public Power Supply System
WSRC	Westinghouse Savannah River Company
yr	year

CONVERSION FACTORS

<u>To Convert From:</u>	<u>To:</u>	<u>Multiply By:</u>
cm (centimeters)	in. (inches)	0.3937
°C (degrees Celsius)	°F (degrees Fahrenheit)	$(^{\circ}\text{C} \times 9/5) + 32$
ha (hectares)	acres	2.471
kg (kilograms)	lb (pounds)	2.205
kg/km ² (kilograms per square kilometer)	lb/mi ² (pounds per square mile)	5.710
kg/s (kilograms per second)	lb/h (pounds per hour)	7.937
km (kilometers)	mi (miles)	0.6214
km ² (square kilometers)	mi ² (square miles)	0.3861
km ³ (cubic kilometers)	mi ³ (cubic miles)	0.2399
L (liters)	gal (gallons)	0.2642
L/s (liters per second)	gal/min (gallons per minute)	15.85
m (meters)	ft (feet)	3.281
m/s (meters per second)	mph (miles per hour)	2.237
m ² (square meters)	ft ² (square feet)	10.76
m ³ (cubic meters)	ft ³ (cubic feet)	35.31
m ³ (cubic meters)	gal (gallons)	264.2
m ³ (cubic meters)	yd ³ (cubic yards)	1.308
m ³ /s (cubic meters per second)	gal/min (gallons per minute)	15,850
µm (micrometers)	in. (inches)	0.00003937
Pa (pascals)	lb/ft ² (pounds per square foot)	47.88
Pa (pascals)	psi (pounds per square inch)	6,894
t (metric tons)	tons (short tons)	1.102

METRIC PREFIXES

<u>Prefix</u>	<u>Symbol</u>	<u>Multiplication Factor</u>
exa	E	1 000 000 000 000 000 000 = 10^{18}
peta	P	1 000 000 000 000 000 = 10^{15}
tera	T	1 000 000 000 000 = 10^{12}
giga	G	1 000 000 000 = 10^9
mega	M	1 000 000 = 10^6
kilo	k	1 000 = 10^3
hecto	h	100 = 10^2
deka	da	10 = 10^1
deci	d	0.1 = 10^{-1}
centi	c	0.01 = 10^{-2}
milli	m	0.001 = 10^{-3}
micro	μ	0.000 001 = 10^{-6}
nano	n	0.000 000 001 = 10^{-9}
pico	p	0.000 000 000 001 = 10^{-12}
femto	f	0.000 000 000 000 001 = 10^{-15}
atto	a	0.000 000 000 000 000 001 = 10^{-18}



11 GLOSSARY

Abnormal occurrence: Any accidental, unplanned, or uncontrolled release of radioactivity.

Absorption (radiation): The process by which the number and energy of particles or photons entering a body of matter are reduced by interaction with the matter.

Accidental air ingress (or ingress of secondary or other fluids): The inadvertent admission of air (or a fluid such as water, steam, or other nonprimary fluid) to the primary cooling system of a modular high-temperature gas-cooled reactor.

Adsorption: The adhesion of a substance to the surface of a solid.

Air quality: Levels of constituents in the outside air, often in comparison to regulatory standards.

Air quality control region: An interstate area designated by the U.S. Environmental Protection Agency as necessary or appropriate for the attainment and maintenance of national ambient air quality standards.

Air quality standards: The legally prescribed level of constituents in the outside air that cannot be exceeded during a specific time in a specified area.

Alkaline: Of, relating to, or containing an alkali, such as a carbonate or hydroxide of an alkali metal.

Alpha particle: A positively charged particle, consisting of two protons and two neutrons, that is emitted during radioactive decay from the nucleus of certain nuclides. It is the least penetrating of the three common types of radiation (alpha, beta, and gamma).

Ambient air: The surrounding atmosphere, usually the outside air, as it exists around people, plants, and structures. (It is not the air in immediate proximity to emission sources.)

Anadromous: Fish that migrate from salt to fresh water to spawn.

Anticipated operational occurrences: Those conditions of normal operation that are expected to occur one or more times during the life of a nuclear reactor.

Aquifer: A saturated geologic unit that can transmit significant quantities of water under ordinary hydraulic gradients; the water can be pumped to the surface through a well, or it can emerge naturally as a spring or outcrop.

Aquitard: A less-permeable geologic unit in a stratigraphic sequence. The unit is not permeable enough to transmit significant quantities of water. Aquitards separate aquifers.

Archaeological sites (resources): Areas or objects modified or made by humans, either prehistorically or historically, and the data associated with these areas and objects.

Artifact: An object produced or shaped by human workmanship of archaeological or historical interest.

As low as reasonably achievable (ALARA): A concept applied to the quantity of radioactivity released in routine operation of a nuclear system or facility, including "anticipated operational occurrences." It takes into account the state of technology, economics of improvements in relation to benefits to public health and safety, and other societal and economic considerations in relation to the use of nuclear energy in the public interest.

Atlatl: A tool used to throw a spear.

Atmospheric dispersion: The process of air pollutants being dispersed in the atmosphere by the wind that carries the pollutants away from their source and by turbulent air motion that results from solar heating of the earth's surface and air movement over rough terrain and surfaces.

Background radiation: Ionizing radiation present in the environment from cosmic rays and natural sources in the earth; background radiation varies considerably with location (see "natural radiation").

Baseline: A quantitative expression of conditions, costs, schedule, or technical progress to serve as a base or standard for measurement during the performance of an effort; the established plan against which the status of resources and the progress of a project can be measured. The environmental baseline is the site environmental conditions as they are projected to occur in 1995 (construction) and 2000 (operations).

Baseline tritium production: Tritium production in sufficient quantity to meet any future production requirements based on historical fluctuations and unspecified projections into the next century.

Basement rocks: The undifferentiated rocks, commonly igneous and metamorphic, that underlie the rocks of interest in a given area.

Basic component: A reactor structure, system, component, or part thereof that is necessary to ensure the (1) integrity of a reactor coolant or moderator pressure boundaries, (2) capability to shut down a reactor and maintain it in a safe shutdown condition, or (3) capability to prevent or mitigate the consequences of accidents that could result in a large release of radiation.

Benthic: Plants and animals dwelling at the bottom of oceans, lakes, rivers, and other surface waters.

BIER V: Biological Effects of Ionizing Radiation; referring to the fifth in a series of committee reports from the National Research Council (National Research Council 1990).

Beta particle: An elementary particle emitted from a nucleus during radioactive decay; it is negatively charged, identical to an electron, and easily stopped, as by a thin sheet of metal.

Biosphere: The portions of the earth and its atmosphere where living things exist.

Biota (biotic): The plant and animal life of a region (pertaining to biota).

Blanket assemblies: In a heavy-water reactor, lithium-aluminum alloy clad tubes positioned in a ring surrounding the radial reflector zone. They prevent neutron damage to the reactor vessel's metal wall by absorbing neutrons from the reflector zone, and they produce tritium.

Bounding accident: A postulated accident that is defined to encompass the range of anticipated accidents and used to evaluate the consequences of accidents at facilities for fuel and target fabrication and processing, waste management, and hazardous materials handling.

Cancer: The name given to a group of diseases characterized by uncontrolled cellular growth.

Capacity factor: Net energy produced (in megawatts) ÷ design power (in megawatts) × calendar year.

Cermet: An alloy of a heat-resistant ceramic compound and a metal.

Cladding: In a reactor, the material that covers each tubular fuel and target assembly.

Class 1E: The safety classification of the electric equipment and systems that are essential to emergency reactor shutdown, containment isolation, reactor core cooling and containment, and reactor heat removal or that are otherwise essential in preventing a significant release of radioactive material to the environment.

Class A facility: A facility engaged in administrative activities considered essential to the overall direction and continuity of the protection program; engaged in research and development, manufacture, production, assembly, or storage of nuclear weapons, weapon assemblies, or military reactors; engaged in major research and development in uranium enrichment or operation of major uranium enrichment facilities; involved in research and development, manufacture, production, or assembly of nonnuclear weapon components, assemblies, and parts essential to the weapons or military reactor programs; or receiving, handling, or storing Top Secret documents (exclusive of keying material for secure communications) over an extended period. Or, a facility that possesses specified quantities of special nuclear material.

Cold standby: Maintenance of a protected reactor condition in which the fuel is removed, the moderator is stored in tanks, and equipment and system layup is performed to prevent deterioration, such that future refueling and restart are possible.

Collective CEDE: The committed effective dose equivalent (CEDE) of radiation for a population.

Community (biotic): All plant and animal populations occupying a specific area under relatively similar conditions.

Complex: A collection of facilities dedicated to the same set of activities.

Complementary cumulative distribution function (CCDF): The CCDF is used to provide information on the frequency of consequence magnitudes exceeding a specific value.

Concentration cycles: The multiplicative factor by which the dissolved solids in cooling water are allowed to concentrate due to evaporation of the water.

Conceptual design: Efforts to develop a project scope that will satisfy program needs; ensure project feasibility and attainable performance levels of the project for congressional consideration and develop project criteria and design parameters for all engineering disciplines; and identify applicable codes and standards, quality assurance requirements, environmental studies, construction materials, space allowances, energy conservation features, health, safety, safeguards, and security requirements and any other features or requirements necessary to describe the project.

Confined aquifer: A permeable geological unit with the following properties: a water-filled pore space (saturated), the capability to transmit significant quantities of water under ordinary differences in pressure, and an upper water boundary that is at a pressure higher than atmospheric pressure.

Configuration: The functional or physical characteristics of hardware or software, as set forth in technical documentation and achieved in a project.

Configuration management: The systematic evaluation, coordination, approval (or disapproval), documentation, implementation, and audit of all approved changes in the configuration of a product after formal identification of its configuration.

Consumptive water use: The difference in the volume of water withdrawn from a body of water and the amount released back into the body of water. Water that is not returned to the body of water can enter the atmosphere through evaporation.

Containment design basis: For a nuclear reactor, those bounding conditions for the design of the containment, including temperature, pressure, and leakage rate. Because the containment is provided as an additional barrier to mitigate the consequences of accidents involving the release of radioactive materials, the containment design basis may include an additional specified margin above those conditions expected to result from the plant design-basis accidents to ensure the containment design can mitigate unlikely or unforeseen events.

Control rods: The elements of a nuclear reactor that absorb slow neutrons and are used to increase, decrease, or maintain the neutron density in the reactor.

Coolant: A substance, either gas or water, circulated through a nuclear reactor or processing plant to remove heat.

Core damage: Damage to a reactor core that would result in exceeding core safety limits.

Credible accident: An accident that has a probability of occurrence greater than or equal to 10^{-6} /yr.

Criteria pollutants: Substances for which national ambient air quality standards are established.

Critical mass: The smallest mass of fissionable material that will support a self-sustaining nuclear chain reaction under specified conditions.

Cultural resources: Areas or objects that are of cultural significance to Native Americans and other defined ethnic groups.

Cumulative impact of effects: An impact on the environment that results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what organization or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

Curie (Ci): A unit of radioactivity equal to 37 billion disintegrations per second; also a quantity of any nuclide or mixture of nuclides having 1 Ci of radioactivity.

Cycles of concentration: The average concentration of dissolved solids in cooling water due to the evaporative process in a cooling tower.

Decibel (dB): A unit for describing the ratio of two powers or intensities, or the ratio of a power to a reference power. In the measurement of sound intensity (noise), the pressure of the reference sound is usually taken as 2×10^{-4} dynes/cm², equal to 0.1 bel or 1 dB.

Decibel, A-weighted: A unit of weighted sound pressure level, measured by the use of a metering characteristic and the "A" weighting specified in American National Standard ANSI S1.4-1971(R176), "Specification for Sound Level Meters."

Decommissioning: Removing facilities contaminated with radiation (such as processing plants, waste tanks, and burial grounds) from service and reducing or stabilizing radioactive contamination. Decommissioning includes the following concepts: (1) decontamination, dismantling, and return of an area to its original condition without restrictions on use or occupancy and (2) partial decontamination, isolation of remaining residues, and continued surveillance and restrictions on use or occupancy.

DECON: Equipment, structures, and portions of a facility and site containing radioactive contaminants are removed or decontaminated to

a level that permits the facility to be released for unrestricted use shortly after cessation of operations.

Decontamination: The removal of radioactive contamination from facilities, equipment, or soils by washing, heating, chemical or electrochemical action, mechanical cleaning, or other techniques.

Deflagration: Rapid oxidation and burning with intense heat.

Depleted uranium: Uranium whose content of the isotope U-235 is less than 0.7%, which is the U-235 content of natural uranium.

Design basis: For nuclear facilities, information that identifies the specific functions to be performed by a structure, system, or component and the specific values (or ranges of values) chosen for controlling parameters for reference bounds for design. These values may be (1) restraints derived from generally accepted state-of-the-art practices for achieving functional goals, (2) requirements derived from analysis (based on calculation and/or experiments) of the effects of a postulated accident for which a structure, system, or component must meet its functional goals, or (3) requirements derived from federal safety objectives, principles, goals, or requirements.

Design-basis accident (DBA): For nuclear facilities, a postulated abnormal event that is used to establish the performance requirements of structures, systems, and components that are necessary to (1) maintain them in a safe shutdown condition indefinitely or (2) prevent or mitigate the consequences of the DBA so that the general public and operating staff are not exposed to radiation in excess of appropriate guideline values.

Design-basis depressurization accidents: Postulated accidents in a modular high-temperature gas-cooled reactor in which a rapid reduction in primary coolant pressure occurs as a result of egress of a portion of the primary coolant system inventory from a breach of the primary coolant system boundary up to the maximum credible flow area.

Design power: The thermal power rating of a tritium-production reactor that, when combined

with the anticipated capacity factor, will produce the goal tritium requirement.

Deuterium (D): A nonradioactive isotope of the element hydrogen with one neutron and one proton in the atomic nucleus.

Dewatering: Pumping water from the soil to ensure proper soil characteristics for construction of facilities. May also be required during operation if the water table impinges foundations.

Direct economic effects: The initial increases in output from different sectors of the economy resulting from some new activity within a predefined geographic region.

Diurnal: Pertaining to animals active during the day.

DOE Office of New Production Reactors: An organization within the Department of Energy, reporting directly to the Secretary, that implements the Department's strategy to provide new production reactor capacity on an urgent schedule for an ensured supply of nuclear materials, primarily tritium, to maintain the nation's nuclear deterrent capability.

Dose: The energy imparted to matter by ionizing radiation. The unit of absorbed dose is the rad, which is equal to 100 ergs per gram of irradiated material in any medium.

Dose equivalent: The product of the absorbed dose from ionizing radiation and such factors that account for differences in biological effectiveness due to the type of radiation and its distribution in the body, measured in rem.

Ecosystem: A complex of the community of living things and the environment forming a functioning whole in nature.

Effective dose equivalent: The radiation dose to the whole body that would have the same biological effect as a given dose equivalent to a particular organ or tissue.

Effective porosity: Interconnected pore volumes that permit the flow of water in a porous medium.

Effluent: A gas or fluid discharged into the environment.

Emergency condition: For a nuclear facility, occurrences or accidents that might occur infrequently during start-up testing or operation of the facility. The equipment, components, and structures might be deformed by these conditions to the extent that repair is required prior to reuse.

Emission standards: Legally enforceable limits on the quantities and/or kinds of air contaminants that can be emitted into the atmosphere.

Endangered species: Species of plants and animals that are threatened with either extinction or serious depletion in an area and that are formally listed by the U.S. Fish and Wildlife Service.

Energy conversion area: A facility that produces electricity from steam generated by reactor heat.

Engineered safety features: For a nuclear facility, features that prevent, limit, or mitigate the release of radioactive material from its primary containment.

Entrainment: The involuntary capture and inclusion of organisms in streams of flowing water. Term often applied to the cooling water systems of power plants/reactors. The organisms involved depend on the intake screen mesh size; they may include phyto- and zooplankton, fish eggs and larvae (ichthyoplankton), shellfish larvae, and other forms of aquatic life.

ENTOMB: Radioactive contaminants are encased (entombed) in a structurally sound and long-lived material (such as concrete), which is maintained and monitored until the radioactivity decays to levels permitting release of the facility for unrestricted use.

Environment, safety, and health program: In the context of the U.S. Department of Energy (DOE), encompasses those DOE requirements, activities, and functions in the conduct of all DOE and DOE-controlled operations that are concerned with impacts to the biosphere; compliance with environmental laws,

regulations, and standards controlling air, water, and soil pollution; limiting the risks to the well being of both operating personnel and the general public to acceptably low levels; and protecting property adequately against accidental loss and damage. Typical activities and functions related to this program include, but are not limited to, environmental protection, occupational safety, fire protection, industrial hygiene, health physics, occupational medicine, process and facilities safety, nuclear safety, emergency preparedness, quality assurance, and radioactive and hazardous waste management.

Environmental audit: A documented assessment of a facility to monitor the progress of necessary corrective actions, to ensure compliance with environmental laws and regulations and to evaluate field organization practices and procedures.

Environmental survey: A documented, multidisciplinary assessment (with sampling and analysis) of a facility to determine environmental conditions and to identify environmental problems requiring corrective action.

Ephemeral stream: A stream whose flow is intermittent.

Estuary: A confined body of water where freshwater flows mix with seawater due to tidal action.

Ethnography: A branch of anthropology dealing with the study of human culture.

Equivalent sound (pressure) level (L_{eq}): The equivalent steady sound level that, if continuous during a specified time period, would contain the same total energy as the actual time-varying sound. For example, L_{eq} (1-h) and L_{eq} (24-h) are the 1-hour and 24-hour equivalent sound level, respectively.

Evapotranspiration: The combined processes by which water is transferred from the earth's surface to the atmosphere; evaporation of liquid or solid water plus transpiration from plants.

Facility: Equipment, systems, buildings, utilities, services, and related activities whose use is directed to a common purpose at a single location.

Faulted condition: Occurrences or accidents that are not expected to occur during the start-up testing or operation of nuclear facilities, but that are postulated because of their consequences and because they represent upper bounds on failures or accidents with a probability of occurrence sufficiently high to require a consideration in design. The equipment, components, and structures might be grossly deformed by these conditions without a loss of their nuclear safety function. It is likely that damage would be extensive enough that repair would be required prior to reuse.

Fission: The splitting of a heavy atomic nucleus into two nuclei of lighter elements, accompanied by the release of energy and generally one or more neutrons. Fission can occur spontaneously or be induced by neutron bombardment.

Floodplain: The portion of a river valley that becomes covered with water when the river overflows its banks at flood stage.

Fluvial: Found or produced in a river.

Food chain: The pathways by which any material entering the environment passes from the first absorbing organism through plants and animals to humans.

Fuel-fabrication facility: The land, buildings, equipment, and processes used to make reactor fuel from raw material. This facility may also be used to assemble the fuel with other materials into components for use in reactors.

Fuel-processing facility: The land, buildings, equipment, and processes used to extract uranium and other materials from used (spent) reactor fuel. This facility may also be used to treat materials that can not be recycled for transfer to waste treatment, storage, or disposal facilities.

Fugitive emissions: Emissions to the atmosphere from pumps, valves, flanges, seals, and other process points not vented through a stack. Also includes emissions from area sources such as ponds, lagoons, landfills, and piles of stored material.

Gamma rays: High-energy, short-wavelength, electromagnetic radiation accompanying fission and emitted from the nucleus of an atom. Gamma rays are very penetrating and can be stopped only by dense materials (such as lead) or a thick layer of shielding materials.

Geology: The science that deals with the earth: the materials, processes, environments, and history of the planet, especially the lithosphere, including the rocks and their formation and structure.

Getter: A material capable of capturing gases. In an NPR light-water reactor, a material incorporated into the tritium target to prevent buildup of pressure in the target and prevent loss of tritium.

Glaze (glaze ice, glazed frost, verglas): A coating of ice, generally clear and smooth but usually containing some air pockets, formed on exposed objects by the freezing of a film of supercooled water deposited by rain, drizzle, or fog or possibly condensed from supercooled water vapor.

Gloveboxes: Chambers designed for operators to work with radioactive materials through ports, wearing special gloves that protect them from radioactivity.

Groundwater: The supply of water under the earth's surface in aquifers.

Habitat: The place or type of site where a plant or animal normally lives or grows.

Hazardous waste: Any solid, semisolid, liquid, or gaseous waste that is ignitable, corrosive, toxic, or reactive as defined by the Resource Conservation and Recovery Act and identified or listed in 40 CFR 261.

Headend: That portion of a reactor-fuel or plutonium-target processing system in which the initial preparation, up to and including dissolution, is conducted.

Headend fuel-processing facility: The part of a reactor fuel-processing facility used for the first stage of fuel processing in which fuel is mechanically and/or chemically treated prior to uranium extraction for recovery purposes. The

headend facility may be separate from, but adjacent to, the rest of the fuel processing facility.

Headend plutonium-target processing facility: The part of a plutonium-target processing facility used for the first stage of target processing, in which targets are mechanically and/or chemically treated prior to plutonium extraction for recovery purposes. The headend facility may be separate from, but adjacent to, the rest of the plutonium-target processing facility.

Heavy-water (D₂O): A form of water (a molecule with two hydrogen atoms and one oxygen atom) in which the hydrogen atoms consist largely or completely of the deuterium isotope. Heavy water has almost identical chemical properties, but quite different nuclear properties, as light water (common water).

Heavy-water reactor (HWR): A nuclear reactor in which circulating heavy water is used to cool the reactor core and to moderate (reduce the energy of) the neutrons created in the core by the fission reactions.

Herpetofauna: Reptiles and amphibians.

High-level waste: The highly radioactive waste material that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid waste derived from the liquid. High-level waste contains a combination of transuranic waste and fission products in concentrations requiring permanent isolation.

Historic resources: The sites, districts, structures, and objects considered limited and nonrenewable because of their association with historic events, persons, or social or historic movements.

Hydraulic conductivity: The constant of proportionality in Darcy's Law of fluid flow that describes the ease with which a porous medium permits fluids to flow and the ease with which the fluid flows given its physical properties.

Hydrology: The science dealing with the properties, distribution, and circulation of natural water systems.

Idaho Fuel Processing Facility: A fuel processing facility currently under construction at the Idaho Chemical Processing Plant, a multipurpose complex at the Idaho National Engineering Laboratory.

Immersion dose: Dose resulting from being surrounded by a medium (air or water) that contains radionuclides.

Impingement: The process by which aquatic organisms too large to pass through the screens of a water intake system become caught on the screens and are unable to escape.

Indirect economic effects: Indirect effects result from the need to supply industries experiencing direct economic effects with additional outputs to allow them to increase their production. The additional output from each directly affected industry requires inputs from other industries within a region (that is, purchases of goods and services). This results in a multiplier effect to show the change in total economic activity resulting from a new activity in a region.

Induced economic effects: The spending of households resulting from direct and indirect economic effects. Increases in output from a new economic activity lead to an increase in household spending throughout the economy as firms increase their labor inputs.

Internals: Any structure or component within a reactor vessel that is not part of the reactor core.

Invertebrate: Animals lacking a backbone or spinal column.

Ion exchange: A unit physiochemical process that removes anions and cations, including radionuclides, from liquid streams (usually water) for the purpose of purification or decontamination.

Ionizing radiation: Radiation that can displace electrons from atoms or molecules, thereby producing ions.

Isotope: An atom of a chemical element with a specific atomic number and atomic mass. Isotopes of the same element have the same number of protons but different numbers of neutrons and different atomic masses.

Lacustrine: Found or formed in lakes.

Large release: A release of radioactive material that would result in doses greater than 25 rem to the whole body or 300 rem to the thyroid at 1.6 km from the control perimeter (security fence) of a reactor facility.

Light water: The common form of water (a molecule with two hydrogen atoms and one oxygen atom) in which the hydrogen atom consist largely or completely of the normal hydrogen isotope (one proton and one neutron).

Light-water reactor: A nuclear reactor in which circulating light water is used to cool the reactor core and to moderate (reduce the energy of) the neutrons created in the core by the fission reactions.

Liquid-metal reactor: A nuclear reactor in which liquid metal, usually sodium or sodium potassium, is used to cool the reactor core.

Lithic: Pertaining to stone or a stone tool.

Lithologic: Structure and composition of a rock.

Long-lead-time procurement items: Equipment and/or construction materials that must be ordered before the estimated start of construction to ensure their availability at the time needed.

Loss-of-coolant accidents: A postulated accident that results from the loss of reactor coolant (at a rate that exceeds the capability of the reactor coolant makeup system) from breaks in the reactor coolant pressure boundary, up to and including a break equivalent in size to the double-ended rupture of the largest pipe of the reactor coolant system.

Low-level waste: Waste that contains radioactivity but is not classified as high-level waste, transuranic waste, spent nuclear fuel, or "11e(2) by-product material" as defined by DOE Order 5820.2A. Test specimens of fissionable material irradiated for research and development only, and not for the production of power or plutonium, may be classified as low-level waste, provided the concentration of transuranic waste is less than 100 nCi/g.

Mandatory standards: Standards adopted by the U.S. Department of Energy (DOE) that define the minimum requirements that DOE and its contractors must comply with. Standards may be classified as mandatory because of applicable federal or state statutes or implementing requirements, or as a matter of DOE policy.

Marsh: An area of low-lying wetland, dominated by grasslike plants.

Megawatt (MW): A unit of power equal to or 1 million watts. Megawatt thermal (MWt) is commonly used to define heat produced, while megawatt electric (MWe) defines electricity produced.

Milestone: An important or critical event that must occur in a project cycle in order to achieve the project objectives. It must be clearly defined and easily measurable, leaving no doubt as to when it is achieved.

Mill: A monetary unit equal to one-tenth of a cent.

Mixed waste: Waste that is both "hazardous waste" and "radioactive waste" as defined in this glossary.

Mixing layer (or height or depth): The layer above the surface through which relatively vigorous vertical mixing occurs.

Modular high-temperature gas-cooled reactor (MHTGR): A relatively small nuclear reactor of standardized design in which graphite (a compound of electrical carbon) is used to moderate (reduce the energy of) the neutrons created in the core by fission reactions and a gas (helium) is used to cool the reactor core. The MHTGR concept proposed for the NPR consists of a complex of eight separate reactor modules, each with its own core, vessel, cooling system, and containment structure.

National ambient air quality standards (NAAQS): Air quality standards established by the Clean Air Act. The primary NAAQS are intended to protect the public health with an adequate margin of safety, and the secondary NAAQS are intended to protect the public welfare from any known or anticipated adverse effects of a pollutant.

National environmental research parks: Outdoor laboratories set aside for ecological research to study the environmental impacts of energy developments and for informing the public of environmental and land use options. The parks were established under the Department of Energy to provide protected land areas for research and education in the environmental sciences and to demonstrate the environmental compatibility of energy technology development and use.

National Register of Historic Places: A list maintained by the National Park Service of architectural, historic, archaeological, and cultural sites of local, state, or national significance.

Natural radiation: Radiation from sources beyond the earth (cosmic radiation) and naturally occurring radiation in rocks, soils, plants, and animals.

Nonattainment area: An air quality control region (or portion thereof) in which the U.S. Environmental Protection Agency has determined that ambient air concentrations exceed national ambient air quality standards for one or more criteria pollutants.

Normal operation: The range of full-power operating conditions that can be achieved when seasonal variations in ambient conditions are taken into account.

NPR site: The primary location for the NPR at each alternative DOE-owned site (Hanford, INEL, and SRS).

Nuclear criticality: A self-sustaining nuclear chain reaction.

Nuclear criticality safety: The prevention or termination of inadvertent nuclear criticality, mitigation of consequences, and protection against injury or damage due to accidental nuclear criticality.

Nuclear facility: A facility whose operations involve radioactive materials in such form and quantity that a significant nuclear hazard potentially exists to the employees or the general public. Included are facilities that (1) produce, process, or store radioactive liquid or solid

waste, fissionable materials, or tritium; (2) conduct separations operations; (3) conduct irradiated materials inspection, fuel fabrication, decontamination, or recovery operations; or (4) conduct fuel enrichment operations. Incidental use of radioactive materials in a facility operation (e.g., check sources, radioactive sources, and X-ray machines) does not necessarily require a facility to be included in this definition.

Nuclear grade: Material of a quality adequate for use in a nuclear application.

Nuclear island: A nuclear island consists of a set of four reactor modules, their support buildings, and operation center.

Nuclear material: Composite term applied to (1) special nuclear material, (2) source material such as uranium or thorium or ores containing uranium or thorium, and (3) by-product material, which is any radioactive material that is made radioactive by exposure to the radiation incident to the process of producing or using special nuclear material.

Nuclide: An atomic nucleus specified by its atomic weight, atomic number, and energy state.

Operable: For a nuclear facility, a situation wherein a reactor and fuel/target cycle facilities are being operated or have the potential for being operated. A reactor and fuel/target cycle facility that cannot be operated on a day-to-day basis because of refueling, extensive modifications, or technical problems is still considered operable.

Operable unit: Defined in 40 CFR 300.6 as "a discrete part of an entire response that decreases a release, threat of release, or pathway of exposure."

Operational readiness review: A structured method for determining that a project, process, or facility is ready to operate or occupy. It includes, as a minimum, a review of the readiness of the plant and hardware, personnel, and procedures. The review includes a determination of compliance with applicable environmental, health, and safety requirements.

Orographic: Pertaining to the physical geography of mountains or mountain ranges.

Other nuclear material: See Figure I-1 of DOE Order 5633.3. This figure defines "other nuclear materials," which include tritium, deuterium, lithium-6, and neptunium-237.

Paleontology: The study of fossils.

Periphyton: Organisms attached to underwater surfaces.

Person-rem: The unit of collective radiation dose commitment to a given population; the sum of the individual doses received by a population segment.

Playa: Level area at the bottom of a desert basin that at times is temporarily covered with water; a dry lake bed.

Pleistocene: Geologic epoch beginning approximately 3 to 5 million years ago.

Pliocene: Geologic period between the Miocene and the Pleistocene periods.

Plutonium: A transuranic, heavy, silvery metal with 15 isotopes that is produced by the neutron irradiation of natural uranium. The isotope plutonium-239 is the most important isotope, used both in nuclear weapons and commercial nuclear power applications.

Plutonium-target processing facility: The land, buildings, equipment, and processes used to extract plutonium from plutonium targets after they have been irradiated in a reactor and to purify the plutonium. The facility may also be used to treat the remaining uranium for recycling and to treat other remaining materials for transfer to waste treatment, storage, or disposal facilities.

Point design: A design for the NPR that comprises a collection of design and component information representing a concept without the benefit of integration criteria, supporting analyses, and optimization studies: design that represents a "point" on the performance curve.

Potentiometric surface: Contoured water-level elevations for wells completed in an unconfined aquifer.

Primary coolant system boundary: In a modular high-temperature gas-cooled reactor, those systems and components that contain the primary coolant. The primary coolant system boundary includes the reactor vessel, circulators, steam generators, heat exchangers, associated primary coolant system piping and valves, and any other system that connects with the primary coolant system to the second isolation valve.

Probable maximum flood: Maximum flood predicted for a scenario having hydrological conditions that maximize the flow of surface waters.

Pyrolysis: Chemical change caused by heat.

Quality assurance plan: A document that contains or references the quality assurance elements established for an activity, group of activities, scientific investigation, or a project, and describes how conformance with such requirements is to be assured for structures, systems, computer software, components, and their operation commensurate with (1) the scope, complexity, duration, and importance to satisfactory performance; (2) the potential impact on environment, safety, and health; and (3) requirements for reliability and continuity of operations.

Radiation absorbed dose (rad): The basic unit of absorbed dose equal to the absorption of 0.01 joule per kilogram of absorbing material.

Radioactive waste: Materials from nuclear operations that are radioactive or are contaminated with radioactive materials, and for which use, reuse, or recovery are impractical.

Radioactivity: The spontaneous decay or disintegration of unstable atomic nuclei, accompanied by the emission of radiation.

Radiograph: Images made on film by ionizing radiation.

Radionuclide: A radioactive nuclide.

Reactor coolant pressure boundary: In a heavy-water reactor, those systems and components that contain the reactor coolant. The pressure boundary includes the reactor vessel, pressure tubes, inlet and effluent plenums, pressurizer, reactor coolant pumps, heat exchanger tubes and plenums, associated reactor coolant system piping and valves, and any other system that connects with the reactor coolant system up to the second isolation valve. The moderator and control rod coolant system are considered part of the reactor coolant boundary.

Reactor core: (1) In a heavy-water reactor: the fuel assemblies, including the fuel and target tubes, control assemblies, blanket assemblies, safety rods, and coolant/moderator. (2) In a light-water reactor: the fuel assemblies, including the fuel and target rods, control rods, and coolant/moderator. (3) In a modular high-temperature gas-cooled reactor: the graphite elements, including the fuel and target elements, control rods, any other reactor shutdown mechanisms, and the graphite reflectors.

Reactor facility: Unless it is modified by words such as containment, vessel, or core, the term reactor facility includes the housing, equipment, and associated areas devoted to the operation and maintenance of one or more reactor cores. Any apparatus that is designed or used to sustain nuclear chain reactions in a controlled manner, including critical and pulsed assemblies and research, test, and power reactors, is defined as a reactor. All assemblies designed to perform subcritical experiments that could potentially reach criticality are also to be considered reactors. Critical assemblies are special nuclear devices designed and used to sustain nuclear reactions. Critical assemblies may be subject to frequent changes in core and lattice configuration, and they may be used frequently as mockups of reactor configurations. Therefore, requirements for modifications do not apply unless the overall assembly room is modified, a new assembly room is proposed, or a new configuration is not covered in previous safety evaluations.

Reactor operations: All activities involved in operating and using a reactor, beginning with the initial loading of fuel in the reactor vessel and ending with the removal of fuel to officially

decommission the reactor or place it in a standby status.

Reactor year: A unit of time by which accident frequency and core damage frequency are measured; it assumes that more than one reactor can operate during the year (a calendar year during which three reactors operated would be the experience equivalent of 3 reactor years) and it assumes that a reactor might not operate continuously for the entire year (a reactor operating only 60% of the calendar year would be the equivalent of 0.6 reactor year).

Recharge: Replenishment of water to an aquifer.

Reference standards: Guides or standards that DOE and its contractors should consider for guidance, as applicable, in addition to mandatory standards.

rem: The unit of radiation dose for biological absorption: equal to the product of the absorbed dose in rads, a quality factor, and distribution factor.

Residual noise level: The residual level represents a low-level limit value to which the ambient environmental noise level frequently drops, but below which it seldom goes.

Reverse-well injection: Process in which solutes are injected into an underlying geologic formation through wells.

Rime: A white, opaque granular deposit of ice formed by the rapid freezing of supercooled water drops as they impinge on an exposed object.

Riprap: A loose assemblage of stones used in water or soft ground as a foundation.

Risk: A quantitative or qualitative expression of possible loss that considers both the probability that a hazard will cause harm and the consequences of that event.

Safe-shutdown earthquake: In the context of a nuclear reactor, as defined by 10 CFR 100, Appendix A: That earthquake which is based upon an evaluation of the maximum earthquake potential considering the regional and local geology and seismology and specific

characteristics of local subsurface material. It is that earthquake which produces the maximum vibratory ground motion for which certain structures, systems, and components are designed to remain functional. These structures, systems and components are those necessary to assure (1) the integrity of the reactor coolant pressure boundary, (2) the capability to shut down the reactor and maintain it in a safe shutdown condition, or (3) the capability to prevent or mitigate the consequences of accidents that could result in potential off-site exposures comparable to the guideline procedures.

Safety analysis report: A safety document providing a concise but complete description and safety evaluation of a site, design, normal and emergency operation, potential accidents, predicted consequences of such accidents, and the means proposed to prevent such accidents or mitigate their consequences. A safety analysis report is designated as final when it is based on final design information. Otherwise, it is designated as preliminary.

Safety Class 1: One of three levels assigned to components, systems, or structures that must be designed to provide certain functions to protect operators, the public, or the environment. This class is concerned with function and/or structural integrity for the mitigation of severe events, including design-basis accidents.

Safety document: A document prepared specifically to ensure that the safety aspects of part or all of the activities conducted at a reactor are formally and thoroughly analyzed, evaluated, and recorded (for example, technical specifications, safety analysis reports and addenda, and documented reports of special safety reviews and studies).

Safety-grade (or safety-related): Describes those structures, systems, and components (SSCs) that are necessary to (1) ensure the integrity of a reactor coolant pressure boundary, (2) shut down a reactor and maintain it in a safe shutdown condition indefinitely, or (3) prevent or mitigate the consequences of a design-basis accident so that the general public and the operating staff are not exposed to radiation in excess of appropriate guideline values. Safety-grade SSCs are designed, built, tested, operated, and

maintained in accordance with the highest-level industrial codes and standards, such as those promulgated by the American Society of Mechanical Engineers (ASME) and the Institute of Electrical and Electronics Engineers. SSCs that are not necessary for the above safety-related functions, but for which certain failure modes could adversely affect SSCs performing those functions, are designated safety-grade with respect to such failure modes. Safety-grade SSCs are subject to the quality assurance requirements of ANSI/ASME NQA-1 (Quality Assurance Program Requirements for Nuclear Facilities).

SAFSTOR: Describes a nuclear facility that is placed and maintained in a condition that allows the nuclear facility to be safely stored and subsequently decontaminated. The SAFSTOR option may include the following phases: chemical decontamination, mechanical decontamination and fixing of residual radioactivity, equipment deactivation, preparation for interim care, interim care (surveillance and maintenance), and final dismantlement.

Scope: In a document prepared pursuant to the National Environmental Policy Act, the range of actions, alternatives, and impacts to be considered.

Seismic: Pertaining to any earth vibration, especially an earthquake.

Severe accident: An accident with a frequency rate of less than 10^{-6} /yr that would have more severe consequences than a design-basis accident, in terms of damage to the facility, off-site consequences, or both.

Shutdown: For a Department of Energy reactor, that condition in which the reactor has ceased operation and the Department has declared officially that it does not intend to operate it further (see DOE Order 5480.6).

Single failure: An occurrence that results in the loss of a component's capability to perform its intended safety functions. Multiple failures resulting from a single occurrence are considered to be a single failure. Fluid and electric systems are considered to be designed against an assumed single failure if neither (1) a single failure of any active component (assuming that

the passive components function properly) nor (2) a single failure of any passive component (assuming that the active components function properly) results in a loss of the system's capability to perform its safety functions.

Sintering: Fusing materials by heating them to high temperatures.

Societal risk: The aggregated risks to all members of a population located within a specified radius around a potential hazard.

Source term: The estimated quantities of radionuclides released to the environment.

Special nuclear material: As defined in Section 11 of the Atomic Energy Act of 1954, special nuclear material means (1) plutonium, uranium enriched in the isotope 233 or in the isotope 235, and any other material which the Nuclear Regulatory Commission determines to be special nuclear material or (2) any material artificially enriched by any of the foregoing.

Stability (of the atmosphere): The atmosphere's tendency to resist or enhance vertical motion or, alternatively, to suppress or augment existing turbulence. Stability is related to both wind shear and temperature in the vertical, but generally the latter is used as an indicator of the condition.

Stack: A vertical pipe or flue designed to exhaust gases and suspended particulates.

Standby: That condition in which a reactor facility is neither operable nor declared excess and in which documentary authorization exists to maintain the reactor for possible future operation (see DOE Order 5480.6).

Standard: A specified set of rules or conditions.

Station blackout: The complete loss of off-site and on-site AC electric power, except for that generated by inverters fed by batteries.

Steppe: An area of grass-covered and generally treeless plains, with a semiarid climate.

Steppe climate (semiarid climate): The type of climate in which precipitation is very slight but sufficient for the growth of short, sparse grass.

Storativity: The volume of water that an aquifer releases from or takes into storage per unit surface area of aquifer per unit change in the component of head (fluid pressure plus elevation) normal to the surface.

Support facilities: In the context of the new production reactor, all the existing, modified, or new facilities needed to support the production of tritium and/or plutonium, except for the reactor facility. Support facilities include fuel and target fabrication facilities; fuel and target processing facilities; waste management facilities; and facilities providing necessary resources such as power, steam, and water.

Surface water: Water on the earth's surface, as distinguished from water in the ground (groundwater).

System: A collection of interdependent equipment and procedures assembled and integrated to perform a well-defined purpose. It is an assembly of procedures, processes, methods, routines, or techniques united by some form of regulated interaction to form an organized whole.

Technical baseline: A configuration identification document (or documents) formally designated and approved at a specific time. Technical baselines, plus approved changes to those baselines, constitute the current configuration identification. The NPR technical baseline is set forth in the Requirements Document.

Technical safety appraisal: A documented, multidiscipline appraisal of selected Department of Energy reactors and nuclear facilities conducted by a team selected by DOE's Deputy Assistant Secretary for Safety, Health, and Quality Assurance. It ensures proper application of particular safety elements of the DOE environment, safety, and health program, nuclear industry lessons learned, and appropriate licensed facility requirements as described in DOE 5482.1B, paragraph 9b.

Threatened species: Any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

Threshold limit values: The recommended concentrations of airborne contaminants to which workers may be exposed according to the American Council of Governmental Industrial Hygienists.

Title I design (preliminary design): Continues a design effort using the conceptual design and the project design criteria as a basis for project development. Title I design develops topographical and subsurface data and determines the requirements and criteria that will govern the definitive design. Tasks include preparation of preliminary planning and engineering studies, preliminary drawings and outline specifications, life-cycle cost analysis, preliminary cost estimates, and scheduling for project completion. Preliminary design identifies long-lead-time procurement items and analyzes risks associated with continued project development.

Title II design (definitive design): Continues the development of a project based on an approved preliminary design (Title I). Definitive design includes any revisions of the Title I effort; preparation of final working drawings, specifications, bidding documents, and cost estimates; coordination with all parties that might affect the project; development of firm construction and procurement schedules; and assistance in analyzing proposals or bids.

Title III inspection (concurrent with construction): Complete architectural and engineering supervision and inspection of construction under the direction of a responsible representative. Includes checking of shop drawings and furnishing of reproducible "as-built" record drawings and marked-up specifications showing construction as actually accomplished.

TMI: Three Mile Island Nuclear Plant Unit 2. An accident at TMI led to an action plan by the Nuclear Regulatory Commission (NRC) and the resolution of severe accident and source term issues; much of the safety knowledge gained from the TMI accident has been incorporated into current NRC regulations.

Transmissivity: A measure of a water-bearing unit's capacity to transmit fluid: the product of the thickness and the average hydraulic

conductivity of a unit. Also, the rate at which water is transmitted through a strip of an aquifer of a unit width under a unit hydraulic gradient at a prevailing temperature and pressure.

Transuranic waste: Radioactive waste that, at the end of institutional control periods, is contaminated with transuranium radionuclides with half-lives greater than 20 years in concentrations greater than 100 nCi/g.

Tritium: A radioactive isotope of the element hydrogen with two neutrons and one proton. Common symbols for the isotope are H-3 and T.

Tritium extraction facility: The tritium-target processing facility that has been already been proposed at the Savannah River Site to support DOE's existing production reactor operations.

Tritium-target fabrication facility: The land, buildings, equipment, and processes used to make the tritium-target elements from raw material.

Tritium-target processing facility: The land, building, equipment, and processes used to extract tritium from irradiated tritium-target elements. This facility may also be used to treat remaining materials before transfer to waste treatment, storage, or disposal facilities.

Unconfined aquifer: A permeable geological unit having the following properties: a water-filled pore space (saturated), the capability to transmit significant quantities of water under ordinary differences in pressure, and an upper water boundary that is at atmospheric pressure.

Undue risk: A level of risk to the health and safety of the public that exceeds that set forth in the design and operation objectives of the facility.

Unreviewed safety question: A proposed change, test, or experiment is considered to involve an unreviewed safety question if (1) the probability of occurrence or the consequences of an accident or malfunction of equipment important to safety evaluated previously by safety analyses will be significantly increased or (2) a possibility for an accident or malfunction of a different type than any evaluated previously

by safety analyses will be created that will result in significant safety consequences.

Unsaturated zone (vadose): A region in a porous medium in which the pore space is not filled with water.

Unusual occurrence: Any unusual or unplanned event that adversely affects or potentially affects the performance, reliability, or safety of a facility.

Unusual occurrence report: A written evaluation of an unusual occurrence that is prepared in sufficient detail to enable a reviewer to assess its significance, consequences, or implications and to determine the means of avoiding a recurrence with minimal additional inquiry.

Upset condition: For a nuclear facility, anticipated occurrences of moderate frequency that might occur several times during start-up testing or operation of the facility. The equipment, components, and structures must withstand these conditions without damage requiring repair. For ASME-code pressure boundary components, this plant design condition corresponds to the "Level B Service Limits" (see also "emergency condition" and "faulted condition").

Uranium: A heavy (atomic mass = 238.03), silvery-white metal with 14 radioactive isotopes. Uranium-235 is most commonly used, as a fuel for nuclear fission. Another isotope, uranium-238, is transformed into fissionable plutonium-239 following its capture of a neutron in a nuclear reactor.

Uranium processing facility: The land, buildings, equipment, and processes used to purify uranium recovered from reactor fuel processing. This is the last step of the fuel processing activity that allows recycling of uranium to other uses.

Water level (water table): Elevation of the top surface of an unconfined aquifer.

Wetland: Land or areas exhibiting hydric soil conditions, saturated or inundated soil during some portion of the year, and plant species tolerant of such conditions.

Zircaloy-4: An alloy of zirconium metal frequently used in nuclear reactors because of its desirable chemical and nuclear properties.

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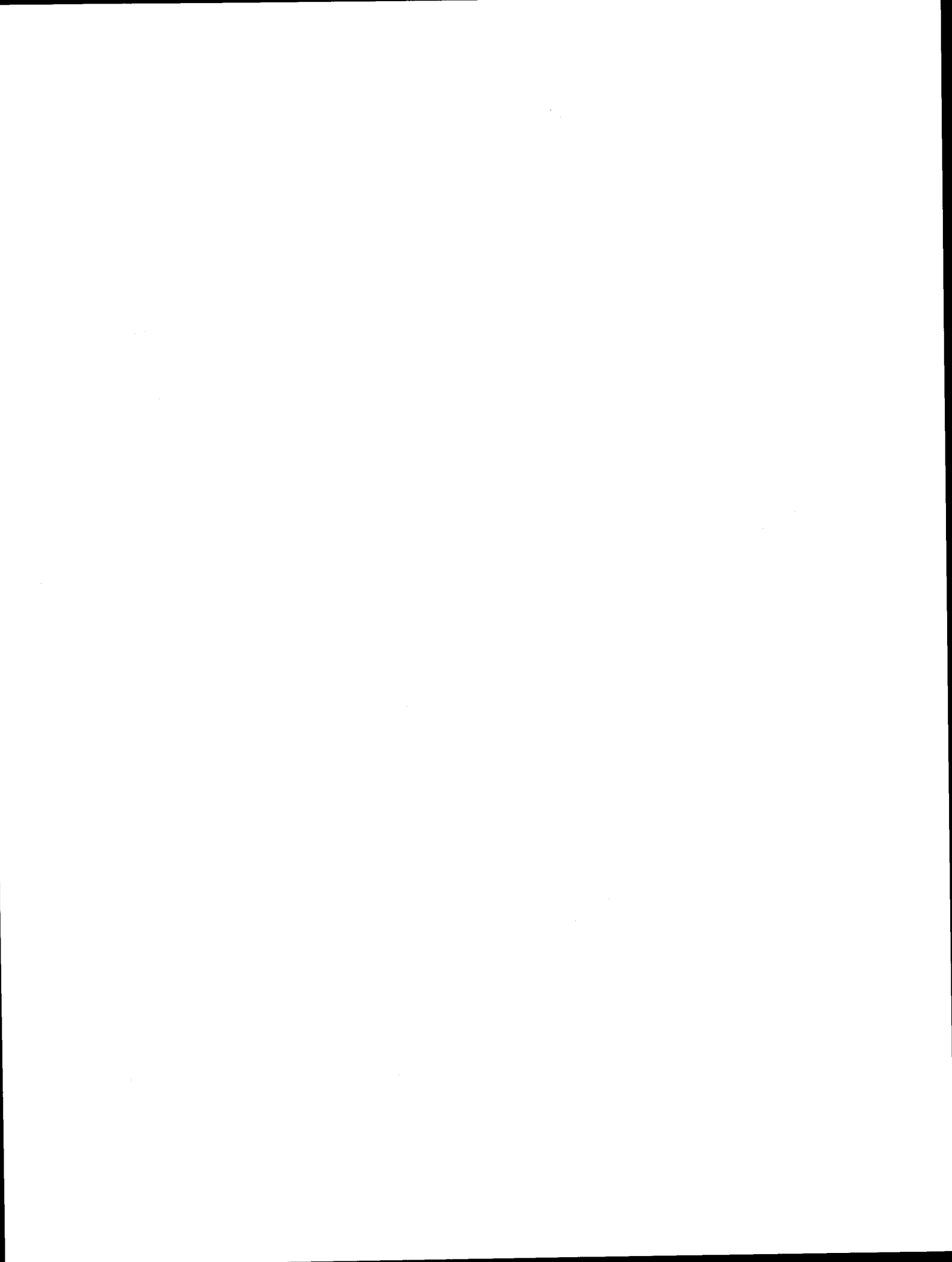
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APPENDIX A:
HEAVY-WATER REACTOR TECHNOLOGY



APPENDIX A: HEAVY-WATER REACTOR TECHNOLOGY

A.1 OVERVIEW

A.1.1 Introduction

Appendix A provides a summary description of the new production reactor (NPR) heavy-water reactor (HWR) technology and the siting and operation of such a facility at each of three alternative DOE sites: the Savannah River Site (SRS) near Aiken, South Carolina (Section A.2); the Idaho National Engineering Laboratory (INEL) Site near Idaho Falls, Idaho (Section A.4); and the Hanford Site near Richland, Washington (Section A.3). It should be emphasized that, except for existing facilities, the descriptions for an HWR represent a conceptual design based on knowledge of the existing HWR reactors at SRS and recent requirements for commercial nuclear power plants. Thus, any specific dimensions, quantities, facility layouts, and processes may well change on the basis of detailed design. This has been taken into account in the analyses in Section 5 and is so noted there. Key assumptions made are as follows:

- The baseline conditions used to assess NPR construction impacts are the local and regional site characteristics before the start of construction. The baseline conditions used to assess NPR operational impacts are the operational impacts of the non-HWR facilities that do or will exist at the time of proposed NPR operation.
- A national high-level waste repository is assumed to be operational within the NPR's lifetime with national transportation plans in effect.
- The Waste Isolation Pilot Plant (WIPP) is assumed to be operational within the lifetime of the NPR.
- Facility decontamination and decommissioning are based on the existing level of planning and available data.
- Spent uranium fuel may be reprocessed on-site, and recovered uranium-235 would be shipped as oxide to the Oak Ridge Y-12 Plant in Oak Ridge, Tennessee. Plutonium product may be processed on-site to its metallic form for the final product.
- Highly enriched uranium will be available from existing sources.

The production system at each site as described in this appendix would include the target and fuel fabrication facilities, the reactor, irradiated fuel and target processing facilities, and appropriate waste management facilities. Facilities to support tritium production, as well as fuel reprocessing and plutonium production, are included. See Section 1 for a discussion of the relationship of these activities to the proposed action and alternatives available for the DOE Reconfiguration PEIS. All of the sites would require a new heavy-water reactor. Some sites,

however, have existing facilities that would be used to support reactor operations; other sites would require construction of new support facilities. The differing needs for construction of new support facilities at the three alternative sites are discussed in Sections A.2.1.1, A.3.1.1, and A.4.1.1. In addition, there would be major differences in cooling water requirements among the three sites (Table A.1, Section A.2.2.9).

A.1.2 Safety and Safety Assurance

The overall policy of the New Production Reactor Program is to provide a level of safety and of safety assurance that meets or exceeds that afforded the public by modern commercial nuclear reactors. To this end, all NPR facilities will be designed, built, and operated in accordance with codes and standards generally accepted for use by the U.S. nuclear industry. The applicable codes and standards include technical guidance documents of the U.S. Nuclear Regulatory Commission (such as applicable portions of the *Code of Federal Regulations*), the American Society of Mechanical Engineers (ASME), the Institute of Electrical and Electronics Engineers, the American Nuclear Society, and other national consensus standards organizations. Furthermore, NPR facilities will be designed, built, and operated in compliance with applicable DOE orders that define safety, environmental, health, reliability, and quality assurance requirements.

A.1.2.1 New Facilities

At the design stage for each facility, an analysis of DOE orders and applicable codes and standards will be made to identify those that are applicable and those that require additions, exceptions, or exemptions. From the analysis, an approved base of orders, codes, and standards will be determined and applied at the earlier design stage. The approved orders, codes, and standards will be reviewed annually or as needed as projects mature. The process for carrying out the analysis, the adoption, and the updating of the orders, codes, and standards under which each new facility is designed, built, and operated is given in the NPR Codes and Standards Management Plan (Jicha 1990a).

A.1.2.2 Existing Facilities

Facilities currently operating in support of other missions and projected to be at least partially used by the NPR program would be operated by the lead organization and reviewed for compliance with existing DOE orders. A Capital Asset Management Process (CAMP) has been implemented to support repairing or replacing aging facilities so that the current complex can continue to perform the Department's defense mission until decisions resulting from the Reconfiguration P&IS can be implemented. In addition, major facility upgrades are being addressed in the Reconfiguration Study with respect to the DOE long-term strategy for continuing fuel reprocessing and virgin plutonium production. Any future modifications to these facilities would be accomplished in accordance with applicable safety, environmental, health, reliability, and quality assurance requirements of DOE orders and modern codes and standards. Facilities currently shut down or on standby will be reviewed for compliance with the appropriate orders, codes, and standards before the facilities would be used to support NPR. If necessary, backfits will bring the facilities into compliance (Jicha 1990a).

A.1.2.3 Specific Requirements Met by the HWR

The HWR would meet the general design requirements as given in DOE/NP-0001, *New Production Reactors Requirements*. Existing facilities that would support the proposed HWR currently comply with or would be upgraded to comply with all DOE orders, including requirements for nonreactor facilities provided in DOE Order 6430.1A, *General Design Criteria for Nuclear Facilities*. The HWR and new support facilities' design, construction, and operation would meet the quality assurance requirements of the NPR program and ASME NQA-1 standards, *QA Program Requirements for Nuclear Facilities*.

A.1.3 Heavy-Water Reactor Technology

A.1.3.1 Reactor

The reactor would be capable of producing tritium, plutonium, or other isotopes. Unlike the other two technologies being considered for the NPR, however, the HWR would not be designed with the capability for producing electricity. The HWR design and operational requirements are relatively site independent, except for cooling water use, and would be designed to meet or exceed the safety and environmental requirements of a modern commercial nuclear power plant.

The HWR would operate at a nominal average power level of 2,500 MW and would dissipate 2,590 MW, allowing for additional heat load from electrical equipment powered by outside electric power. Heat would be dissipated mainly to the atmosphere via cooling towers. Makeup water to replace water loss from tower evaporation, drift, and blowdown would come from the Columbia River at Hanford, from deep wells at INEL, and from the Savannah River at SRS. To bound the impacts of heat dissipation, the EIS assumes a maximum of 3,300 MWt for heat dissipation via the cooling towers.

For the EIS, it was assumed that normal operation for tritium production involves a uniform charge of assemblies containing driver fuel (80 wt% enriched uranium-aluminum) and targets. Plutonium production would normally operate with a mixed charge of driver-fuel/target assemblies, analogous to charges used in the existing SRS reactors. As in existing SRS reactors, the HWR would also be capable of operating with a uniform charge of fuel/target assemblies.

The initial heavy-water inventory for an HWR (750 t) now exists in inventories at SRS, but use of heavy water would require purification, detritiation, and upgrading to meet standards for the NPR. The EIS assumes that a Heavy-Water Processing Facility would be constructed and operated as part of the HWR complex, and the existing heavy-water inventory would be transported from SRS to Hanford or INEL if either site were selected for an HWR.

A.1.3.2 Fuel and Tritium-Target Cycle

Tritium production in the HWR would involve the use of highly enriched uranium (up to 93 wt% uranium-235) alloyed with aluminum as reactor fuel to sustain a nuclear reaction. The reaction would produce neutrons that would be absorbed by the lithium-6 in the

lithium-aluminum targets to produce tritium. Figure A.1 shows the major facilities, material flows, and interfaces required for HWR tritium production. Interfacility transfers would be made by rail, truck transport, or pipeline, as appropriate, for the material being transferred.

Highly enriched uranium and lithium would be shipped to the HWR site where they would be alloyed with aluminum and fabricated into fuel tubes and target tubes, respectively. The fuel tubes and target tubes would be combined to form a fuel and target assembly that would contain three fuel tubes nested concentrically and two target tubes -- an inner target tube within the three nested fuel tubes and an outer target tube outside the three fuel tubes.

Components for a new charge would be delivered to the Reactor Facility from fabrication facilities. The components would be inspected, assembled, flow tested, and stored before being introduced into the reactor. Following charging into the reactor and irradiation, the components would be discharged and transported to the disassembly basin, where the target tubes would be separated from the fuel tubes and allowed to cool so that short-lived isotopes would decay. A 1-month cooling period for tritium targets and 1-year cooling period for spent fuel is assumed for the EIS. After cooling, the target tubes would be processed to remove the tritium. The residual target matrix (lithium-aluminum alloy) would be discarded as solid radioactive waste. After cooling, the fuel tubes would be processed to separate the uranium from the fission products. The fission products would be sent to the high-level waste management system. The uranium could be recovered, converted to an oxide form, and shipped off-site, where it would be converted to its metallic form and recycled into the fuel fabrication operation.

A.1.3.3 Fuel/Plutonium-Target Cycle

Plutonium production in the HWR would use highly enriched uranium (60-80 wt% uranium-235) alloyed with aluminum as reactor fuel to drive the nuclear reaction and produce neutrons. The depleted uranium targets absorb neutrons and produce plutonium. Figure A.2 shows major facilities, material flows, and interfaces associated with HWR plutonium production.

The highly enriched uranium would be received from off-site and alloyed with aluminum and fabricated into fuel tubes on-site. Fuel tubes would be nested to produce a fuel assembly. The fuel assembly for plutonium production would be very similar to the fuel and target assembly used for tritium production. In plutonium production, the amount of lithium would be reduced in the inner target tube and eliminated from the outer tube (i.e., the outer tube would be aluminum).

The depleted uranium targets (0.2 wt% uranium-235) would be cast, extruded, and machined into short annular cylinders off-site. Currently at SRS, these cores are nickel-plated, inserted into double-wall aluminum cans, and hot-die sized to metallurgically bond the core to the aluminum. Two of the clad cylinders are nested, and then 18 pairs of nested cylinders are stacked to form a target assembly.

Charging of the reactor, irradiation, and discharging in the plutonium production mode would be the same as described for the tritium production mode, with the exception of the irradiation schedules noted in Section A.1.3.1. Transfer of the irradiated components to the disassembly basin and storage to allow decay of short-lived radionuclides would occur as in the tritium production mode.

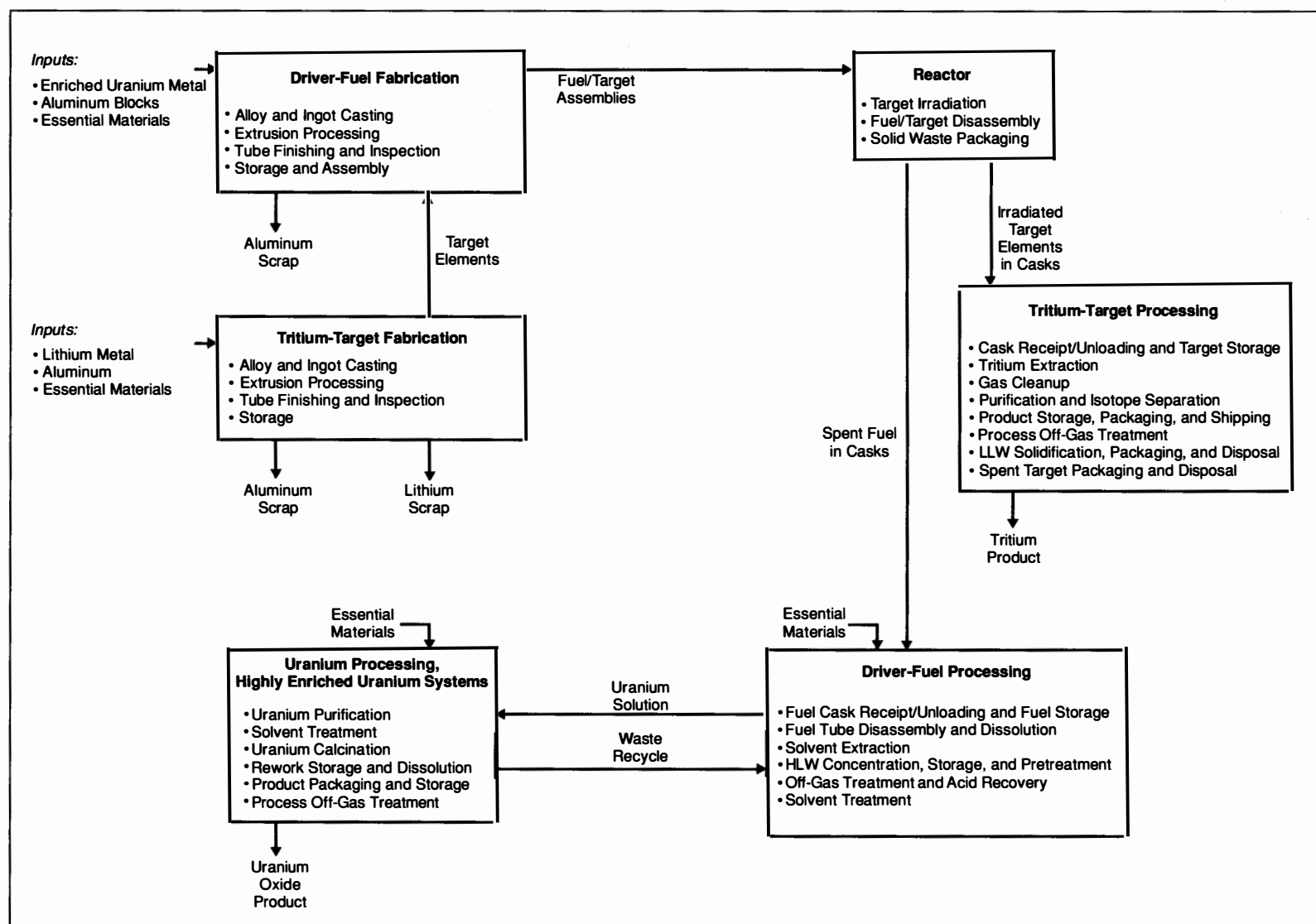


FIGURE A.1 HWR Tritium Production Fuel Cycle (Source: WHC 1989a, Fig. 3-1)

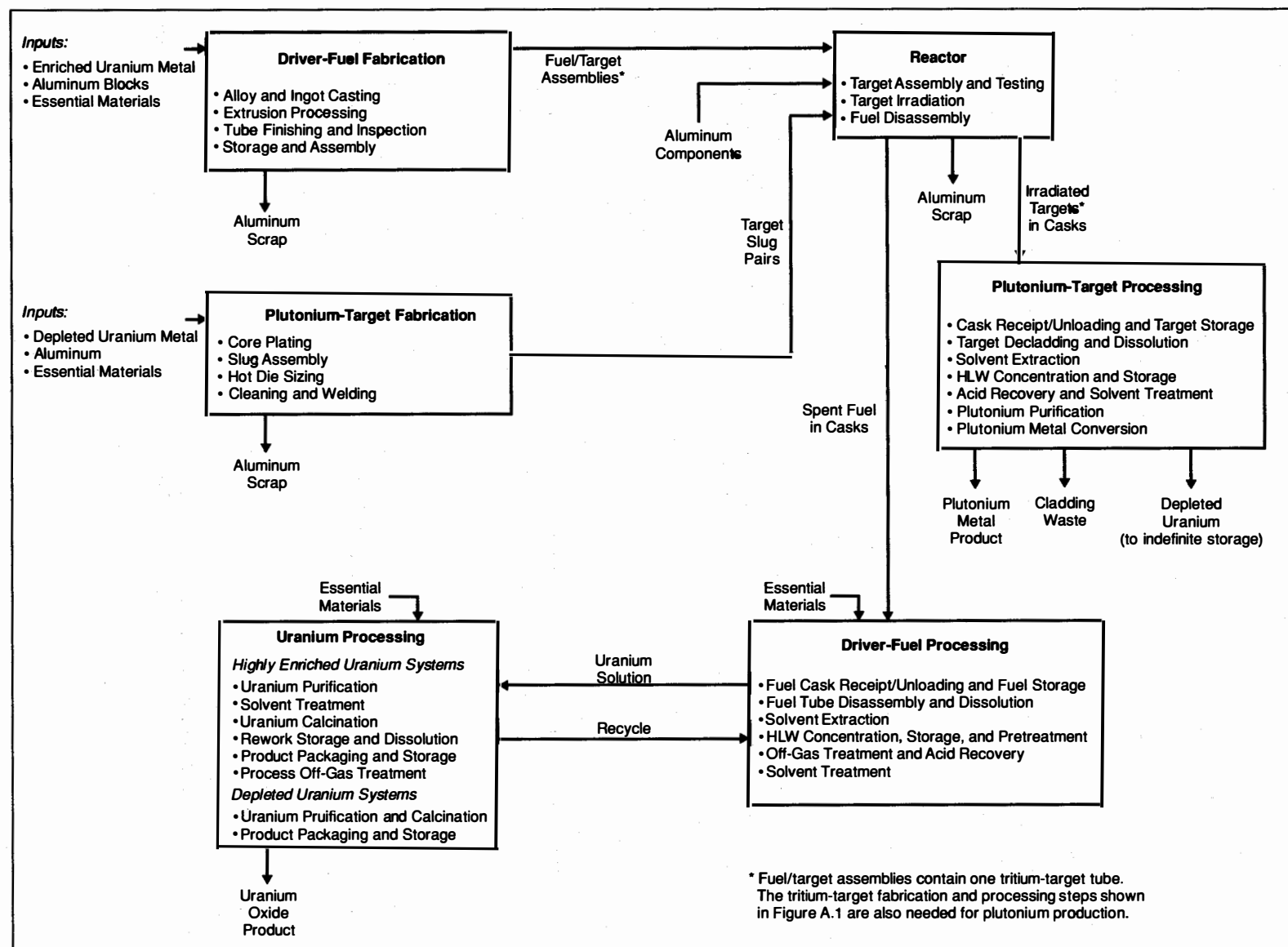


FIGURE A.2 HWR Plutonium Production Fuel Cycle (Source: WHC 1990)

After the target assemblies have cooled, they could be processed to recover the plutonium. The fission products would be sent to the high-level waste management system, and the recovered depleted uranium would be converted to uranium trioxide (UO_3) and stored on-site.

After the fuel assemblies have cooled, they could be processed to recover the fissile material (uranium-235) for recycle. The fission products that result from this operation would be sent to the site's high-level waste management system (see Appendix M). The uranium would be converted to UO_3 and shipped off-site, where it would be converted to the metallic form for recycle into the fuel fabrication operation.

The driver-fuel assemblies for plutonium production would also contain a tritium-target element. These elements could be removed at any convenient time after irradiation and sent for processing after cooling (Section A.1.3.2).

A.1.3.4 Waste Management

The DOE conducts its environmental management activities at Hanford, INEL, SRS, and other DOE sites pursuant to compliance agreements with state and Federal regulatory authorities. These agreements guide DOE activities at the sites under applicable environmental laws, regulations, and other standards. Compliance with the terms of these negotiated agreements is one of the highest of DOE's priorities. The DOE's NPR operations will be conducted consistent with commitments DOE has made and will make in these agreements. If it should become necessary, DOE will work with the regulators to incorporate NPR needs into existing agreements or to develop new agreements to ensure continued compliance. Under no circumstances will DOE's performance pursuant to any existing compliance agreement be compromised or diminished as a result of the NPR project. If there are discrepancies between the waste stream volume and waste treatment capacity figures in the DEIS and in existing compliance agreements, or those currently in negotiation, the figures in the compliance agreements will prevail.

Each facility would produce gaseous, liquid, and solid wastes. Gaseous wastes would be treated within each facility to reduce the toxic and radioactive contents to acceptable levels before discharge into the atmosphere in accordance with applicable Federal, state, and local regulations. Liquid wastes would be treated within each facility either to reduce the toxic and radioactive contents to an acceptable level for discharge to the environment or to an acceptable state for receipt at the existing liquid waste treatment system on each alternative site. In either case, solid waste would be produced. Solid waste would generally be treated within each facility to a form where it can be further treated, disposed of, or stored within the waste management system existing at each alternative site. High-level solid waste would be stored and then shipped to a national high-level waste repository. Transuranic waste would be stored before shipment to the Waste Isolation Pilot Plant in Carlsbad, New Mexico, or another appropriate facility.

A.2 HEAVY-WATER REACTOR TECHNOLOGY AT SRS

A.2.1 Introduction

This section provides information on the proposed design and operation of a heavy-water reactor at the Savannah River Site (SRS). The contents of this section are largely abstracted from Westinghouse Savannah River reports for the reactor (WSRC 1991a) and the support facilities (WSRC 1991b), except where otherwise referenced.

A.2.1.1 New and Existing Facilities Required for the NPR

The SRS is an integrated site for the production of tritium and plutonium using heavy-water reactor technology. All of the facilities needed for fabrication and postirradiation processing of HWR fuel and targets currently exist at SRS. The site also has waste management facilities designed to handle wastes produced by HWR fabrication and processing facilities. The EIS assumes the HWR support facilities will continue operation for the 40-year life of the NPR. Only a new Heavy-Water Reactor Facility and a new Heavy-Water Processing Facility would need to be constructed to support a new heavy-water reactor at SRS.

Because fabrication of fuel and targets and their subsequent processing after irradiation at SRS would use existing facilities and processes, siting a new heavy-water reactor at SRS would increase material use, utility use, staffing requirements, releases to the environment, wastes, and occupational radiation doses over those presently occurring at the existing fuel and target fabrication and processing facilities (assuming existing production reactors continue to operate).

A.2.1.2 Location

The new heavy-water reactor site at SRS would be centrally located (Figure A.3). The specific location and its selection are discussed in Section 3.3.2.

A.2.1.3 Existing Facilities, Utilities, and On-site Transportation

Fuel and target fabrication for tritium and plutonium production would be carried out in existing buildings in the M Area. Spent fuel processing would be carried out in Building 221-H (H-Canyon) in the H Area. Tritium-target processing would be carried out in a new Tritium-Target Processing Facility, the Replacement Extraction and Purification Facility, in the H Area. Plutonium-target processing would be carried out in Building 221-F (F-Canyon) in the F Area. These areas are shown in Figure A.3. Existing sitewide waste management facilities are described in Section A.2.9.

The existing electricity transmission and steam systems at SRS are described in Section 3.3.3.3. The site also has several pumping stations on the Savannah River. The pumping stations supply cooling water to the main distribution headers for delivery to reactor areas. Cross-connections allow for access to more than one pumping station. The HWR would use water from this water distribution system.

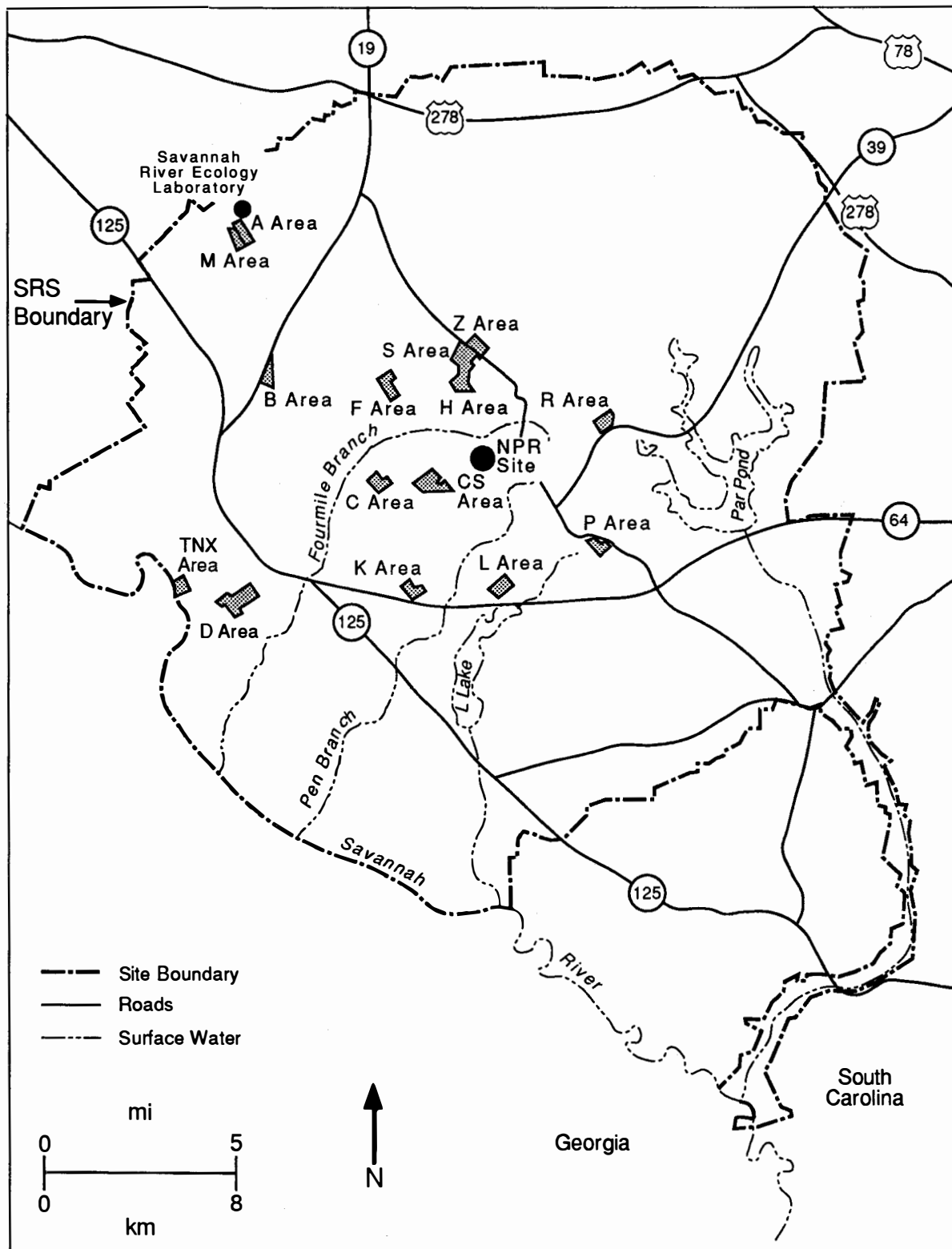


FIGURE A.3 Location of the Proposed NPR Site and Existing Facilities at SRS (Source: Modified from WSRC 1991a)

The existing on-site transportation system is described in Section 4.3.9. The Savannah River accommodated barge traffic during construction of the existing reactors; however, the waterway is no longer maintained for commercial shipping. For the EIS, it is assumed that construction and operation of a heavy-water reactor at SRS would not involve transport of any materials or components by barge. If SRS is selected, and if upon completion of the detailed design, barging is proposed, then further environmental review may be warranted.

A.2.2 Heavy-Water Reactor Facility

The Reactor Facility described here is a preconceptual design based on the reactors currently operating at SRS, except where otherwise referenced. The reactor design and operational requirements are relatively site independent, and they would meet or exceed all current national standards for nuclear plant design (Section A.1.2).

The design features adapted specifically for SRS include cooling tower performance, cooling tower antibiofouling and blowdown requirements, site grade that promotes natural gravity flow, and reactor building modifications for construction below the relatively high local groundwater levels.

A.2.2.1 Plant Structures

The generic arrangement of an HWR facility is shown in Figure A.4. The SRS facility would be identical to the generic arrangement, except there would be no fabrication facilities. Fabrication at SRS would be accomplished in existing facilities.

The HWR facility would occupy about 61 ha and would consist of the reactor containment building, which would house the reactor and primary heat exchangers; fuel and target assembly and storage areas; refueling equipment; an irradiated fuel and target storage area; the adjacent control building, which would house the control room; various support buildings; site utilities; and site services. Structures used in the reactor heat dissipation system would include an intake basin, an effluent basin, three cooling towers, and a pumphouse. Functions of these structures are described in the Secondary Cooling System discussion in Section A.2.2.9.

The support buildings would include a machine shop capable of working on contaminated components and a radwaste building for handling solid and liquid radioactive wastes. Together, the reactor and support facilities would cover less than 132 ha. A Heavy-Water Processing Facility to service the HWR would be constructed on SRS, but outside the Reactor Facility plan shown in Figure A.4.

A 930-m² administration building containing offices, toilets, a cafeteria, canteen, and medical office would be needed to house and service reactor technical staff and other personnel. A 650-m² shop, stores, and tool area would be located nearby. A reactor simulator center also would be constructed to provide normal and emergency reactor training. Finally, the HWR facility would include the site utilities (communications, electricity, steam, water, potable water, and sanitation services) and services (perimeter security fences, guardhouse and access gates, railroad lines, roads, and facility parking).

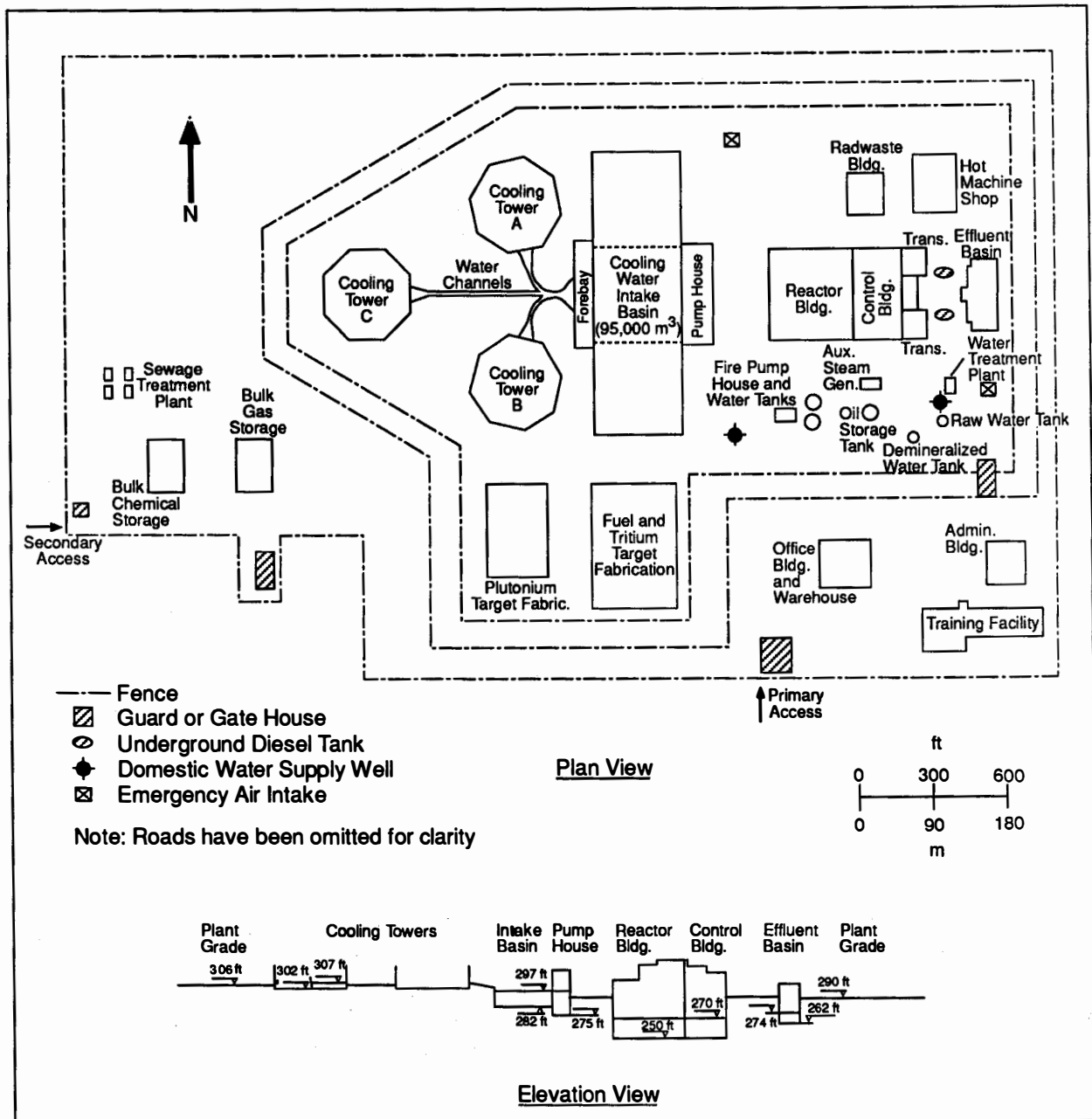


FIGURE A.4 Generic HWR Facility (Source: Modified from WHC 1989b)

A.2.2.2 Nuclear Reactor Systems

The HWR is based on a low-pressure, low-temperature application of nuclear power specifically designed to produce strategic nuclear materials and special radioisotopes; however, the reactor vessel and primary cooling configuration would be similar to that used in commercial LWR nuclear power technology. The HWR differs from the LWR in two major respects. First, heavy water (D_2O) is used as the reactor coolant and moderator. The use of heavy water gives better neutron economy and production efficiency. Second, the use of annular fuel and target assemblies promotes more efficient production. Coolant discharged from the core and the moderator would exit the reactor tank and pass through separate heat exchangers located in the reactor containment building. The heavy water in the tank surrounding the fuel would represent the bulk moderator. Less than 10% of the reactor heat would be generated in the moderator space because of gamma heating; the bulk of the heat would be generated in the core.

The HWR design would incorporate a core lattice structure capable of using a variety of fuels and targets, as in existing SRS production reactors.

A.2.2.3 Engineered Safety Features

The major engineered safety features include the reactor containment building; the emergency core cooling system to provide makeup coolant flow heat removal for an extended period, following either a loss-of-coolant accident or a loss-of-pumping accident; emergency shutdown safety rods independent of the control rods; neutron poison injection of gadolinium nitrate into the moderator space of the reactor tank; and a backup residual heat removal system capable of removing decay heat from the reactor if the primary coolant fails to circulate.

A.2.2.4 Reactor Containment

The reactor containment building would be a Reactor Safety Class 1 (DOE Order 5480.6) structure housing the reactor, charge and discharge operations, moderator and primary coolant loops including heat exchangers, and other reactor containment services. Its purpose is to limit any routine and potential accidental releases of radioactivity to the environment and to protect the plant systems from external environmental forces. The containment building would be designed to withstand various combinations of external loads, including seismic events, winds, icing, tornado forces, and excess pressures and temperatures resulting from normal and accidental conditions.

The containment configuration described here is preconceptual but is expected to be comparable to that of a modern, commercial pressurized-water reactor. The internal volume would be about 80,000 m³. The design and test pressure of the containment would be certified in accordance with applicable ASME pressure vessel codes and standards.

A circulating ventilation system with atmospheric driers would be used to collect and control tritiated water vapor during normal operation, thus reducing routine leakage of tritium. The containment would also include such features as heat removal sprays, hydrogen ignitors, and long-term residual heat removal systems to mitigate potential radiological releases under severe accident conditions.

A hot-cell refueling canyon would be located above the reactor head to provide additional isolation during charge and discharge operations (Jicha 1990b).

A.2.2.5 Fuel and Target Handling

Fuel and target handling would involve receipt and storage of new components in an assembly area, charge and discharge operations with computer-controlled cranes, and cooling and disassembly of irradiated components in a spent fuel storage building. The assembly area would be physically connected to the reactor containment building by a transfer port and two isolation valves. This area would provide space for storage of more than one full charge of assembled unirradiated components. Materials would be received, assembled, flow tested, inspected, stored, and then transferred to the reactor charging machine.

The charge and discharge process would involve two machines. One machine would introduce fresh components into the reactor, and the other machine would remove irradiated components. Both machines would operate in a shielded hot-cell refueling canyon located above the reactor head in the containment building. The machines would be mechanical bridge and trolley machines, which provide three-dimensional movement. Items removed by the discharge machine would be flushed and cooled while being moved to an underwater transfer station. Concurrently, the charging machine would pick up a new item and move it to the vacated position. Routinely handled items would include fuel, targets, housings, in-core instrumentation, control rods, and other reactor core components.

Assemblies discharged from the reactor would be transferred to the disassembly area through a transfer port and isolation valves. The disassembly area would consist of a water-filled concrete basin where irradiated assemblies would be stored, disassembled, and prepared for shipping for chemical processing or, in the case of scrap metal, for burial. It would also include equipment for handling casks in which irradiated components would be shipped. Disassembled components would be transported in shipping casks by rail or truck to the appropriate processing facility.

A.2.2.6 Heavy-Water Processing

A new Heavy-Water Processing Facility would be built adjacent to the reactor to purify the existing inventory of heavy water and to remove tritium before start-up and during operation. The facility would include modules dedicated to heavy-water feed preparation, to high-tritium heavy-water distillation, and to heavy-water detritiation. There would also be a control room, production support facilities, and an analytical laboratory.

The heavy-water feed preparation module would be housed in a one-story concrete structure with a floor area of 1,490 m². The high-tritium heavy-water distillation module would be housed in a one-story reinforced-concrete building with a gross floor area of 446 m² and adjoining distillation columns rising 55 m above grade, surrounded by a metal-sided structure. The heavy-water detritiation module would be housed in a multilevel (including basement) reinforced-concrete structure with a floor area of 930 m², with a metal-sided portion rising 21 m above the rest of the structure. The gross area of the service and support facilities would be approximately 5,600 m². The dedicated land area during operation would be 17 ha.

The heavy-water feed preparation facility would process heavy-water feed material, which has high activity, high conductivity, or turbidity, before it is sent to the distillation or detritiation facility. The facility would contain a steam-heated evaporator, a condenser, and a condensate storage tank to remove radioactivity. It would also contain filters, an emulsifier, a decanter to remove oil, and deionizers to remove ionic impurities.

High-tritium heavy-water distillation would be a continuous multistage process that concentrates heavy water with compositions in the range from 1.25 mol% to 99 mol% D_2O to the required reactor purity of 99.75 mol% D_2O . Tritium concentrations would be greater than 0.03 Ci/L. The distillation would be done under vacuum, which would be produced by a two-stage steam ejector.

The heavy-water detritiation process would consist of a vapor phase catalytic exchange (VPCE) front end and a cryogenic distillation back end. (The Heavy-Water Processing Facility would be sized to produce 1,000 t/yr of heavy water.) The front end would consist of a series of multiple stages, each containing an evaporator, a superheater, a catalytic reactor, and a water and deuterium separator-condenser. A single compressor would provide deuterium flow for all stages. Detritiated heavy water would be separated from the deuterium stream during the final stage and returned for use in the heavy-water inventory. Feed material for the facility would be reactor-grade heavy water (greater than 99 mol% D_2O and free of organic and inorganic contaminants). The overall efficiency of tritium removal would be 80% to 90%.

The distillation portion of the process would consist of a single cold box housing a system of cryogenic distillation columns. A stream of mixed hydrogen isotopes would be passed from the VPCE to the low-tritium column, which would produce a purified deuterium stream for recycle to the VPCE.

A.2.2.7 Power Conversion System

Because of the relatively low exit coolant temperature in the HWR as designed, power conversion would not be feasible.

A.2.2.8 Utilities

Emergency diesel generators would consist of the following, divided between two engine houses: eight DC motor generator sets to provide emergency DC power to the primary coolant circulating pumps (two of which are spares); two AC generator sets to provide emergency AC power for house loads; and a dedicated emergency diesel generator to provide 100-kVA auxiliary and standby power for lighting, security, monitoring, and communications.

Rail and truck service would be needed to accommodate fuel and component delivery; also, facilities would be needed for unloading and storing fuel oil. Water would be supplied by gravity flow from the 95,000-m³ cooling water intake basin to cool the diesel generators during operation.

To ensure an uninterruptible power supply, two 60-kW rectifier battery-inverter sets, each of 30-minute capacity, would provide instrument power continuity between electrical loss and diesel generator operation.

Helium used as an inert blanket gas in reactor systems would be received in bulk by rail and would be unloaded into cylinders for storage. The on-site storage area would be $1,700 \text{ m}^3$ at $7.23 \times 10^6 \text{ Pa}^*$ in a small standard construction building.

In addition, three air compressors would be needed for instrument and breathing air. Each compressor would operate at $14.2 \text{ m}^3/\text{min}$ at $1.03 \times 10^6 \text{ Pa}$.

Steam would be available by tying into the existing area distribution system at the powerhouse and running a line overland to the HWR area. The steam requirement, primarily for heavy-water rework, would be 4.8 kg/s at $2.24 \times 10^6 \text{ Pa}$. The design of the on-site overhead and underground lines for steam, air, helium, pipe supports, and water lines, and for process, storm, and sanitary sewers, would depend on the site layout. A sanitary water treatment plant sized for an HWR population of 300 would be provided, including tanks to equalize flows. The disposition of the sanitary waste is described in Section A.2.2.10.

A.2.2.9 Heat Dissipation Systems

Secondary Cooling System

The HWR would use cooling towers with full recycle of the effluent stream. Water makeup requirements would compensate for evaporative, drift, and blowdown losses associated with the operation of the cooling tower and evaporation from water reservoir basins.

The secondary cooling system would consist of a circulating water subsystem (not generally safety related) and a nuclear service water subsystem (safety related) (Figure A.5). Both subsystems would provide water to cool the shell side of heat exchangers in the various processes. The two subsystems would share some equipment and structures (e.g., the intake basin as the ultimate heat sink). All shared items would meet stringent requirements for safety-related systems.

The circulating water subsystem would include a $95,000\text{-m}^3$ cooling water intake basin to supply water during normal operations and to act as the ultimate heat sink for safe shutdown; an adjacent pumphouse to supply cooling water to the various heat exchangers of the containment and control buildings; and a $3,800\text{-m}^3$ effluent basin and pumping system to return heated water to the cooling towers.

The three cooling towers would be constructed of concrete and filled with high-surface-area material. Each tower would sit on a $7,600\text{-m}^3$ concrete collection basin, which, in turn, would be 3 m above the intake basin water level. (Water would flow by gravity through concrete channels to the intake basin.) The towers would be capable of dissipating 3,300 MWt of heat. Discharge of tower blowdown would be to the C-Area discharge canal, which, in turn, discharges via Castor Creek to Fourmile Branch and then to the Savannah River. The peak and annual quantities of water required for cooling a new 3,300-MWt HWR reactor at the Savannah River Site are shown in Table A.1. The quantity of water listed as "temperature control" would be river water that is mixed with the blowdown stream to meet state of South Carolina water discharge standards.

*Scientific notation: $7.23 \times 10^6 = 7,230,000$.

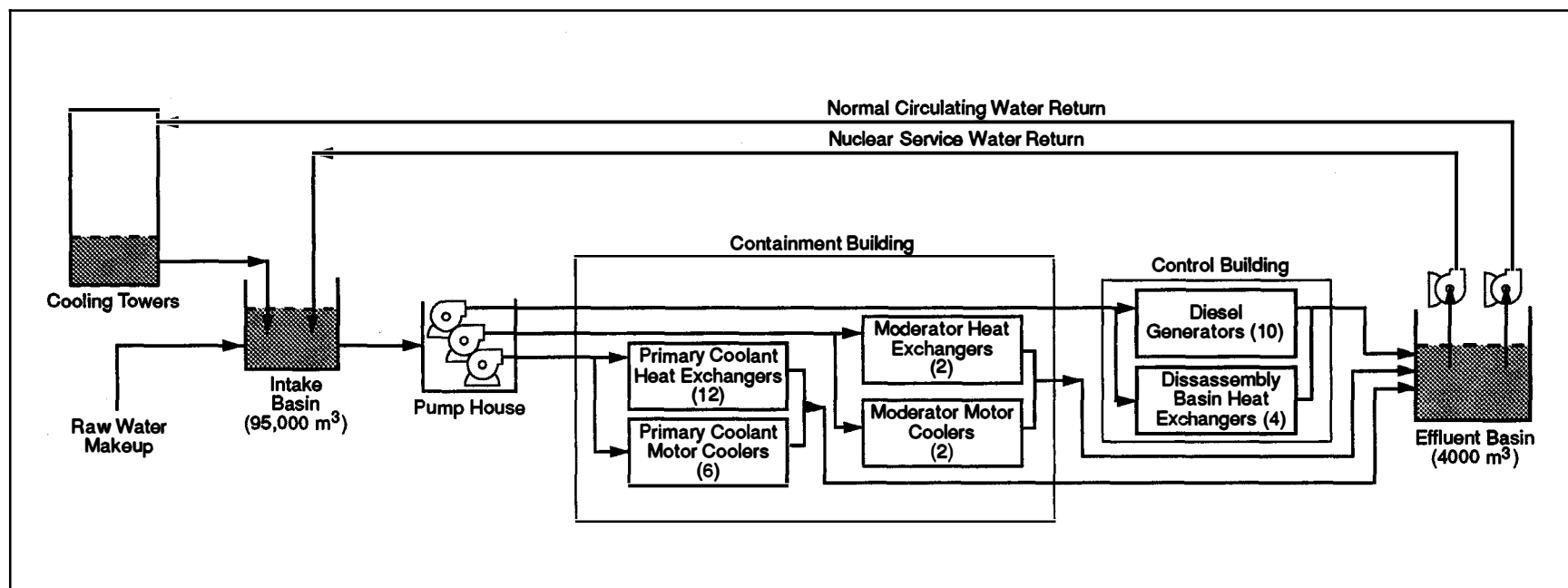


FIGURE A.5 HWR Secondary Cooling System at SRS (Source: Modified from WSRC 1991a)

TABLE A.1 Estimated Water Use for HWR
Cooling Towers at 3,300-MWt Reactor Power
(Bounding Case; Steam Bypass Mode)^a

Type of Water Use	Hanford	INEL	SRS
Evaporation			
Peak (m ³ /s)	1.15	1.14	1.11
Annual (10 ⁶ m ³)	34.4	34.1	33.4
Drift			
Peak (m ³ /s)	0.004	0.004	0.004
Annual (10 ⁶ m ³)	0.12	0.12	0.12
Blowdown			
Peak (m ³ /s)	0.28	0.28	0.73
Annual (10 ⁶ m ³)	8.5	8.4	21.8
Concentration factor	5	5	2.5 ^b
Makeup			
Peak (m ³ /s)	1.43	1.42	1.84
Annual (10 ⁶ m ³)	43.0	42.6	55.3
Temperature control			
Peak (m ³ /s)	NR ^c	NR	1.18
Annual (10 ⁶ m ³)	--	--	35.1

^aPeak values are based on the month of greatest water use. Annual values are based on the averages of 12 months.

^bConcentration limited to 2.5 at SRS in order to meet discharge requirements for dissolved solids.

^cNR = not required.

Conversion factors: 1 m³ = 264.2 gal;
1 m³/s = 15,850 gal/min.

Source: UE&C 1990.

Because the cooling towers would constantly evaporate water, the concentration of dissolved solids in the circulating water would increase with time and must be controlled by discharging a portion of the circulating water to the Savannah River. The concentration of dissolved solids in the circulating water and, consequently, the blowdown would be maintained at approximately 2.5 times the concentration of the makeup water. To minimize the deposit of alkaline scale materials in the circulating water system, sulfuric acid would be continuously fed to the system; no other scale or corrosion inhibitors would be used. Biological fouling in the circulating water system would be controlled by intermittent chlorination. Chlorination would occur a maximum of three times per day during the summer months, when biological activity is at its peak. To ensure that no chlorine is discharged to the environment, blowdown would

be terminated during chlorination and would not be resumed until the total residual chlorine in the circulating water had dropped to less than 0.0001 mg/m^3 .

Water Treatment Systems

At SRS, potable water would come from on-site wells that would draw water from the lower Cretaceous sands. As a result, two water treatment systems would be needed: one system would treat potable water and one system would condition Savannah River water for use in the secondary cooling water system. Chemicals used in these treatments are listed in Table 3.12 of WSRC 1991a.

The potable well water treatment system, which has a capacity of $0.0063 \text{ m}^3/\text{s}$, would consist of disinfection, clarification, and filtration, including activated charcoal filtration, as required. The water flow would be used by wash and sanitary facilities and for some miscellaneous equipment cooling.

Secondary cooling water would be treated by the continuous injection of sulfuric acid to control the pH of the circulating water in the range from 7.8 to 8.0. No other scale or corrosion inhibitors would be used. Biological fouling would be controlled by intermittent chlorination. Blowdown would be terminated during chlorination.

The system that supplies demineralized water to the facility would consist of two distinct physical and chemical processes: the pretreatment system, which includes disinfection, clarification, and filtration; and the demineralization system, which includes activated carbon adsorption, mechanical degasification, and demineralization by ion exchange. (The quality of the Savannah River, which is the water source for these processes, is discussed in Section 4.3.3.)

The cation and anion resins in the demineralizer units would be regenerated with sulfuric acid and sodium hydroxide, respectively. Following each regeneration, the regenerant solutions would be neutralized before discharge to the nonradioactive waste treatment system. The intermittent regenerant flow would range from 9.5×10^{-4} to $1.9 \times 10^{-3} \text{ m}^3/\text{s}$ and would contribute an average of 180 to 1,520 kg/d maximum of total dissolved solids to the nonradioactive waste treatment system.

Other Reactor Cooling Water Systems

Figure A.6 is a schematic of the overall water flow in the reactor plant, including raw water inlet and discharge requirements. An existing raw water intake structure on the Savannah River would provide river water for raw water makeup. An access line to the existing SRS river water supply line, which passes approximately 900 m from the reactor site, would be constructed.

The safety-related nuclear service water subsystem would provide secondary cooling water to components essential for safe reactor shutdown. The cooling water intake basin would serve as the ultimate heat sink if the normal cooling system were inoperable. The $17,800\text{-m}^2$ surface area of the intake basin would be adequate to cool the reactor and provide other essential services. Water temperatures in the intake basin would reach a maximum of 49°C in 13 days. At that time, heat rejection by evaporative cooling would equal heat input.

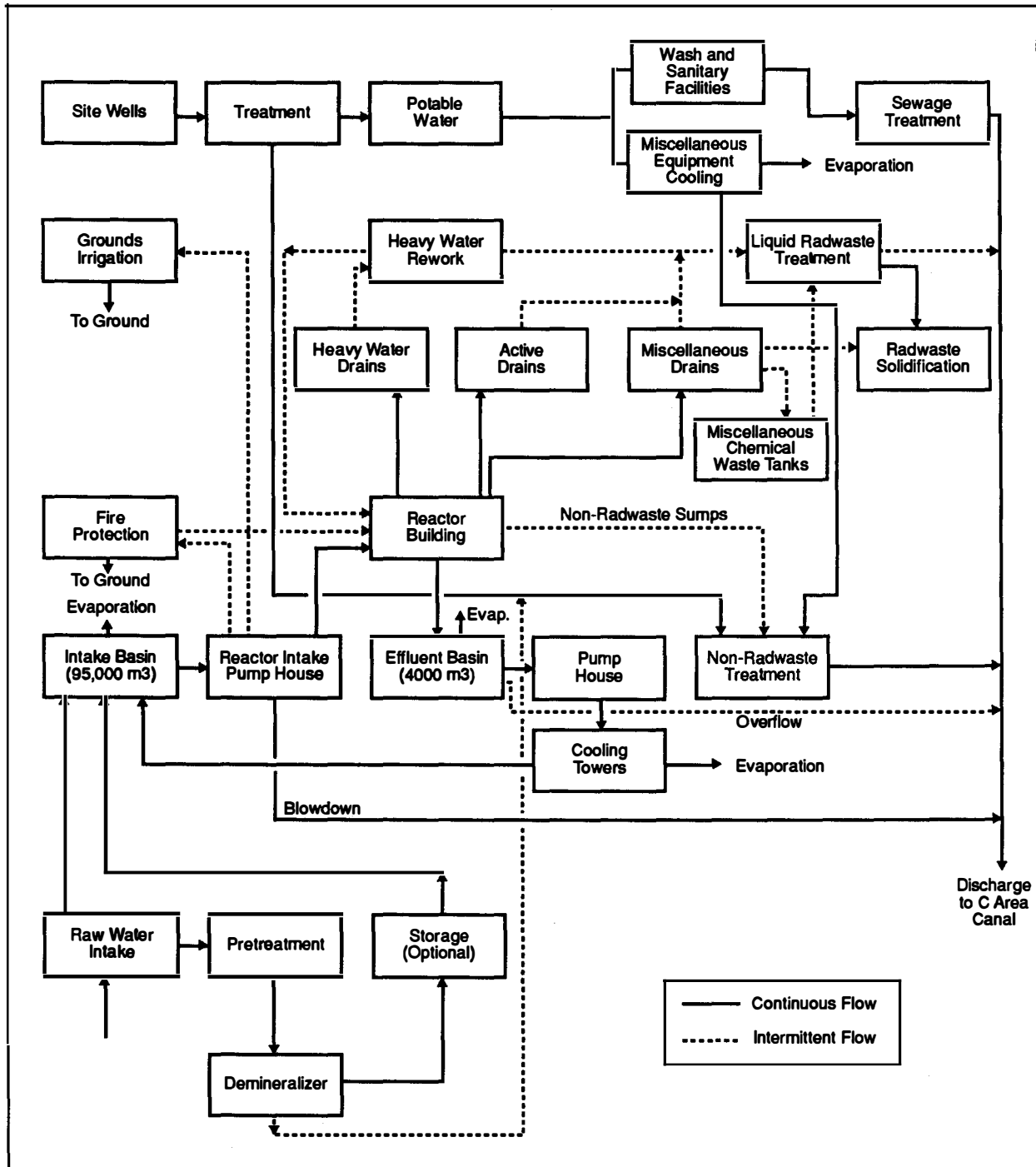


FIGURE A.6 Schematic of Heavy-Water Reactor Water Flow at SRS (Source: Modified from WSRC 1989a)

A.2.2.10 Waste Management

For the purpose of this EIS, it is assumed that spent fuel would ultimately be disposed of in a Federal repository. Spent fuel processing is analyzed in this EIS as part of the original mission of NPR, which included the production of virgin plutonium-239. However, plutonium production is no longer part of the NPR proposed action. The Waste Management PEIS will assess the impacts of wastes from reprocessing of spent fuel from DOE reactors.

The quantities and types of wastes to be managed depend upon whether spent fuel is reprocessed and whether plutonium is produced. Estimates in this appendix were prepared on the basis that it is reasonably foreseeable that spent fuel could be reprocessed and plutonium produced. If it is decided not to continue those activities, the impacts upon waste management systems, from NPR operations, would be less than shown here.

Radioactive waste management would include gaseous, liquid, and solid waste systems. The maximum estimated system requirements and design process flows for the NPR are shown in Appendix M. Heavy-water reactor radioactive waste management for the HWR would be similar to current practices at SRS.

Gaseous Waste Processing

Gaseous radioactive waste management would collect, process, and discharge to the environment vented gases that would emanate from the primary coolant or from systems that would treat and recover primary coolant. The discharge gas would be monitored for radionuclide content and concentration and for the presence of hazardous gases.

Gaseous radioactive wastes would be collected by a vent-collection header (Jicha 1990b), compressed by a centrifugal-type blower, electrically preheated to an acceptable temperature (above dew point), recombined in a catalytic recombiner, cooled and dewatered, monitored, and discharged through a filtered vent. Two trains would be provided for redundancy. The design and operation of the gaseous waste processing system will ensure that in-plant radiation doses and exposures to operators and releases to the environment will be as low as reasonably achievable. Exposure and releases will comply with DOE orders 5400.5, *Radiation Protection of the Public and the Environment*; 5480.11, *Radiation Protection for Occupational Workers*; and 5820.28, *Radioactive Waste Management*.

The system would be designed to collect and treat all radioactive and hazardous gases vented by plant equipment that receives direct input from the primary coolant system. The principal contributors to the gaseous waste processing system would be HWR high- and low-activity vents, various heavy-water collection sump vents, the degasifier vent, heavy-water upgrade system vents, miscellaneous equipment vents, and gas analyzer vents (Jicha 1990b).

The reactor tank cavity, the air gap between the reactor tank and the surrounding concrete structure (biological shield) in existing SRS reactors, is a source of air activation products. In the HWR, air in the gap would be removed by flooding with inert gas or borated water (Jicha 1990b).

In the HWR with full containment, a gas control system may be implemented. A recirculating vapor recovery system, consisting of high-volume blowers, would circulate the air

in the containment building through a vapor recovery system to remove tritium. The collected water would be directed to the appropriate liquid waste processing stream, and the bulk of the flow would be recirculated to the containment building after vapor recovery. The hot-cell refueling canyon would use a dedicated ventilation system with vapor recovery during refueling operations. A fraction of the flow would be directed to a building stack for maintenance of proper pressure differentials. This exhaust flow would pass through vapor recovery and high-efficiency particulate air (HEPA) and activated charcoal filters to remove particulates and any iodine present in the building atmosphere (Jicha 1990b). The spent filters would be compacted and disposed of within the solid waste treatment system (see the Solid Waste Processing discussion that follows).

Exact release points cannot be specified with certainty at this conceptual phase of the HWR program. It is assumed at this time that all gaseous effluent releases from gaseous radioactive waste processing systems would be directed to a common discharge stack at 30 m above grade.

Liquid Waste Processing

In the present system at SRS, liquid radioactive waste streams are segregated in eight different types of collection tanks: high-level radioactive waste, low-level radioactive waste, chemical waste, laundry waste, decay tanks, demineralizers, decontamination solution, and a final disposal tank. Segregation of the waste permits recycling of heavy water for plant use and allows efficient processing of liquid radioactive waste batches that differ in the amount of solids, chemicals, and radioactivity present.

A radioactive drain subsystem collects potential liquid radioactive waste from sumps and transfers it to collection tanks. Liquid collected in the heavy-water sumps is first analyzed for heavy-water content and then transferred to the heavy-water purification rework system or to an appropriate collection tank for processing if rework is uneconomical.

If the water quality meets the requirements for release, the contents of the collection tanks can be discharged directly to the environment. Otherwise, the waste can be transferred to decay tanks, where the radioactivity level can be allowed to decay before release; treated in an ion-exchange and filtration treatment subsystem before discharge to the environment; or transferred to the SRS sitewide waste management system for immobilization (Section A.2.9).

Traces of tritium would likely accumulate on the spent fuel surfaces. To limit tritium levels to acceptable values in the atmosphere above the spent fuel basin, some water effluent would be discharged to the secondary side of the reactor cooling system, where it would serve as partial water makeup for blowdown and evaporative losses. An average continuous flow of 1×10^4 m/s would be assumed. Water from the spent fuel basin would pass routinely through sand and demineralizer filters and would be recirculated to maintain its purity.

Spent resins and filters from the treatment of low-level liquid wastes would be treated in the low-level solid waste treatment system (see the Solid Waste Processing discussion that follows).

All treated liquid effluents from the HWR would be discharged to the common cooling tower blowdown line. At SRS, this discharge line would be directed to the C-Area discharge

canal, except for the discharge from the disassembly basin, where the flow is directed to the secondary coolant system. During HWR operation, low-volume wastewater streams would be produced from a number of sources: backwash and regenerant from the water treatment plant; blowdown from plant air conditioning systems and equipment cooling water; equipment and floor drains, including bearing and seal leakage and oily wastes; waste from the liquid radioactive waste treatment system; backwash from condensate polishing system; preoperational fluid system cleanliness verification flush; and metal-cleaning waste. In addition, the circulating water system would produce wastes, consisting of cooling tower blowdown, cooling tower drift, and spray pond blowdown.

Chemicals used to treat water and wastes are given in Table 3.12 of WSRC 1991a. All low-volume waste streams, except the liquid radioactive wastes and heavy-water drains in the reactor building, would be collected, monitored for radioactivity, and directed to the nonradioactive waste treatment system, which would consist of an inlet and surge chamber where the effluents from the various building sumps would be collected; a chemical addition chamber, where sodium hydroxide or sulfuric acid and a flocculent aid would be added; two settling basins, where solid materials would be allowed to settle; an oil skimmer; associated chemical treatment equipment; and an effluent monitoring system. The treated wastewater would be discharged to the cooling tower blowdown line when its pH is acceptable. The settling basins would be periodically drained, and accumulated solids would be removed for landfill disposal.

The concentration of dissolved solids in the secondary cooling water system is assumed would be maintained at 2.5 times the concentration of the makeup water (2.5 cycles of concentration). Chemicals added to the circulating water system would minimize the deposit of alkaline scale materials. The required amount of chemicals would depend on the calcium concentration and the alkalinity of the makeup water.

For analysis, chemical treatment of the circulating water system at SRS would be similar to the chemical treatment proposed for the WNP-1 system at Hanford, where sulfuric acid would be continuously fed to the system to control the pH and alkalinity of the circulating water. No other scale or corrosion inhibitors would be used. Biological fouling in the circulating water system would be controlled by intermittent chlorination, a maximum of three times per day during the summer months when biological activity is at its peak. To control chlorine discharges to the Savannah River, blowdown would be terminated during chlorination. Blowdown would not be resumed until the total residual chlorine in the circulating water had dropped to less than specified values. The actual rate of chlorine addition would be adjusted to the specific conditions of the Savannah River water quality at the time of HWR operation.

The estimated effluent water discharge at SRS is presented in Table A.2. All liquid discharges from the heavy-water reactor at SRS would be directed to the C-Area discharge canal, except for the disassembly basin purge, which would be directed to the secondary coolant flow. Discharge compositions are given in Appendix P.

A Sanitary Waste Treatment Plant would be sited with the heavy-water reactor at SRS. All sanitary wastewater would be collected by gravity at the on-site sewage treatment plant. The sanitary system would be designed to treat 95 m³/d, using an activated sludge treatment system consisting of primary sedimentation and extended aeration. Secondary liquid would be discharged to the plant blowdown discharge point, with an assumed average flow of 1×10^{-3} m³/s. The digested sludge would be pumped from the sludge holding tank into portable tanks and disposed of on-site.

TABLE A.2 Treated Liquid Effluent Discharge Points at SRS

Discharge Source	Estimated Quantity (m ³ /s)		Discharge Point
	Average	Maximum	
Sewage treatment	0.001	0.003	Discharge canal
Liquid radwaste treatment	0	0.005	Discharge canal
Nonradwaste treatment	0.002	0.060	Discharge canal
Secondary system blowdown	--	0.73	Discharge canal
River water blend of blowdown	--	1.18	Discharge canal
Disassembly basin purge	0.00013	--	Secondary coolant

Conversion factor: 1 m³/s = 15,850 gal/min.

Source: WSRC 1991a.

Nonradioactive hazardous wastes generated at SRS would include oils, solvents, and acids associated with plant operation and maintenance. Treatment and disposal of nonradioactive hazardous wastes at the HWR would comply with DOE requirements and applicable Federal, state, and local regulations.

Solid Waste Processing

At SRS, low-level radioactive solid waste is classified into four main categories. Each group of wastes is handled separately, but all are disposed of in trenches on-site. Mixed waste is described in Section 4.3.10.4.

Nonradioactive hazardous wastes generated by the HWR would include contaminated plastics, gloves, rag stock, and other materials associated with plant operation and maintenance. Such wastes would be compacted and packaged before disposal. Treatment and disposal of nonradioactive hazardous wastes at the HWR would comply with DOE requirements and applicable Federal, state, and local regulations. Ordinary trash would be compacted on-site and disposed of in the SRS sanitary landfill.

A.2.3 Fuel and Tritium-Target Fabrication

A.2.3.1 Facility Description

Fuel and tritium-target fabrication for the heavy-water reactor at SRS would involve two existing facilities: Building 320-M, which is 48 m wide by 64 m long, and Building 321-M, which is about 38 m wide by 122 m long. These buildings would have casting areas, billet assembly areas, extrusion areas, inspection and finishing areas, offices, and shops.

A.2.3.2 Fuel and Target Description

The fuel and target assembly would consist of five concentric tubes plus a sleeve housing. The inner and outer target tubes would be lithium-aluminum alloy clad in aluminum, and the middle and outer fuel tubes would be uranium-aluminum alloy clad in aluminum. The arrangement of the various tubes for a representative tritium production design is shown in Figure A.7. The core of the HWR fuel assembly would be 3.8 m long; the overall length would be about 4.6 m. A total of 438 assemblies would be in the HWR at a time.

A.2.3.3 Process Description

Building 320-M, which is a one-story structure, would be used to produce lithium-aluminum billets, to preextrude the lithium-aluminum billets into logs, and to machine and nest the logs into coextrusion billets. Building 321-M would be used to prepare the uranium-aluminum billets and preextrude them to form logs. The logs would be machined, assembled into coextrusion billets, and then coextruded to produce fuel tubes. Building 321-M would also be used to coextrude the lithium-aluminum billets to form target tubes.

A.2.3.4 Process Effluents and Wastes

The ventilation system for the Tritium-Target Fabrication Facility would consist of a single air inlet system where air is filtered and then preheated or cooled as required. The administrative and computer areas would be supplied by one part of the ventilation system and would have a separate discharge. Air in other areas of the facility (mechanical areas, vault, casting, and machining area) would be exhausted through a double set of HEPA filters. The casting and machining equipment would have additional ventilation equipment to control the dust and particulate material that may be generated at these pieces of equipment. These flows would also be discharged through a double set of HEPA filters. The only radionuclides released to the atmosphere would be uranium, mainly uranium-235. The principal chemicals released to the atmosphere would be freons, argon, and helium.

The aqueous releases from fuel and tritium-target fabrication would be low-level liquid wastes from tube cleaning operations. The only radioactive material released would be uranium, mainly uranium-235.

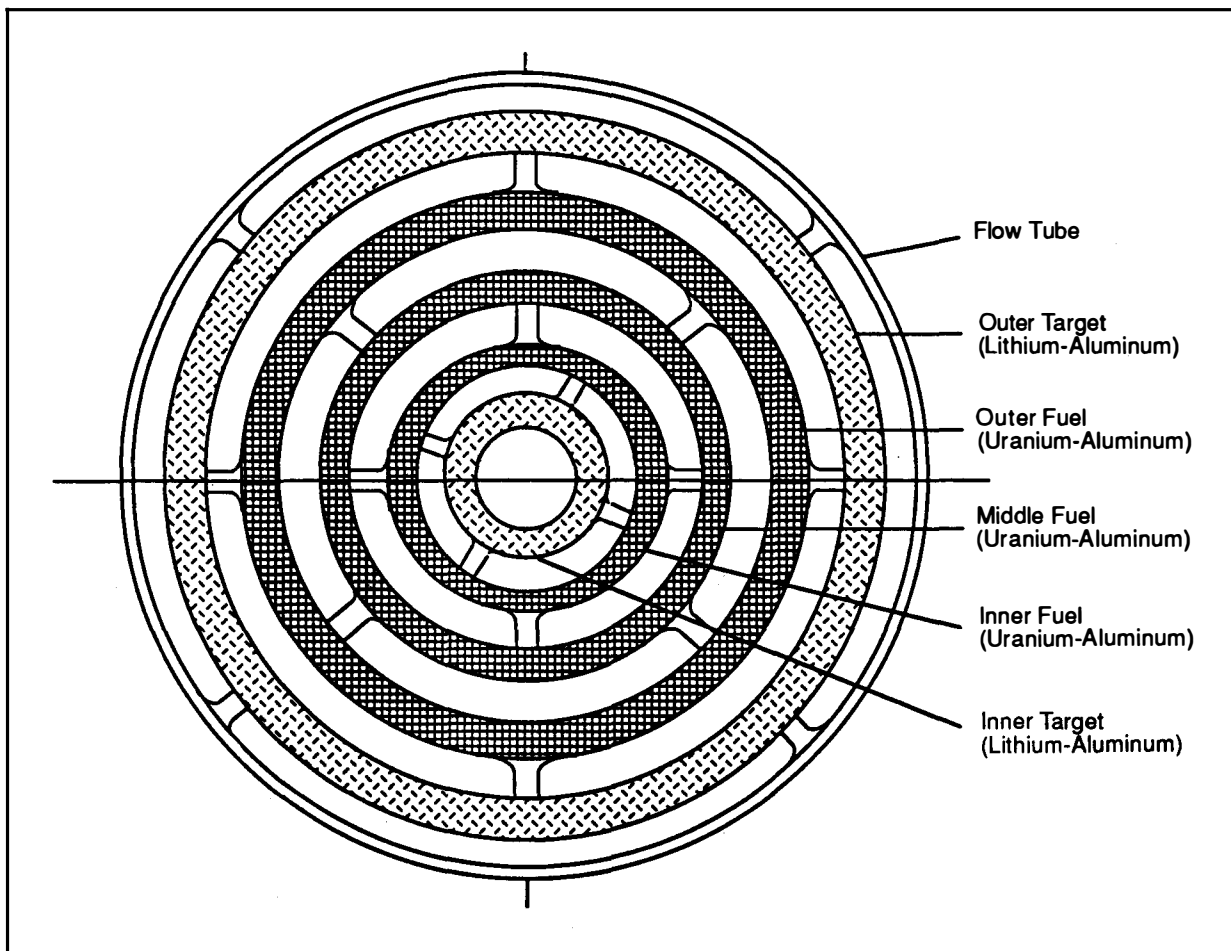


FIGURE A.7 HWR Fuel and Tritium-Target Assembly Configuration at SRS (Source: Modified from WSRC 1991b)

Solid wastes from fuel and tritium-target fabrication would include low-level waste produced mainly as slurry waste from the area wastewater treatment facility and used HEPA filters; hazardous wastes, primarily fluorocarbon compounds used as degreasing agents; and nonradioactive nonhazardous waste.

A.2.4 Fuel/Plutonium-239 Target Fabrication

A.2.4.1 Facility Description

The fuel assemblies for plutonium-239 production would be fabricated in buildings 320-M and 321-M (Section A.2.3.1). The plutonium-target slugs would be fabricated in Building 313-M. This building has cleaning, etching, nickel-plating, bonding, autoclaving, inspection, and finishing areas, and offices and shops.

A.2.4.2 Fuel/Target Description

The plutonium production driver-fuel assembly would be similar to the tritium-target assembly. The fuel for plutonium production would have a lower uranium enrichment, less lithium in the inner target tube, and no lithium in the outer target tube compared with the tritium-target assembly. The proposed HWR target assembly would consist of two concentric stacks of slugs of depleted uranium clad in aluminum (Figure A.8).

A.2.4.3 Process Description

The process to fabricate fuel for plutonium production would be similar to the process described in Section A.2.3.3 for tritium targets. The process used to fabricate depleted uranium targets (Figure A.8) would be a minor variation of the process discussed in Section A.2.3.3 and would involve three major process steps.

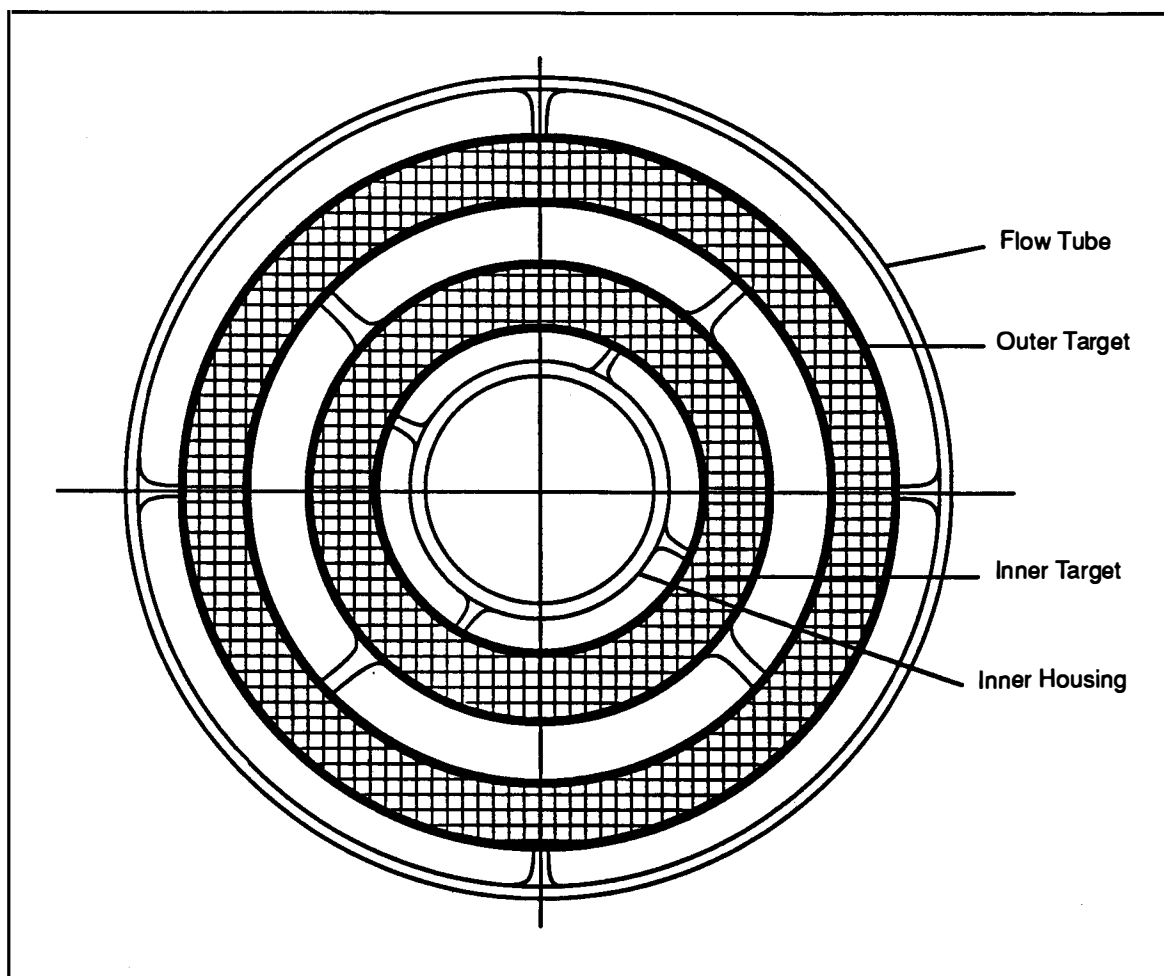


FIGURE A.8 Heavy-Water Reactor Plutonium-Target Assembly at SRS (Source: Modified from WSRC 1991b)

First, finished hollow, cylindrical, nickel-plated, depleted uranium cores would be procured from DOE contractors. Second, the nickel-plated cores would be assembled into the annulus of double-wall aluminum cans with integral bottoms, heated in an inert argon atmosphere, coated with a graphite and water lubricant and a high-pressure, high-temperature-resistant grease, and pressed through a die-plug tooling that bonds the aluminum-can walls onto the nickel-coated uranium core. Finally, the slugs would be cleaned by a ground walnut shell abrasive in a blast cleaner to remove the residual die-sizing lubricant. The final cleaned product would be steam autoclaved to test cladding integrity and to provide a protective oxide film on the surface of the aluminum cladding.

Slug failures in the autoclave typically result in complete disintegration of the uranium metal. Such uranium in the steam condensate would not be recycled, but would be collected and stored as waste material. Slugs rejected at any point in the fabrication process, with the exception of autoclaving, would be recovered, and the uranium cores would be recycled to the feed end of the slug fabrication process.

Assembly components would be mechanically inspected in Building 313-M and shipped directly to the reactor, where the depleted uranium target slugs would be assembled into target assemblies.

A.2.4.4 Process Effluents and Wastes

The ventilation system for the fuel/plutonium-target fabrication facilities would be similar to the ventilation system used in tritium production (Section A.3.4). The only radionuclide released to the atmosphere would be uranium, mainly uranium-235. The principal chemicals would be fluorocarbons, argon, and helium.

Aqueous releases from fuel/plutonium-target fabrication would be low-level liquid wastes from tube, slug, and aluminum component cleaning operations. The releases would be low-level liquid waste; the only radioactive material would be uranium, mainly uranium-235.

Solid wastes produced as part of the fuel/plutonium-target fabrication operation would include low-level waste, produced mainly as slurry waste from the area wastewater treatment facility, and used HEPA filters; mixed waste from uranium-target production; hazardous wastes, mainly fluorocarbons used as degreasing agents; and nonradioactive nonhazardous waste.

The nonradioactive gases released via the stack would be air and gases from the process (argon, helium, and nitrogen).

A.2.5 Spent Fuel Processing

For the purpose of this EIS, it is assumed that spent fuel would ultimately be disposed of in a Federal repository. Spent fuel processing is analyzed in this EIS as part of the original mission of NPR, which included the production of virgin plutonium-239. However, plutonium production is no longer part of the NPR proposed action. The Waste Management PEIS will assess the impacts of wastes from reprocessing of spent fuel from DOE reactors.

A.2.5.1 Facility Description

The spent fuel at SRS is highly enriched uranium fuel that has been irradiated in the reactors. These spent fuel assemblies are processed through Building 221-H (H-Canyon) and associated facilities to recover uranium from the spent fuel.

Building 221-H is a massive, reinforced-concrete structure designed to withstand external blast pressures of 4.8×10^4 Pa. The building is 255 m long, 37 m wide, and 20 m high and has 31,000 m² of floor space. The building consists of seventeen 13-m sections and one 28-m section located at the south end. Combined, these 18 sections form a "double-canyon" structure for processing radioactive material. The two canyons are surrounded by piping, chemicals, ventilation equipment, and operating personnel areas. All equipment that handles potentially highly radioactive materials is located in one of two parallel longitudinal building sections. These sections are designated the "Hot Canyon" and the "Warm Canyon" to indicate the radiation intensities of the materials being processed. Major vessels and pumps are isolated in the 18 sections or cells, which have massive removable covers. Remote maintenance is performed by using modified industrial bridge cranes.

An engineered ventilation system maintains controlled airflow from areas that have little or no contamination to areas of greater contamination. Ventilation air and off-gas from process vessels are treated to minimize the radioactive material released to the environment.

Air treatment systems used in H-Canyon include condensers, absorbers, and filters. Air exhausts from the canyon pass through a very large sand filter to remove particulate radionuclides before being released to the atmosphere. Because H-Canyon was originally designed to process fuel from five reactors, its capacity is adequate to serve the three existing SRS reactors plus the spent fuel from the proposed NPR.

A.2.5.2 Process Description

The H-Canyon facility currently uses multistage solvent extraction to separate uranium, neptunium, and fission products from irradiated uranium fuels containing 1.1-94 wt% enriched uranium-235. Figure A.9 shows the process flow. Before being processed, the irradiated fuels are aged approximately 1 year to allow short-lived radionuclides (i.e., iodine-131) to decay. In Building 221-H, aluminum-clad fuels are dissolved in nitric acid using a mercury catalyst. Uranium is separated from fission products by multistage solvent extraction of the dissolved product with tributyl phosphate in kerosene. The solvent extraction operation produces purified nitrate streams of uranium, a high-level waste stream containing most of the fission products present in the irradiated fuel, and low-level aqueous waste streams such as condensed evaporator overheads.

The purified nitrate streams produced by the solvent extraction operation are converted to solids. Uranium is converted from nitrate to oxide (UO₂) by a process in which the uranium nitrate is evaporated and then thermally denitrated. Plutonium nitrate solution is converted to oxide in the HB line located on top of Building 221-H. Spent fuel processing for the NPR would separate uranium and fission products from the spent fuel.

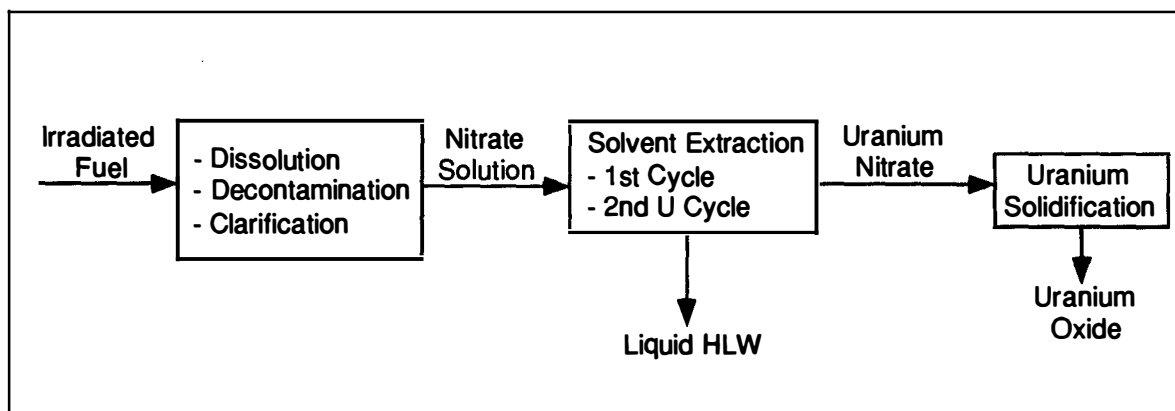


FIGURE A.9 Flow Diagram for Processing Irradiated Fuel to UO_3 at SRS (H Area)
(Source: Modified from WSRC 1991b)

A.2.5.3 Process Effluents and Wastes

The operation of the H-Canyon produces gaseous, liquid, and solid wastes. The gaseous wastes are primarily wastes associated with the dissolution of the spent fuel. These gaseous wastes are released to the atmosphere after treatment for iodine adsorption and after filtering through HEPA filters. Releases of radioactivity are discussed in Sections 5.3.2, 5.3.3, and 5.3.4 of WSRC 1991b and in Appendix H of the EIS.

The high-level aqueous waste from H-Canyon processes contains essentially all of the fission products, activation products from irradiation of cladding and other components, aluminum associated with the fuel, and chemicals added during processing. The nitric acid waste stream is neutralized with sodium hydroxide before being discharged from the building to the underground tanks in the H-Area tank farm. Nitric acid from the high-level gaseous waste is recovered for reuse. The HWR incremental amount is estimated to be about one-third the volume resulting from the three operating reactors at SRS. The NPR low-level liquid wastes produced during operation of the H-Canyon would be processed through the F- and H-areas Effluent Treatment Facility. Radioactive solid waste also would be produced during the fuel processing activities.

A.2.6 Tritium-Target Processing

A.2.6.1 Facility Description

Tritium-target processing would take place in the new Replacement Extraction and Purification Facility at SRS. The facility would consist of two attached structures: a process building and a support building. One structure would house the processes, laboratory, and other activities associated with handling tritium and other radioactive materials. It would also include enclosed truck docking facilities, a target cleaning and drying room, a crucible storage room, and a furnace room.

The process building would be a 2,800-m² reinforced-concrete structure constructed to resist a design-basis earthquake and tornado and wind loadings. The building would include a hot cell for receiving, storing, and processing irradiated target rods.

Most of the process operations and hot laboratory analyses would be carried out in nitrogen-blanketed gloveboxes to ensure tritium containment. The hot cell would contain two or more vacuum furnaces for extracting tritium from the irradiated targets. The hot cell would be about 12 m high. Airlocks would separate the furnaces from the rest of the hot cell.

The support building would be a 1,900-m² one-story structure, containing nonradioactive support activities, including offices, a lunch room, nonradioactive maintenance areas, and nonradioactive ventilation systems.

A.2.6.2 Process Description

The irradiated assemblies are moved from the reactor to the spent fuel pool. After 1 month or more, the tritium-target tubes would be withdrawn from the assemblies. The target tubes, along with the blanket assemblies and the control rods, would be transferred as bundles by cask trailer to the new Replacement Extraction and Purification Facility. The target tubes, blanket assemblies, and control rods would be washed within the shielded transport cask, then placed in a crucible, inserted into a furnace, and heated to drive off the gases, including the tritium product. The gas stream from the furnace, mainly helium and hydrogen isotopes, including tritium, would pass through a palladium diffuser to separate the hydrogen isotopes from helium and other impurities.

The hydrogen isotopes would be purified using a thermal cycling absorption process. This process would cycle the gas between two beds of palladium-coated kieselguhr. One bed would be heated to drive off the gases; the other bed would be cooled to promote gas absorption. Tritium separation would be accomplished because the tritium would be preferentially retained on the palladium-coated kieselguhr. The purified tritium would be sent to the loading facility, where tritium reservoirs are filled. A process flow diagram is presented in Figure A.10.

A.2.6.3 Process Effluents and Wastes

The only gaseous radioactive release expected from the Tritium-Target Processing Facility would be tritium, either as gaseous tritium or tritiated water. The estimated releases would total less than 5,000 Ci/yr. The materials handled in the process and the off-gas treatment system would ensure that no releases of radioactive particulates would occur. The release of radioactivity from tritium-target processing is discussed in Sections 6.3.2, 6.3.3, and 6.3.4 of WSRC 1991b.

All low-level (tritiated) liquid wastes produced by the tritium-target processing operation would be solidified within the facility. Solid low-level wastes would include the solidified liquids, spent catalysts and resins, spent uranium beds, spent HEPA filters, spent targets, and miscellaneous items (i.e., gloves and clothing). These wastes would be packaged and disposed of within the sitewide waste management system (Section A.2.9).

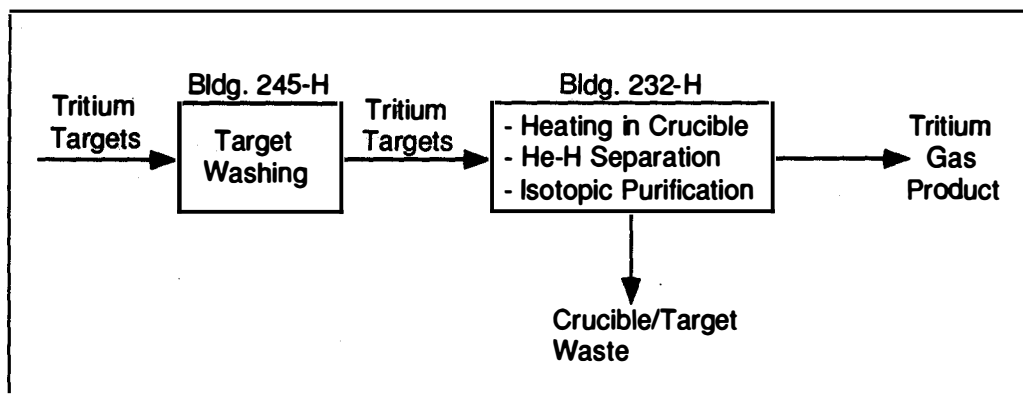


FIGURE A.10 Flow Diagram for Existing Tritium-Target Processing at SRS (Source: Modified from WSRC 1991b)

A.2.7 Fuel/Plutonium-Target Processing

A.2.7.1 Facility Description

Building 221-F (F-Canyon) is a double-canyon structure very similar in design to the H-Canyon structure (Section A.2.5.1), but 3.3 m wider. Irradiated depleted uranium targets at SRS, which are the source of new plutonium, are presently processed through Building 221-F and its associated facilities to recover uranium and plutonium from the spent fuel.

A.2.7.2 Process Description

The F-Canyon facility uses the Plutonium-Uranium Extraction (PUREX) process to separate uranium, plutonium, and fission products contained in the irradiated targets. The process flow is shown in Figure A.11.

In the PUREX process, a sodium hydroxide solution is used to dissolve aluminum cladding from the targets. After the cladding has been dissolved, the uranium target is dissolved in nitric acid. Uranium and plutonium are separated from fission products and from each other by multistage solvent extraction with tributyl phosphate in kerosene. The uranium is converted from the nitrate form to UO_3 in the A line. The plutonium nitrate solution is converted to metal in the B line in Building 221-F (Figure A.11).

A.2.7.3 Process Effluents and Wastes

Operation of the F-Canyon produces gaseous, liquid, and solid wastes. The gaseous wastes are generally associated with the dissolution of the irradiated targets. These gaseous wastes are released to the atmosphere after treatment by appropriate absorption or filtration. The release of radioactivity is discussed in Sections 7.3.2, 7.3.3, and 7.3.4 of WSRC 1991b.

The high-level aqueous waste from the F-Canyon processes is similar to the waste described for H-Canyon (Section A.2.5.3), except the volume from NPR operated in the

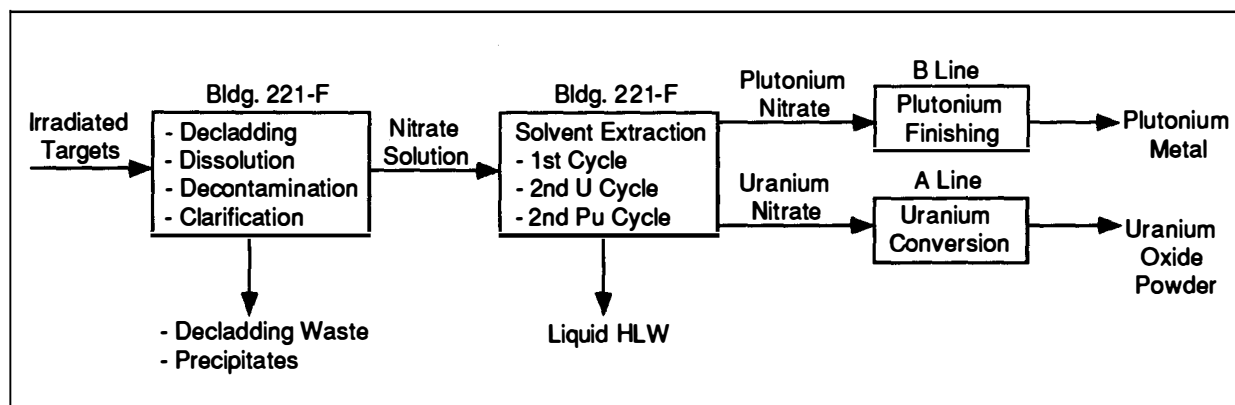


FIGURE A.11 Flow Diagram for Plutonium-Target Processing at SRS (Source: Modified from WSRC 1991b)

plutonium production mode would be less than the volume from the tritium production mode. The low-level liquid wastes are processed through the F- and H-areas Effluent Treatment Facility. Solid wastes would be produced by depleted uranium-target processing operations.

A.2.8 Plant Operation

The resource requirements for normal operation of the HWR and its support facilities are summarized in Table A.3. The additional staff needed to operate each facility in support of the HWR is shown in Table A.4.

The estimates of operational requirements assume continued operation of the existing P, K, and L reactors and the simultaneous use of the support facilities for the fabrication and processing of fuel and targets for the NPR and for the P, K, and L reactors. The requirements (except for staffing) attributed to NPR were estimated for the increase over a baseline experienced in full operation of P, K, and L reactors. These additional requirements would be well within the existing SRS capacity. The additional NPR staffing requirement was computed as follows: the increase required by NPR was added to the baseline number required in support of P, K, and L operations, and the total was divided by four.

A.2.9 Sitewide Waste Management

The NPR support facilities would produce a variety of waste types: high-level liquid radioactive waste; low-level radioactive aqueous wastes; radioactive solid waste (low- and intermediate-level solid waste); transuranic (TRU) waste; hazardous waste; mixed waste, which contains both radioactive and hazardous components; and other wastes (nonradioactive nonhazardous waste). Flowcharts for liquid and solid wastes for the HWR complex are presented in Appendix M. All these wastes are currently being generated and managed at SRS in a manner consistent with DOE orders and applicable Federal, state, and local regulations. In addition, improvements are being made to and planned for the waste management systems.

TABLE A.3 Estimated Annual Commodity Requirements for Operation of the HWR Complex

Commodity	Unit	Hanford		INEL		SRS	
		Tritium Mode	Plutonium Mode	Tritium Mode	Plutonium Mode	Tritium Mode	Plutonium Mode
Energy							
Electric energy	MWh	774,000	813,000	757,000	793,000	796,000	791,000
Fuel (diesel, gasoline, kerosene)	L	1.33×10^6	1.33×10^6	1.27×10^6	1.26×10^6	3.78×10^6	4.39×10^6
Steam	kg	6.64×10^8	6.92×10^8	6.63×10^8	6.61×10^8	9.31×10^7	9.98×10^7
Steam coal ^a	t	440	7,740	Electric	Electric	10,000	16,000
Materials							
Metals							
Aluminum for alloying/casting	t	18	8.60	18	8.60	18	8.60
Aluminum components	t	27	15.5	27	15.5	27	15.5
Depleted uranium (0.2% U-235)	t	0	414	0	414	0	414
HEU ^b metal (60-80% U-235)	t	2.6	2.5	2.5	2.5	2.6	2.5
Lithium metal (Li-6 enriched)	kg	280	45	280	45.4	280	45
Stainless steel	kg	150	10	150	10	150	10
Chemicals/cleaners/dissolvers							
Decontamination solutions	L	75,000	119,000	80,000	107,000	75,000	119,000
Degreaser	t	19	9.30	19	9.30	19	9.30
Hydroxylamine nitrate (18%)	t	4.95	28	0	0	0	60
Hydrazine (11.3M)	t	40	47	38.6	38.6	38.6	38.6
Nitric acid (fresh) (50 wt%)	L	180,000	960,000	53,000	1.35×10^6	310,000	2.1×10^6
Phosphoric acid	t	0.50	13.6	0.50	13	0.50	11

TABLE A.3 (Cont'd)

Commodity	Unit	Hanford		INEL		SRS	
		Tritium Mode	Plutonium Mode	Tritium Mode	Plutonium Mode	Tritium Mode	Plutonium Mode
Chemicals/cleaners/ dissolvers (cont'd)							
Sodium hydroxide (50 wt%)	t	86.6	427	29	388	169	423
Sodium nitrate	t	0	86.4	0	114	0	787
Sodium nitrite	t	0	22.7	0	22.7	3	10.8
Sulfuric acid	t	1,800	1,800	1,800	1,800	1,770	1,770
Water							
Cooling system	m ³	4.3×10^7	4.3×10^7	4.26×10^7	4.26×10^7	5.53×10^7	5.53×10^7
Process and other	m ³	1.29×10^6	1.54×10^6	1.83×10^6	1.98×10^6	4.02×10^6	3.32×10^6
Work force ^c	Workers	1,249	1,124	1,037	1,532	851	971

^aSome Hanford steam electrically produced; all INEL steam electrically produced; all SRS steam obtained from existing coal-fired steam plants.

^bHEU = highly enriched uranium.

^cHWR operation at SRS assumes concurrent operation of existing K, L, and P reactors.

Source: Roman 1991.

**TABLE A.4 HWR Operations Staffing Requirements
(Number of Employees)**

Facility	Hanford	INEL	SRS ^a
Reactor Facility and subfacilities ^b	470	470	470
Tritium-Target Fabrication	76	76	76
Plutonium-Target Fabrication	81	81	81
Spent Fuel Processing			
Tritium mode	495	283	75
Plutonium mode	495 ^c	283 ^c	75
Tritium-Target Processing			
Tritium mode	130	130	21
Plutonium mode	0 ^d	0 ^d	0 ^d
Plutonium-Target Processing	495	620	82
Waste Management	78	78	209
Total			
Tritium mode	1,249	1,037	851
Plutonium mode	1,124	1,532	917

^aAssumes operation of existing K, L, and P reactors.

^bIncludes 120 workers at the Heavy-Water Processing Facility.

^cIncluded in plutonium mode total.

^dExcludes workers to process one tritium target per driver-fuel assembly.

Sources: Bean 1990; Bowman 1990; Evans 1990.

A.2.9.1 Waste Management Facilities

The principal waste treatment and disposal facilities expected to be in full operation at the time of initial start-up of the NPR are described in this section. Some of these facilities are in the design or construction phase.

The DOE's NPR operations will be conducted consistent with commitments DOE has made and will make in compliance agreements with state and Federal regulatory authorities. If it should become necessary, DOE will work with the regulators to incorporate NPR needs into existing agreements or to develop new agreements to ensure continued compliance. Under no circumstances will DOE's performance pursuant to any existing compliance agreement be compromised or diminished as a result of the NPR project. If there are discrepancies between the waste stream volume and waste treatment capacity figures in the DEIS and in existing compliance agreements, or those currently in negotiation, the figures in the compliance agreements will prevail.

There are 51 large, carbon steel, reinforced-concrete subsurface tanks for storing and processing aqueous high-level radioactive wastes. The H-Area tank farm contains 29 tanks, and the F-Area tank farm contains 22 tanks.

A Saltstone Mixing and Disposal Facility would be located in the Y Area. This facility would be used to dispose of wastes generated by the Building 300-M Fuel Fabrication Facility. A second Saltstone Mixing and Disposal Facility would be operated in the Z Area. This facility would process low-level liquid filtrates from the in-tank precipitation process and from Effluent Treatment Facility concentrates. Slightly contaminated aqueous wastes would be mixed with flyash, slag, and cement in the saltstone facilities. Grout would be pumped via pipeline into an engineered vault and allowed to solidify into saltstone.

The Defense Waste Processing Facility would be used to immobilize high-level waste sludge and separate cesium, strontium, and plutonium in borosilicate glass; encapsulate the waste glass mixture in steel canisters; and store the canisters in a surface facility until shipment to a Federal repository. Baseline operations at SRS are projected to generate wastes at an average of 150 canisters per year. The processing of NPR wastes at the Defense Waste Processing Facility would add 10 to 30 canisters per year.

There are two effluent treatment facilities for processing low-level aqueous waste. One facility is located in the Fuel and Fabrication Area (M Area); the second facility, which is in the H Area, services the F and H areas. Treatment processes would include filtration, reverse osmosis, and ion exchange.

The Waste Certification Facility will continue to process currently generated TRU waste drums containing more than 100 nCi/g of TRU materials. The information required by the Waste Isolation Pilot Plant (WIPP) waste acceptance requirements is recorded, and X-rays verify that the contents would be acceptable for disposal at WIPP or another appropriate facility. Drums that meet WIPP requirements are labeled and bar-coded before shipment to WIPP or another facility.

The proposed Transuranic Waste Processing and Storage Facility will treat or process TRU waste and prepare it for certification and permanent disposal at WIPP or another appropriate facility, or disposal as low-level waste. Processing would consist of opening packages, sorting the waste, and preparing packages that comply with specific disposal requirements.

The proposed Consolidated Waste Incinerator Facility will be used to detoxify and reduce the volume of solid and liquid combustible hazardous, radioactive mixed, and low-level radioactive waste generated at SRS. Ash and blowdown produced from the incineration processes will be stabilized in a cement matrix before being sent to the Resource Conservation and Recovery Act (RCRA)-permitted Hazardous/Mixed Waste Disposal Area.

A.2.9.2 Liquid Waste Processing

Radioactive liquid wastes are either high- or low-level waste and are processed accordingly. High-level aqueous waste is produced by the spent fuel processing operations in Building 221-H and by the depleted uranium-target processing operations in Building 221-F. In addition to the fission products, the waste stream contains activation products resulting from irradiation of the fuel and depleted uranium elements, aluminum associated with the fuel, and chemicals added to the process to effect the recovery and purification of the uranium and plutonium.

The nitric acid waste stream is neutralized with sodium hydroxide before it is discharged from the buildings to large underground high-level waste storage tanks. In the tanks, the waste forms a residual liquid and a solid, which is mainly insoluble hydroxides and oxides. The solid, called sludge, settles to the bottom of the waste tanks. The liquid is evaporated as much as possible, and the remaining liquid is processed for disposal.

Processing liquid wastes consists of several steps. First, in-tank precipitation (decontamination) of the liquid is effected by the addition of sodium tetraphenylborate and sodium titanate to precipitate radioactive compounds (mainly cesium) and to adsorb strontium and plutonium from the supernate. The solution is then filtered, and because the resulting filtrate contains less than 0.1% of the initial radioactivity, it is considered a low-level radioactive mixed waste stream. This stream is transferred to the Saltstone Mixing and Disposal Facility in the Z Area, where it is mixed with flyash, slag, and cement. The slurry (saltstone) produced by the mixing of these materials is pumped to disposal vaults, where it is allowed to harden. Although the incoming waste stream contains hazardous constituents, the resulting saltstone is nonhazardous and is disposed of in non-RCRA-permitted vaults.

Second, the sludge is washed to remove the aluminum and other soluble salts. The washed sludge and the precipitate removed by the decontamination process are slurried and pumped to the Defense Waste Processing Facility, where the mixture is treated, combined with glass formers, and vitrified into a borosilicate glass matrix for disposal in a Federal high-level waste repository.

Low-level aqueous wastes are mainly produced in the fuel/plutonium-target processing areas and in the fuel and target fabrication areas. The streams are mainly evaporator overheads and wash solutions that contain low but measurable quantities of radioactive materials and chemicals. These streams are processed through one of two effluent treatment facilities. The M-Area facility receives wastewaters from the fuel and target fabrication activities. The H-Area facility services the H- and F-area fuel processing and plutonium-target processing activities, respectively. Both facilities are used to reduce the radioactivity and chemical concentrations to very low levels before the water is released to on-site streams, in accordance with conditions specified in National Pollution Discharge Elimination System permits. The concentrated wastewater from the F and H areas is transferred to the H-Area tank farm for subsequent transfer to the Saltstone Mixing and Disposal Facility for solidification and disposal. The concentrated waste from M-Area treatment would also be transported to the Saltstone Mixing and Disposal Facility.

A.2.9.3 Solid Waste Processing

Operation of the HWR would produce low-level waste (e.g., equipment, contaminated protective clothing, plastic sheeting, spent HEPA filters from off-gas systems, and spent resins from low-level liquid waste treatment). Material with a surface dose rate of less than 300 mR/h at 8 cm would not exceed limits requiring classification as waste for greater confinement disposal or as transuranic waste. The waste may include significant amounts of tritium; however, if tritium is involved, the material would be stored in above-grade concrete vaults until the tritium has decayed. If the material does not contain tritium, the waste would be packaged in waste containers and disposed of in underground concrete vaults.

Operation of the fuel processing and plutonium-target processing facilities would produce additional low-level (which SRS classifies as intermediate-level) solid waste. This material would have a surface dose rate of greater than 300 mR/h at 8 cm and would include spent melt crucibles and failed equipment. It would be buried in underground concrete vaults.

These operations would also produce transuranic waste because of the irradiation of uranium. The low-level waste that contains transuranic materials at levels between 10 and 100 nCi/g would be buried in underground concrete vaults. Waste containing transuranic materials at levels greater than 100 nCi/g are classified as transuranic waste and would be sent to the Waste Certification Facility or another appropriate facility, where the activity level, waste form, and packaging would be certified for shipment to the Waste Isolation Pilot Plant or another appropriate facility. Additional waste treatment before shipping would take place in the Transuranic Waste Processing and Storage Facility.

The combustible mixed waste (except for polychlorinated biphenyls [PCBs]) would be processed through the Consolidated Incinerator Facility, which would destroy some of the hazardous waste components. The ash from the incinerator would be stabilized as ashcrete and sent to the Hazardous/Mixed Waste Disposal Area. The PCBs would be sent off-site for treatment and disposal. The noncombustible portion of the mixed waste would be compacted, stabilized, and disposed of at the RCRA-permitted Hazardous/Mixed Waste Disposal Area. Hazardous waste would be treated in the same way as mixed waste.

A.3 HEAVY-WATER REACTOR TECHNOLOGY AT HANFORD

A.3.1 Introduction

This section provides information on the proposed design and operation of a heavy-water reactor at Hanford. The contents of this section are largely abstracted from Hanford reports for the reactor (WHC 1989a) and for the support facilities (WHC 1989b), except where otherwise referenced. These reports refer in large part to Savannah River reports that describe a heavy-water reactor (WSRC 1991a) and its support facilities (WSRC 1991b) constructed and operated at SRS.

A.3.1.1 New and Existing Facilities Required for the NPR

A new reactor and new support facilities would need to be constructed for an HWR at Hanford. To adapt the HWR to Hanford, the HWR Reactor Facility described in Section A.2.2 would need to be modified in the following areas: the facility layout, cooling water requirements for operation under Hanford meteorological conditions, raw water intake and discharge systems, the circulating water subsystem waste, and the off-site electric power system.

Fuel and tritium targets would be fabricated in a new building constructed near the reactor. Plutonium targets would also be fabricated in a new building separate from but adjacent to the facility for fuel and tritium-target fabrication. A Heavy-Water Processing Facility would be constructed near the reactor. This facility would be used to purify and upgrade the initial heavy-water inventory (presently in storage at SRS) and the operational heavy water. Tritium targets would be processed in a new facility installed in the existing Fuels and Materials

Examination Facility. Spent fuel and plutonium targets would be processed in the new Spent Fuel Processing Complex, which would be constructed in the Hanford 200-East Area. Existing and planned waste management facilities would support all NPR operations.

A.3.1.2 Location

The proposed NPR site for a heavy-water reactor facility is in the southeast portion of DOE's Hanford Site in Benton County, Washington. The regional location and the boundaries of the Hanford Site are discussed in Section 3.3. The location of the HWR facility (Figure A.12) and its selection are discussed in Section 3.3.2.

A.3.1.3 Existing Facilities, Utilities, and On-site Transportation

The existing Fuels and Materials Examination Facility would be used for tritium-target processing (Section B.2.3.1). Existing sitewide waste management facilities are described in Sections 4.1.10 and A.3.9. Existing electric transmission, steam, and water systems are described in Section 3.2.3.1. On-site transportation is described in Section 4.1.9.

A.3.2 Heavy-Water Reactor Facility

The information provided in Section A.2.2 for the heavy-water reactor at SRS is adequate for the HWR adaptation at Hanford, except for the following. The description of the plant structures gives the actual orientation of the site and indicates the structures that would be constructed on-site. The description of the circulating water subsystem has been revised to reflect the effects of cooling tower water use and the raw water intake and discharge system at Hanford. Additional information on bounding water use reflects raw water makeup requirements for operation under Hanford meteorological conditions. Information on the circulating water subsystem waste reflects chemical composition and metal concentration in Columbia River water and in the cooling tower blowdown. Information on the off-site electrical power supply reflects the Hanford electric power supply system.

A.3.2.1 Plant Structures

The HWR site at Hanford (Figure A.4) is similar to the heavy-water reactor site at SRS (Section A.2.2), except that the orientation takes advantage of the natural slope at Hanford (also shown in Figure A.4), which provides gravity flow for the circulating water subsystem. The HWR structures include the reactor building, control building, reactor support buildings, heavy-water purification building, pumphouses, water intake and effluent basins, cooling towers, and other necessary administrative and support facilities. The reactor site would also include the tritium-target and plutonium-target fabrication facilities described in Sections A.3.3 and A.3.4, respectively.

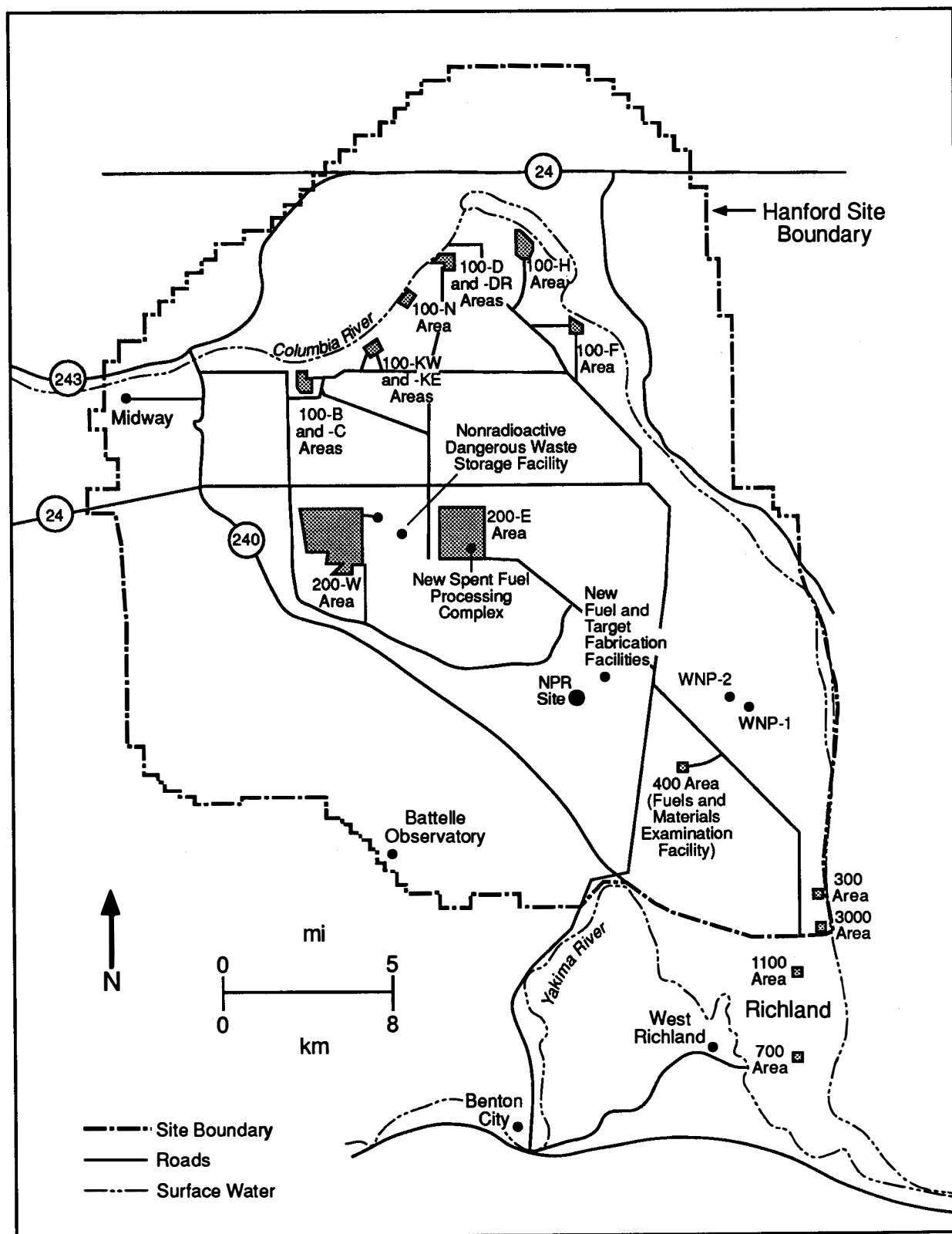


FIGURE A.12 Locations of the Proposed NPR Site and Existing Facilities at Hanford (Source: Modified from PNL 1989)

A.3.2.2 Heat Dissipation Systems

Cooling System

The cooling system would include three cooling towers, a 95,000-m³ intake basin, a pumphouse, a secondary cooling system for all processes, a 3,800-m³ effluent basin, and a pumping system that returns heated water to the cooling towers. The water would be chlorinated raw water, which, during normal reactor operation, would be pumped from the intake basin through the shell side of the heat exchangers.

The cooled water from each tower would flow under gravity through a flume to the intake basin. Some circulating water would be discharged to the Columbia River as blowdown to prevent excessive buildup of dissolved solids. Makeup water for water lost by evaporation, drift, and blowdown would be pumped from the Columbia River.

Water would enter each cooling tower and flow downward through polyvinyl chloride fill material countercurrent to the airflow provided by nineteen 150-hp fans. Each concrete cooling tower would be approximately 18 m above grade and approximately 76 m in diameter. The water level in each cooling tower basin would be approximately 3 m above the water level in the intake basin to permit gravity flow.

The maximum water evaporation would occur during July or August; the average rate for these months would be 1.15 m³/s. The makeup water requirement would be 4.3×10^7 m³/yr if the plant were to operate continuously at peak power. The coincidental blowdown to maintain five cycles of concentration in the circulating water would be 8.5×10^6 m³/yr (all under the bounding case; see Table A.1).

Raw Water System

The raw water system would be an open-loop system that provides the plant makeup water from the Columbia River. This system would operate over the full range of normal plant operating conditions. The quantity of makeup water would mainly be dependent on water losses from the circulating water subsystem in the form of cooling tower evaporation, drift, and blowdown. The projected maximum demand for raw water is 1.43 m³/s. The peak makeup water flow represents less than 0.1% of the regulated minimum Columbia River flow.

The raw water intake pumphouse would be constructed on the west shore of the Columbia River, approximately 11 km from the NPR site at River Mile 361.5. The pumphouse would contain three pumps; two pumps would supply the plant's maximum water requirements and a third pump would serve as a spare. Two pumps would also supply makeup water required by the plant when the unit is not operating. Each pump would discharge into a pipe header that would convey the raw water from the river to the intake basin. The intake system would be composed of three water inlets located above the riverbed and three inlet lines approximately 335 m long running below the riverbed to the pumphouse sump. The river depth at the intake point would be 4.2 m during minimum river flow (1,020 m³/s). The intake and discharge configurations are shown in Figure A.13. The water inlets would be designed to limit openings to a maximum of 0.93 cm and to limit intake velocity to a maximum of 0.15 m/s. This design velocity would be well below the acceptable limit required for protection of small fish

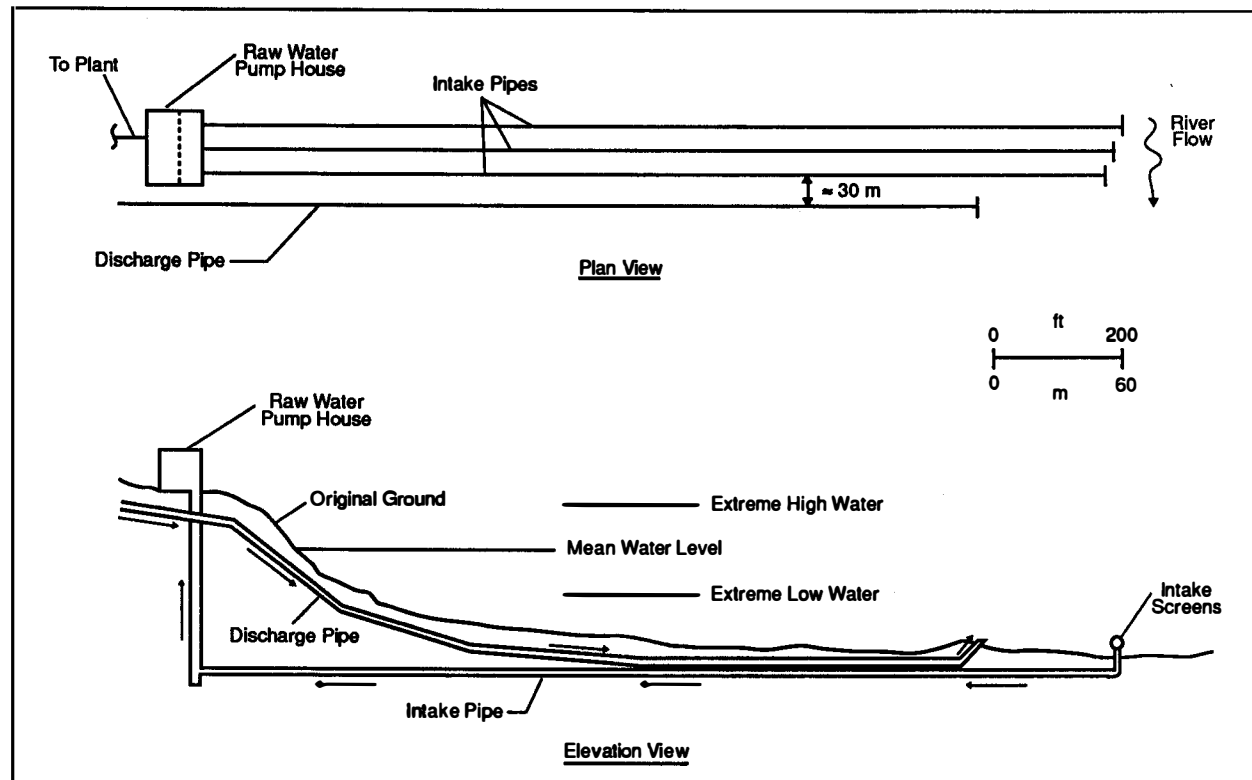


FIGURE A.13 HWR Intake and Discharge Configurations at Hanford (Source: Modified from WHC 1989a)

when water is being taken into the system. The river velocity would always be greater than the inlet velocity and would be along the faces of the inlets, thus tending to wash fish and debris clear.

The discharge system would be a single pipe running from the plant to the Columbia River. The pipe would enter the river approximately 30 m downstream of the intake, continue along the river bottom, and terminate in a single discharge nozzle about 167 m from the river's low-water line. Riprap would prevent pipe movement or riverbed scour.

The maximum HWR blowdown flow rate to the Columbia River would be approximately $0.28 \text{ m}^3/\text{s}$; however, the discharge line would accommodate a maximum discharge rate of $0.4 \text{ m}^3/\text{s}$ if it were necessary to blow down at lower cycles of concentration.

The HWR may be operated with significant seasonal variations in actual peak power. To bound potential thermal emissions, a peak reactor power of 3,125 MWt is assumed, with a designed heat dissipation system capacity of 3,300 MWt. The raw water makeup requirements for operation at 3,300 MWt are given in Table A.1.

A bounding estimate of annual makeup water requirements can be derived by assuming that the annual makeup water requirement is 100% of the monthly average makeup requirements for the year, or $4.3 \times 10^7 \text{ m}^3/\text{yr}$ for five cycles of concentration of the secondary coolant.

Water Treatment System

Cooling tower blowdown would be discharged to the Columbia River. The concentration of dissolved solids in the circulating water would be maintained at approximately five times the concentration of the makeup water (five cycles of concentration).

For alkaline scale control, sulfuric acid would be continuously fed to the system; no other scale or corrosion inhibitors would be used. Biological fouling in the circulating water subsystem would be controlled by intermittent chlorination using the same technique mentioned in Section A.2.2.9.

Principal chemicals added to the blowdown during water treatment would be chloride and sulfate compounds. Metals added to plant effluent would include chromium, nickel, and iron, which are products of component erosion. Although other chemicals and erosion products would exist in the blowdown as a consequence of plant operation, the amounts would be negligible relative to the natural concentration of chemicals and metals in Columbia River water.

A.3.2.3 Electric System

The Hanford off-site electric power supply to the main site is provided by the H.J. Ashe Substation, which is capable of supplying two independent power sources via separate parallel 230-kV transmission lines.

A.3.3 Fuel and Tritium-Target Fabrication

Fuel and tritium targets would be fabricated in a new facility that would be constructed adjacent to the reactor (Figure A.4). Two fabrication buildings would be provided to avoid mixing highly enriched uranium and depleted uranium materials. One building would be used to produce highly enriched uranium driver fuel and tritium targets. Another building would be used to produce plutonium targets. Plutonium-target fabrication is discussed in Section A.3.4.

A.3.3.1 Facility Description

The Tritium-Target Fabrication Facility would resemble a typical industrial plant. It would consist of windowless, steel or prefabricated concrete slab structures with associated service and office buildings. It would be seismically hardened and designed to withstand earthquakes, tornados, and extreme winds. The building would also be designed to control the spread of contamination within the facilities and prevent the uncontrolled release of radioactive material to the environment.

A single facility (nominally 7,400 m²) similar to the facility shown in Figure A.14 would be provided at Hanford. The facility would include areas for alloying, casting, machining, extrusion, inspection, and assembly. Auxiliary services would include a maintenance shop, an electronic and instrumentation shop, clothes-changing rooms, restrooms, lunchrooms, offices, and a metallurgical and chemical laboratory. Outside the main building would be small storage buildings for lithium and aluminum components.

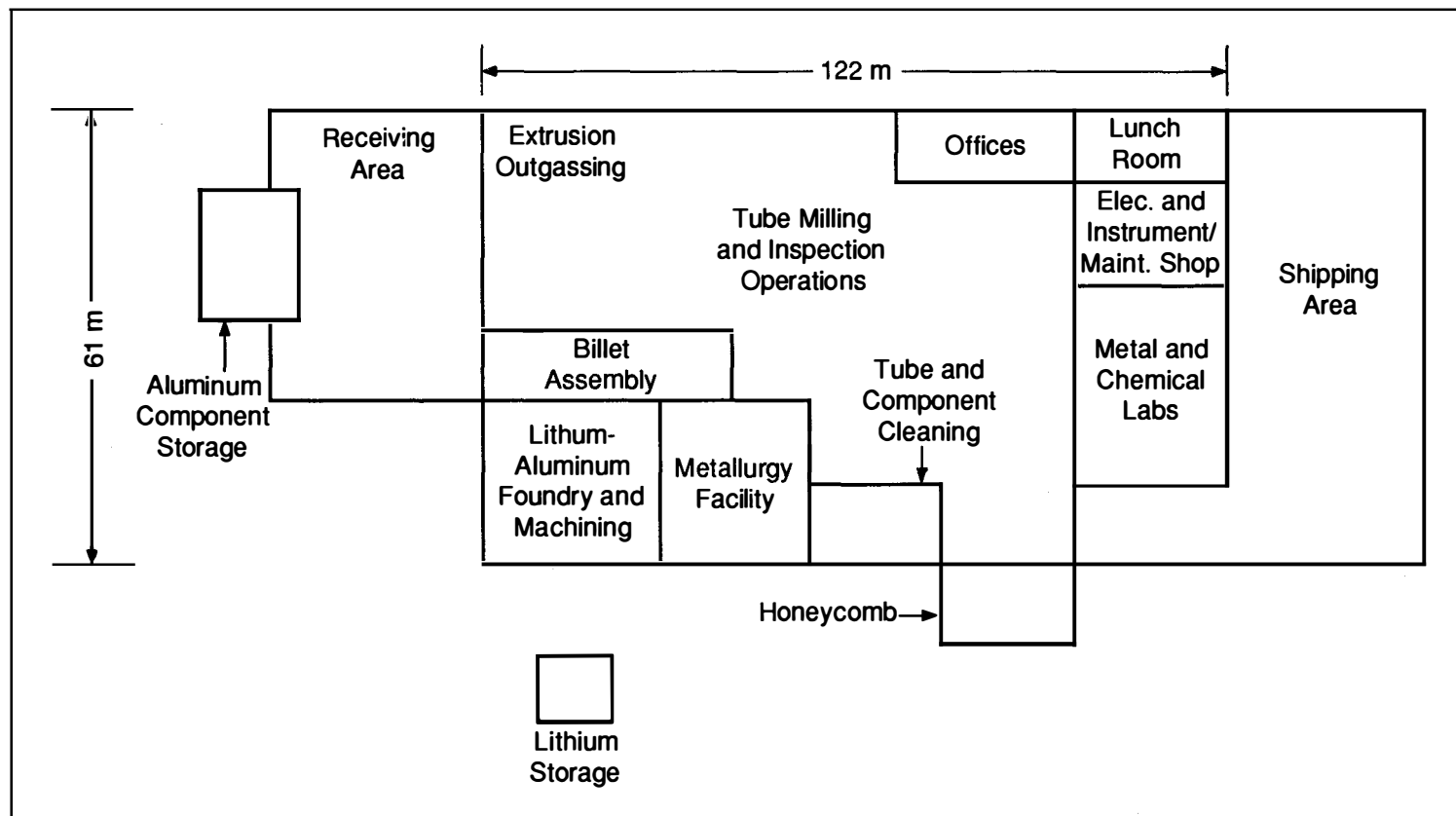


FIGURE A.14 Tritium-Target Fabrication Facility at Hanford (Source: Modified from WHC 1989b)

A.3.3.2 Fuel and Target Description

A description of the fuel and target assembly is given in Section A.2.3.2.

A.3.3.3 Process Description

Section A.2.3.3 describes the tritium-target fabrication processes currently conducted at SRS. The same processes would be used in the single Tritium-Target Fabrication Facility at Hanford.

A.3.3.4 Process Effluents and Wastes

Radioactive and nonradioactive liquid wastes from the solid, mixed, and RCRA wastes generated from fuel and tritium-target fabrication would be similar to wastes for the heavy-water reactor at SRS (Section A.2.3.4), except that they would be treated, packaged, and transferred in accordance with the Hanford sitewide waste management system (Section A.3.9).

The ventilation system for the Tritium-Target Fabrication Facility would use a single air inlet system, where air would be filtered and then preheated or cooled as required. The administrative and computer areas would be supplied by one section of the ventilation system and would have a separate exhaust. Other areas (mechanical, vault, casting, and machining areas) would use an isolated air supply system that would be exhausted through a double set of HEPA filters. The casting and machining equipment would have additional ventilation equipment to handle the dust and particulate materials that might be generated in the vicinity of this equipment. Flows from this equipment would also be discharged through a double set of HEPA filters.

The radioactive particulate releases from the 12-m-high facility stack are estimated on the basis of the generic HWR support facilities document (WSRC 1989b) and will be tabulated in a forthcoming technical memorandum. No gaseous radioactive effluents are expected from the fabrication facility, except for minute amounts of radon-219 and radon-222, which are present in the uranium-235 and uranium-238 decay chains. Quantities of radon-219 and radon-222 would vary according to the age of the uranium feed material (the time since the material was last processed), but are expected to be less than 0.001% of the uranium release values.

A.3.4 Fuel/Plutonium-Target Fabrication

Plutonium targets would be fabricated in a new Plutonium-Target Fabrication Facility that would be adjacent to but physically separate from the new Tritium-Target Fabrication Facility. Fuel for the plutonium production driver-fuel assemblies would be fabricated in the Target-Tritium Fabrication Facility. Thus, both fabrication facilities would operate in support of plutonium production, while only the Tritium-Target Fabrication Facility would operate in support of tritium production.

A.3.4.1 Facility Description

The Plutonium-Target Fabrication Facility would meet the criteria described in Section A.2.4.1. The Hanford facility would be similar to the SRS facility, but would be downsized to support a single HWR.

A.3.4.2 Fuel/Target Description

The driver-fuel and the fuel/target assemblies would be as described for SRS (Section A.2.4.2).

A.3.4.3 Process Description

The fabrication of driver-fuel assembly components and plutonium production assembly components at Hanford would be the same as the fabrication processes at SRS (Section A.2.4.3).

A.3.4.4 Process Effluents and Wastes

Radioactive and nonradioactive liquid wastes from the solid, mixed, and RCRA wastes generated in the support facilities would be similar to wastes for the heavy-water reactor at SRS (Section A.2.3.4).

The ventilation treatment system for the Plutonium-Target Fabrication Facility would be similar to the system for the Tritium-Target Fabrication Facility. In the plutonium production mode, radioactive particulate releases from both stacks would mainly result from fuel fabrication activities and are, therefore, included in the data for the fuel fabrication stack. Again, no gaseous effluents would be released, except for minute amounts of radon-219 and radon-222, which are present in the uranium-235 and uranium-238 decay chains.

A.3.5 Spent Fuel Processing

Spent fuel processing would require construction of a new Spent Fuel Processing Complex. The new facility would accommodate fuel/plutonium-target processing systems; however, installation of the plutonium-target processing system would be deferred until plutonium production is required.

A.3.5.1 Facility Description

The Spent Fuel Processing Complex would be located in the Hanford 200-East Area. Figure A.15 indicates the proposed location of the new facility and its relation to existing facilities. Capabilities incorporated in the Spent Fuel Processing Complex for plutonium-target processing are described in Section A.3.7.

The complex would consist of two main buildings for the processing of spent fuel. Both buildings would be steel-reinforced-concrete structures designed to preclude undue risk to the

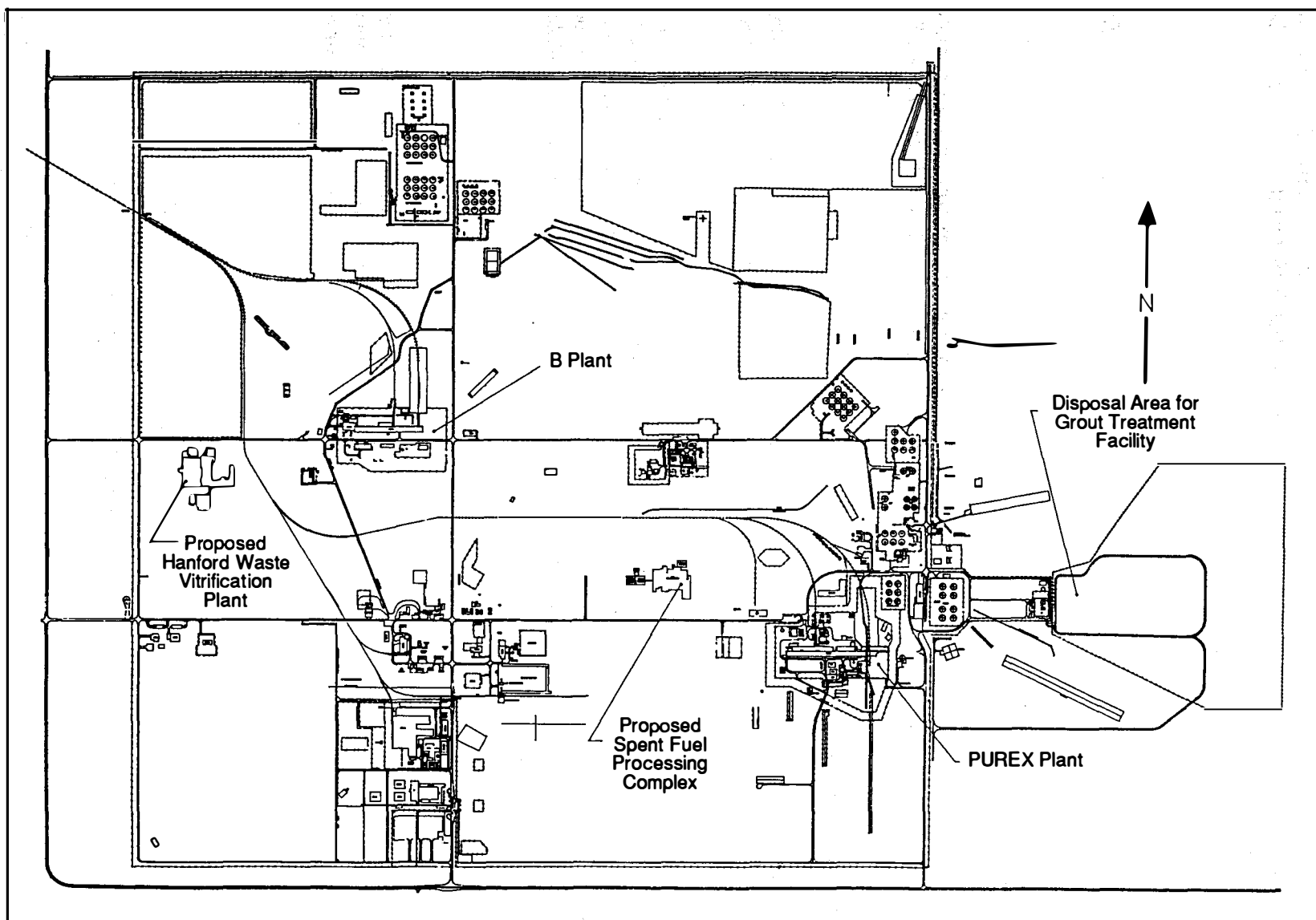


FIGURE A.15 HWR Spent Fuel Processing Complex at Hanford (Source: Modified from WHC 1989b)

off-site population, operating personnel, facilities, and the environment during normal and abnormal operating conditions. Both buildings would also be designed to resist tornadoes, extreme winds, floods, earthquakes, aircraft, explosions, externally generated missiles, internal pressurization, criticality, and other design-basis accidents.

The fuel processing building would contain the equipment for fuel receipt and storage, headend operations, solvent extraction process operations, and ancillary operations such as process off-gas treatment and waste treatment. The uranium recovery building would contain the equipment for concentration of the uranyl nitrate solution from the fuel processing building, the conversion of the solution to uranium oxide, and ancillary operations.

The fuel processing building would be a rectangular structure with overall dimensions of 74 m by 142 m by 37 m high, with a maximum height above grade of 23 m. The uranium recovery building would also be a rectangular structure with dimensions of 30 m by 27 m by 14 m high, with a maximum height above grade of 8 m. The two buildings would be connected by an underground, shielded pipe encasement containing lines for process and waste solution transfers as well as redundant spares. The pipe encasement would provide for leak detection. Figure A.16 gives the layouts of the two buildings.

The processes associated with the Spent Fuel Processing Complex would be contained within shielded cells, where necessary, and in areas designed to limit personnel radiation exposures consistent with as low as reasonably achievable principles.

Support buildings would be required for activities not directly related to the physical processes (e.g., administration, radiation zone, clothes-changing rooms).

A.3.5.2 Process Description

Figure A.17 provides a general description of spent fuel processing. After storage, spent fuel would be directed to the headend process of electrolytic dissolution. The dissolution system would be supported by off-gas systems and solution storage vessels. The dissolver product that results from this process would be transferred to the solvent extraction separation system for uranium recovery.

The solvent extraction process described for the heavy-water reactor at SRS (Section A.2.5.2), but eliminating the neptunium solvent extraction process, is also adequate for spent fuel processing at Hanford. A uranyl nitrate solution would be produced for transfer to the uranium recovery building. The product conversion process for uranium oxide, which would be carried out in the uranium recovery building, would be based on thermal denitration of uranyl nitrate to UO_3 (Section A.2.5.2).

Pretreatment of high-level waste is proposed for separating inert materials and short-lived radioisotopes from the high-level waste. Pretreatment would reduce the volume of vitrified waste that would be sent to a geologic repository for disposal. The driver-fuel processing system would be based on a dedicated high-level waste pretreatment system.

The primary constituent of HWR driver-fuel high-level waste would be aluminum. Initially, high-level waste would be concentrated for acid recovery and recycle. The basic acidic

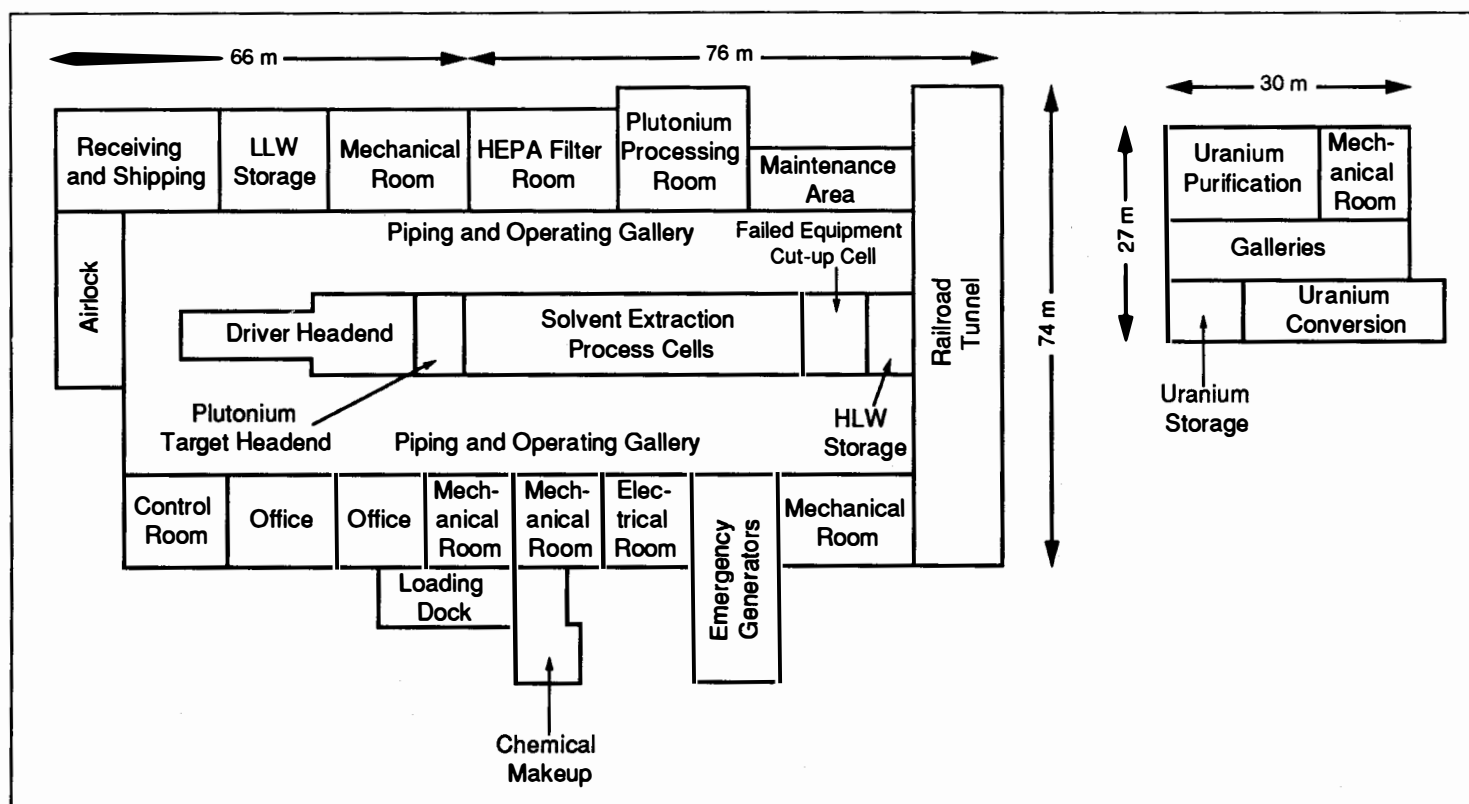


FIGURE A.16 Layouts of HWR Fuel Processing and Uranium Recovery Buildings at Hanford (Source: Modified from WHC 1989b)

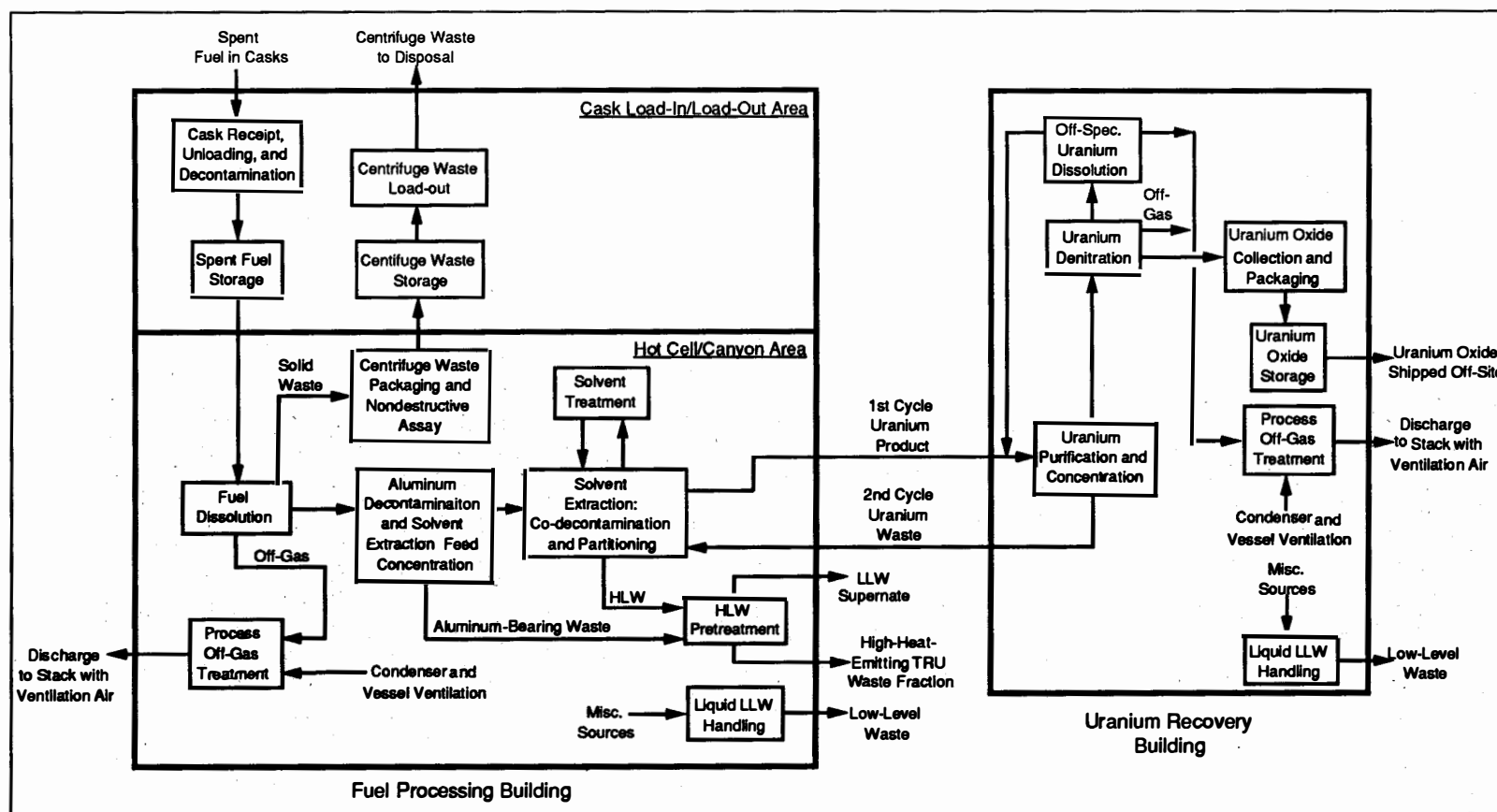


FIGURE A.17 Spent Fuel Processing at Hanford (Source: Modified from WHC 1989b)

concentrated high-level waste would then be made by adding sodium hydroxide. Transuranic components and strontium would be precipitated in the basic solution and removed by a series of solid and liquid separation steps. Water would be added at intermediate steps to remove additional soluble inerts from the precipitate.

The supernate from solid and liquid separation would be processed in an ion-exchange column to remove cesium. The supernate solutions would be transferred to double-shell tanks in the existing waste management system for ultimate disposal in grout.

Cesium concentrate from the ion-exchange process would be combined with the transuranic solids fraction to form a waste fraction containing the transuranic components and most of the major high-level waste heat emitters. The transuranic fractions from pretreatment activities would be stored in separate double-shell tanks before feeding the material to the Hanford Waste Vitrification Facility.

A.3.5.3 Process Effluents and Wastes

The fuel processing building would be used to treat off-gas from all process equipment and ventilation zones that are potential sources of radioactive contamination. A schematic showing the major elements of the planned fuel processing building ventilation system is given in Figure A.18. Off-gas from each process area would pass through HEPA filters near the source to minimize the size of the treatment systems. The uranium recovery building ventilation system would be designed with a similar philosophy. Each building would have separate stacks.

The proposed process off-gas systems in both buildings would remove nitrogen oxides (NO_x) and iodine. In addition, the process off-gas system for the fuel processing building would remove ammonia when processing plutonium targets. Radioactive particulates and gaseous releases from the fuel/plutonium-target processing facilities are discussed in Section 4.1.7 and in Appendix H.

During normal operation, the amount of ventilation air released to the environment through the fuel processing building stack would be $1.18 \text{ m}^3/\text{s}$. The stack would be about 60 m high and 3 m in diameter and would have an exit gas temperature of 30°C . While this discharge would be ventilation air, it would also contain NO_x as a nonradioactive effluent. The amount of NO_x released to the environment from normal operations in the tritium mode is estimated at 1,400 kg/yr. For operation in the plutonium mode, the amount of NO_x released to the environment from normal fuel processing building operations is estimated at 9,000 kg/yr; ammonia releases are estimated at 730 kg/yr.

During normal operation of the uranium recovery building, approximately $23.8 \text{ m}^3/\text{s}$ of ventilation air would be released to the main stack. The stack would be about 45 m high and 1.5 m in diameter and would have an exit gas temperature of 30°C . The ventilation air would also contain NO_x , mainly from the denitration process. The amount of NO_x released to the environment from normal operations is estimated at 35 kg/yr in the tritium mode and 7,900 kg/yr in the plutonium mode.

There would be no planned releases of radioactive liquid effluents to the environment from the fuel processing facilities. Radioactive and nonradioactive wastes would be segregated. Nonradioactive nonhazardous and potentially hazardous would also be segregated.

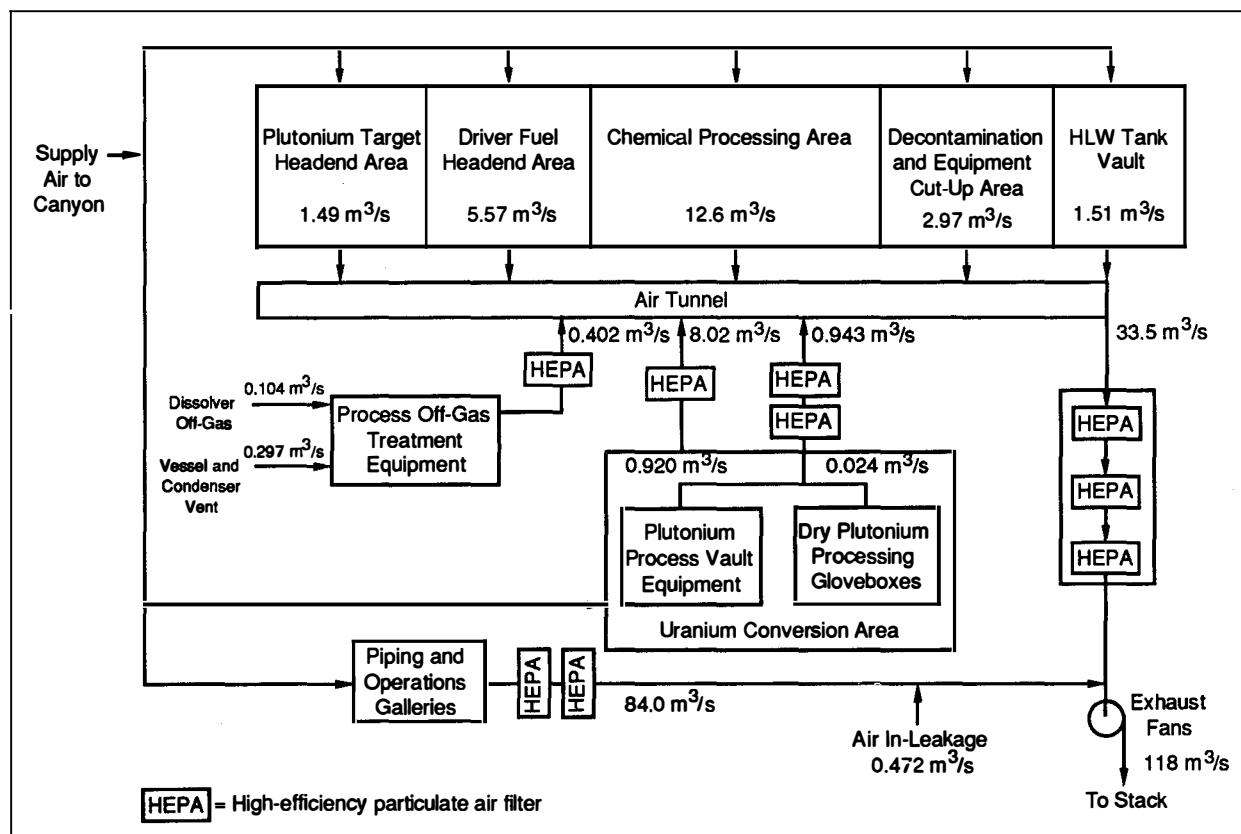


FIGURE A.18 Heating, Ventilating, and Air Conditioning System for the Fuel Processing Building at Hanford (Source: Modified from WHC 1989b)

Low-level liquid wastes would result from concentrator overheads and steam condensates, and from solvent treatment waste, flushes, decontamination waste, and supernate solutions from high-level waste pretreatment. These wastes would be transferred to double-shell tanks in the existing sitewide waste management system for ultimate disposal in grout.

Nonradioactive liquid waste (service waste and sanitary waste) would be generated as a result of normal operations. Service waste would include nonprocess steam condensate, waste from corridor and floor drains, and nonregulated cold chemical waste. Sanitary waste would include water from all sanitary services for the facilities and would not contain radionuclides.

Six types of solid waste would be generated from spent fuel processing during normal operations. High-level solid waste that has been pretreated to reduce volume would contain the transuranics and most of the major heat-emitting fission products. This waste would be transferred for processing at the Hanford Waste Vitrification Facility.

Low-level solid wastes would include spent ion-exchange resins for liquid waste treatment and spent HEPA filters from gaseous waste treatment.

Nonradioactive solid waste would also be produced from normal operations of the fuel processing facilities. This waste would mainly consist of office trash and shipping containers.

No hazardous waste from spent fuel processing has been identified in the generic HWR support facilities document (WSRC 1991a). It is assumed that hazardous waste described in Section 6.3.8 of the generic LWR support facilities document (WHC 1989b) would be typical of hazardous wastes generated by fuel processing activities.

Transuranic components and strontium would be precipitated in the basic solution and removed by a series of solid and liquid separation steps. The supernate from solid and liquid separation would be processed in an ion-exchange column to remove cesium. The supernate solutions would be transferred to double-shell tanks in the existing sitewide waste management system for ultimate disposal in grout.

A.3.6 Tritium-Target Processing

Tritium-target processing systems at Hanford would be installed in the existing Fuels and Materials Examination Facility.

A.3.6.1 Facility Description

The Fuels and Materials Examination Facility is described in Appendix B, Section B.2.3.1.

A.3.6.2 Process Description

Tritium-target processing for Hanford would be similar to the process described for SRS (Section A.2.6.2).

A.3.6.3 Process Effluents and Wastes

The existing Fuels and Materials Examination Facility exhaust stack is rectangular in cross section, approximately 2.4 m by 4.6 m by 36 m high, and is located on the north side of the facility. The estimated off-gas flow is 38 m³/s, and the estimated discharge temperature is 30°C. Flow sheets for off-gas treatment systems would be developed during the conceptual design phase. Modifications to the ventilation system would be required for tritium-target processing. The gases would include mixtures of argon and nitrogen with hydrogen isotopes, including tritium. These gases would be sent to one of two collection tanks, depending on the composition of the gas.

Elemental tritium would be sent directly to a uranium hydride bed. Gases containing hydrogen oxides would be sent through a uranium decomposer. All gases containing argon or nitrogen would be sent to a four-stage diffuser unit. The operations of the decomposer and diffuser are described in Section A.2.6.2. The hydrogen isotopes would be collected on the uranium hydride bed. The hydrogen would then be sent to the gas collection system.

Other gases would be collected in two tanks. The contents of these tanks would be sampled and analyzed for tritium contamination. If tritium levels are acceptable, the gases would be sent to the purge cleanup system and discharged to the stack. If tritium concentration is high, the gas would be recycled through the diffuser.

No radioactive particulate releases are expected from the Tritium-Target Processing Facility. The materials used in the processes, plus the thorough treatment of off-gas streams for tritium removal, would ensure that no significant radioactive particulates would be released. The only gaseous radioactive releases from the Tritium-Target Processing Facility would be tritium in its elemental form (T_2 or HT) and as tritiated water (T_2O or HTO). The estimated release of tritium totals less than 1,000 Ci/yr. Less than 10 Ci/yr of the release would be as tritiated water.

A.3.7 Fuel/Plutonium-Target Processing

Plutonium production spent fuel processing and plutonium-target processing would be accomplished in the Fuel Processing Facility that would be used to process tritium production spent fuel. No modifications to the fuel processing equipment or flow sheet would be necessary for processing the plutonium driver-fuel assembly; however, additional equipment would be needed in the fuel processing and uranium recovery buildings for processing the plutonium targets (depleted uranium).

A.3.7.1 Facility Description

The fuel processing building (Section A.3.5.1) contains sufficient space to accommodate the additional equipment required for plutonium-target processing. Installation of the new equipment would comply with the same design considerations and criteria used during the original plant design and construction.

A.3.7.2 Process Description

The processing of fuel elements from plutonium-target driver-fuel assemblies is generally identical to the processing of tritium-target fuel assemblies (Section A.3.5.2). The annual fuel assembly throughput for plutonium production would be less than the throughput for tritium production, however. Plutonium targets would also be processed in the new Fuel Processing Facility, using the process described for SRS (Section A.2.7.2). Figure A.11 is a diagram of the plutonium-target processing system.

A.3.7.3 Process Effluents and Wastes

The process effluents and wastes generated from irradiated fuel/plutonium-target processing would be similar to effluents and wastes generated from spent fuel processing for tritium production (Section A.3.5.3).

A.3.8 Plant Operation

The resource requirements for normal operation of the reactor and its support facilities for NPR are summarized in Table A.3. The additional staffing requirements for operation of each of the facilities are shown in Table A.4.

A.3.9 Sitewide Waste Management

Except for gaseous waste, the NPR wastes would be pretreated and prepared for disposal via the Hanford waste management facilities. Both existing and planned facilities identified by the Hanford waste management plan (DOE 1988) would be used. The waste treatment flowcharts and disposal modes are given in Appendix M.

A.3.9.1 Waste Management Facilities

The existing 31-ha Central Solid Waste Landfill is approximately 4 km north of the WNP-1 site. Low-level solid waste is disposed of in earth-covered trenches at the landfill. About 15% of the area is designated as interim disposal for hazardous solid waste.

The DOE's NPR operations will be conducted consistent with commitments DOE has made and will make in compliance agreements with state and Federal regulatory authorities. If it should become necessary, DOE will work with the regulators to incorporate NPR needs into existing agreements or to develop new agreements to ensure continued compliance. Under no circumstances will DOE's performance pursuant to any existing compliance agreement be compromised or diminished as a result of the NPR project. If there are discrepancies between the waste stream volume and waste treatment capacity figures in the DEIS and in existing compliance agreements, or those currently in negotiation, the figures in the compliance agreements will prevail.

The Radioactive Mixed Waste Storage Facility would be used to segregate and store mixed wastes. Effluent treatment facilities would be used for the treatment of low-level liquid wastes in the Fuels and Materials Examination Facility, the spent fuel processing area, and the 200-East Area. Four septic tile fields in the reactor area, the Fuels and Materials Examination Facility, the spent fuel processing area, and the 200-East Area would receive sanitary wastes from those areas.

The tank farm in the 200-East Area would be used to store high-level wastes and would provide interim storage for high-level wastes from spent fuel and plutonium-target processing before solidification at the planned Hanford Waste Vitrification Facility and subsequent shipment to the national high-level waste repository.

The Waste Receiving and Processing Facility would receive solid radioactive waste from the generating facility and segregate the waste into transuranic and nontransuranic wastes. This facility would be used to segregate waste from any generating facility that did not have this capability. Transuranic waste would be prepared and certified for shipment to the Waste Immobilization Pilot Plant or another appropriate facility. Nontransuranic waste would be prepared for on-site storage or for disposal at the landfill.

A.3.9.2 Liquid Waste Processing

Radioactive liquid wastes would mainly be generated by the fuel fabrication, fuel processing, and plutonium-target processing systems. Radioactive liquid wastes would generally be solidified and packaged for disposal in the generating facilities. High-level liquid wastes from the Fuel Processing Facility would be converted to a vitrified solid in the Hanford Waste

Vitrification Facility. Newly generated high-level waste would be mixed with Hanford Waste Vitrification Facility feed materials from existing waste inventories to minimize overall waste volumes disposed of in a repository. As a result, there is some uncertainty regarding the increase in waste that would be produced for repository disposal. The transuranic waste fraction would also be converted to a vitrified solid.

Low-level liquid wastes would be concentrated and converted to grout in existing Hanford waste management facilities. Low-level liquid wastes would include solutions from the Fuel Processing Facility and fuel/plutonium-target fabrication systems. The ultimate treatment of the waste evaporator condensate to reduce chemicals and radioactivity to acceptable levels has not been determined. Future plans anticipate implementation of additional condensate treatment processes, after which the treated water may be recycled, discharged to the ground, evaporated, or discharged to the Columbia River.

A.3.9.3 Solid Waste Processing

The solid wastes generated by the support facilities (i.e., failed equipment, failed filters, and other radioactive solid wastes) would be routinely packaged for disposal in the generating facility when possible. Some solid wastes would be transferred to the planned Waste Receiving and Processing Facility for segregation and processing. Nonradioactive hazardous waste would be collected, packaged, and stored in the Nonradioactive Dangerous Waste Storage Facility before shipment off-site to a licensed disposal facility. Packaging and disposal requirements for wastes would be determined by the level of radioactivity and the type of radioisotope (transuranic or nontransuranic). Transuranic waste would be stored and packaged for shipment to the Waste Isolation Pilot Plant or another appropriate facility, unless the specific activity of the waste is too high. Nontransuranic waste would generally be packaged in the generating facility for disposal on-site. Other solid wastes (i.e., trash and used packing materials) would be disposed of in the Central Solid Waste Landfill.

A.4 HEAVY-WATER REACTOR TECHNOLOGY AT INEL

A.4.1 Introduction

This section provides information on the proposed design and operation of a heavy-water reactor at the Idaho National Engineering Laboratory (INEL). The contents of this section are abstracted from EG&G 1989, except where noted. The EG&G document refers to the Savannah River documents for much of the Reactor Facility description (WSRC 1991a) and for the support facilities descriptions (WSRC 1991b); these documents describe a preconceptual, generic design for an HWR. This section makes frequent reference to Section A.2, which was also largely abstracted from the Savannah River documents.

A.4.1.1 New and Existing Facilities Required for the NPR

The major differences among the heavy-water reactor facility at INEL and the heavy-water reactor facilities at SRS and Hanford are the source of water, the method used to dispose cooling tower blowdown, and the manner in which the wastes would be integrated with existing

and planned INEL waste treatment facilities. Also, a different mix of existing and usable facilities exists at INEL, and, therefore, a different mix of new and existing facilities would result.

A new Reactor Facility would be constructed. The facility would include a new Heavy-Water Processing Facility to purify and upgrade the initial heavy-water inventory (presently in storage at SRS) and the operational heavy water. A new Fuel Fabrication Facility for both tritium and plutonium production and new tritium- and plutonium-target fabrication and processing facilities would be required. Because solvent extraction and denitration for both tritium and plutonium production could take place in the new Fuel Processing Facility being constructed at the Idaho Chemical Processing Plant, only a new Headend Fuel Processing Facility would be required for the spent fuel processing activities.

A.4.1.2 Location

The INEL site is located in southeastern Idaho (Section 2.1.2). The HWR complex would be located on a 500-ha site approximately 0.8 km north and 3.2 km east of the Idaho Chemical Processing Plant (Figure A.19). The location of the site and its selection are described in Section 3.2.2.

A.4.1.3 Existing Facilities, Utilities, and On-site Transportation

Spent fuel and plutonium-target processing would be carried out in a combination of existing and new additions to the Idaho Chemical Processing Plant. Waste management would be provided in existing facilities at the Idaho Chemical Processing Plant and at the Radioactive Waste Management Complex. These facilities are described in Section A.4.9.1; their locations are shown in Figure A.19.

The electric transmission system is described in Section 3.1.3.2. Water for the HWR and its support facilities would be pumped from the Snake River Plain aquifer at a depth of 145 m. Annual withdrawals for the NPR would constitute only a small fraction of the annual discharge from the aquifer to the Snake River. Water in the aquifer is of relatively good quality and would require only minor treatment.

The INEL and its associated facilities are served by an extensive transportation network (Section 4.2.9).

A.4.2 Heavy-Water Reactor Facility

The nominal power level of the reactor would be 2,500 MWt, and the design power level for the cooling towers would be 3,300 MWt. The description of the heavy-water reactor facility at Hanford (Section A.3.2) is applicable for the INEL adaptation. Other major exceptions to the Reactor Facility designs discussed in Section A.2.2 are described in the following sections.

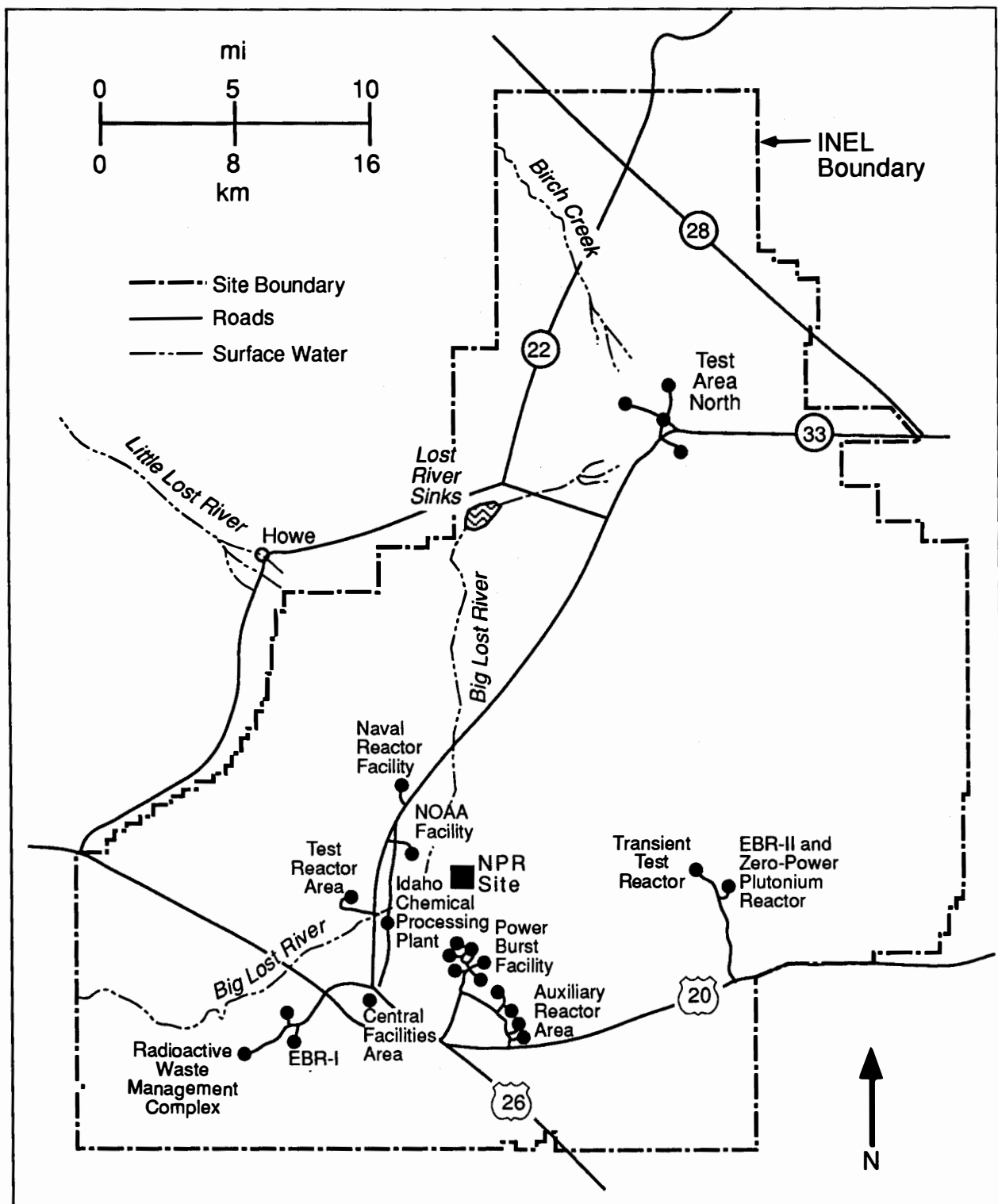


FIGURE A.19 Locations of the Proposed NPR Site and Existing Facilities at INEL (Source: Modified from EG&G 1989)

A.4.2.1 Heat Dissipation Systems

Secondary Cooling System

Unlike the reactor facilities at SRS and Hanford where cooling water blowdown is discharged to a river, cooling tower blowdown at INEL would be discharged to one or more lined evaporation ponds. (A full discussion of this aspect of the INEL design is given later in this section.) The secondary cooling system would require a maximum of 1.42 m³/s of makeup water for the evaporation, drift, and blowdown from the cooling towers, based on five cycles of concentration in the cooling tower water at a bounding reactor power level of 3,300 MWt. At INEL, the makeup water and all other water for the HWR would be obtained from deep wells in the Snake River Plain aquifer. The water source at INEL is described in detail in the Water Treatment System discussion (Section A.4.2.1). The bounding Reactor Facility water requirement, including the cooling towers, would be 1.48 m³/s.

The one or more lined evaporation ponds would be conservatively sized to dispose of the annual blowdown quantity, assuming the reactor is operated at its design capacity. The size of the evaporation pond would be equivalent to a 2,513-m square pond. Assuming a 30% contingency in size, and assuming the evaporation pond at INEL would use secondary heat from the reactor to maintain a 4°C temperature during the winter, the pond would be 8.2 km². The depth of the pond would be about 1-2 m.

Both cooling tower blowdown and drift would contain chemicals from cooling tower water chemistry adjustments (EG&G 1989, Table 4-1). The sludge in the cooling tower basin would be removed periodically and disposed of as a low-level radioactive waste. It is estimated that about 21,500 t of deposited solids would accumulate per year. These sludges would be packaged and sent to the Waste Experimental Reduction Facility for treatment and disposal. No sludges would be flushed to the groundwater or the Snake River Plain aquifer.

Water Treatment System

Water from deep wells at INEL contains considerably more chemicals, dissolved solids, and suspended solids than river water at SRS or Hanford. At INEL, the treatment of process and service water would consist of pumping the raw water from the aquifer through ion-exchange resins. Periodically, the resins would be back flushed with sulfuric acid and sodium hydroxide; the blowdown would go to a retention pond. Any wastewater released to the environment would meet or exceed the quality of water initially removed from the aquifer. Turbine condenser cooling water would be treated with sulfuric acid to control its pH, and would be chlorinated to prevent biological fouling of the system.

A.4.2.2 Waste Management

At INEL, the Reactor Facility waste management systems would be integrated into the sitewide waste management system.

Gaseous Waste Processing

During reactor operation, air circulating through the process areas would pick up radioactive gases: tritium in the form of DTO, carbon-14 in the form of carbon dioxide, iodine, and fission product noble gases (primarily krypton and xenon isotopes). The Reactor Facility would include a detritiation system for the reactor coolant and moderator systems; a vapor recovery system to collect the vapor in the spaces of the heavy-water systems; a reactor tank cavity activation center; and a system of HEPA and activated carbon filters that would be installed in the containment structure heating, ventilating, and air conditioning system to reduce the amount of iodine and tritium in containment.

During reactor refueling and retargeting, flushing equipment would be attached to the discharge machine to remove most of the reactor coolant before the fuel and target assemblies are placed in the disassembly basin. The basin would completely enclose the assembly to collect vapor from the tritium-containing coolant and to ensure cooling during discharge.

While fuel assembly failures would be infrequent, in case of failure, the discharged failed assembly would be placed in a container that would isolate the failed assembly from the cooling basin water. Fission product gases and particulate activity would be released into the container. These gases would be vented to an off-gas system for recovery of halogens. Radioactive particulates would be trapped by passing the water through a filter-deionizer system.

High-pressure tanks would hold short-lived high-activity gases. After decay, these gases would be released to the appropriate gas cleanup and release system.

Used filters and resins would be treated as solid radioactive waste (Section 4.2.2.3).

Liquid Waste Processing

The Reactor Facility would control, collect, store, and segregate the liquid radioactive waste. The wastes would be segregated as high-level waste, low-level waste, chemical waste, laundry waste, decontamination solutions, and demineralizer solutions. A radioactive drain subsystem would collect radioactive and potentially radioactive liquid waste from sumps located around the reactor, the detritiation system, the radioactive waste system, and the control building, as well as other areas of the facility. These wastes would be processed on the basis of contamination levels. Wastes meeting prescribed radioactivity levels would be discharged to the service waste system, where they could be held, recycled, treated, and monitored to ensure that they meet applicable release standards. Other wastes would be shipped to the Idaho Chemical Processing Plant for processing, immobilization, and storage until an appropriate disposal site is designated.

Liquid wastes would also be collected from the chemical laboratory, the laundry, and hot machine shop decontamination operations, and routed to holding tanks for subsequent processing or release. If the nonradioactive liquid waste meets the water quality requirements for release, the contents of the collection tanks would be discharged directly to an evaporation pond.

In handling irradiated production assemblies, heavy water and traces of tritium would be carried into the disassembly basin. Activation products from the surface of the assemblies would also accumulate in the water and in sludge buildup on the bottom of the basin. Water from the disassembly basin would be purged to the secondary cooling system to maintain a low level of tritium concentration in the basin. In the HWR, this discharge would be directed through the Effluent Treatment Facility. The facility would have filters and resin beds for capture of activation and fission products carried into the disassembly basin. The resulting resins would be treated as radioactive solid wastes (see the Solid Waste Processing discussion that follows). The tritium would remain in the discharged water, which would be directed to the secondary side of the cooling system and, therefore, to the cooling towers. Sludge accumulated in the basin would be extracted from the basin and stabilized in cement before disposal. The sludge removal and treatment process would be used infrequently because the water in the basin would be continuously filtered. While treated radioactive effluents at SRS and Hanford would be released to a river, these effluents at INEL would be released to lined evaporation ponds, or treated and recirculated, or volume reduced and grouted.

Spent demineralizer resins and used filters produced in the treatment of the liquid radioactive wastes would be processed as low-level solid waste.

Solid Waste Processing

Radioactive solid wastes produced at the Reactor Facility would be similar to solid wastes at SRS. After reduction at the Waste Experimental Reduction Facility, the solid wastes would be disposed of in shallow land burials at the Radioactive Waste Management Complex.

Certain solids, such as HEPA filters and deionizer resins, might be sent to the New Waste Calcining Facility for leaching of radionuclides, which are treated as high-level waste. Deionizer resins containing long-lived fission products might also be stabilized in cement or other stabilizing material and packed in drums. The drums containing the resin would be transported by shielded carrier for on-site disposal.

Reactor scrap metal from the disassembly of irradiated fuel and target assemblies containing up to 250 Ci/yr would be compacted using remote handling, as required. The compacted metal pieces would be placed in shielded casks for transport to and disposal in the Radioactive Waste Management Complex. Transuranic solid waste would be processed through the Stored Waste Experimental Pilot Plant to certify that it meets waste acceptance criteria before shipment to the Waste Isolation Pilot Plant or another appropriate facility.

Mixed and Hazardous Waste Processing

Mixed wastes (e.g., oily rags used in the maintenance of a pump used in radioactive service) would be treated in the appropriate sitewide Radioactive Mixed Waste Storage Facility. At the Reactor Facility, nonradioactive hazardous wastes would include oils, solvents, acids, contaminated plastics, gloves, rag stock, and other materials associated with plant operation and maintenance. Collection and interim storage of such wastes would be necessary. Radioactive, hazardous, and unregulated (other) wastes would be segregated and stored at the Hazardous Waste Storage Facility until sufficient containers accumulate for shipment to an approved off-site treatment, storage, and disposal facility.

Other Waste Processing

Other wastes from the Reactor Facility would include trash, treated sanitary wastewater, and solids. Trash would be compacted at the Reactor Facility and disposed of in an INEL sanitary landfill. Sewage would be disposed of via a site sewage treatment plant and attached septic field. The field would be sized to serve the Reactor Facility and the other support facilities at the NPR site, and to operate for the 40-year design life of the HWR.

A.4.3 Fuel and Tritium-Target Fabrication

A new Tritium-Target Fabrication Facility similar to the facility described in Section A.3.3.1 for Hanford would be constructed near the reactor on the NPR site. The facility would be about 8,600 m² in area. The fuel and tritium-target assembly and the processes for its fabrication would be the same as described in Section A.2.3 for the heavy-water reactor at SRS. The description of the process effluents and wastes for Hanford (Section A.3.3.4) would also apply to INEL, except that the liquid and solid wastes would be disposed of within the INEL sitewide waste management system.

A.4.4 Fuel/Plutonium-Target Fabrication

A new 5,100-m² facility for plutonium-target fabrication would be located near the reactor. The building and equipment would be similar to the facility currently used at SRS, but would be upgraded to meet current safety requirements. The facility would use the service and office facilities at the Tritium-Target Fabrication Facility. The plutonium-target fabrication process would be the same as described in Section A.2.4 for the heavy-water reactor at SRS. The process effluents and wastes described for Hanford (Section A.3.4.4) would also apply to INEL, except liquid and solid wastes would be disposed of within the INEL sitewide waste management system.

A.4.5 Spent Fuel Processing

Figure A.20 gives the major steps used to process HWR spent fuel in the existing Idaho Chemical Processing Plant. First, spent fuel would be received and stored in the existing Fuel Storage Facility, which is part of the Fluorinal Dissolution Process and Fuel Storage Facility. Second, the aluminum-clad fuel would be converted to an aluminum-nitrate, uranyl-nitrate solution in the new Headend Fuel Processing Facility. Finally, this highly enriched uranium solution would be transferred to the Fuel Processing Facility, which is under construction, for uranium purification and conversion of the uranyl nitrate to UO₃.

A.4.5.1 Facility Description

The Fuel Storage Area is complete and began operation in 1984. It contains a large, water-filled basin in which the fuels can be unloaded from shipping casks and stored underwater. A knockout panel installed in the original construction to allow for pool expansion would be used to adapt the facility for the receipt, underwater temporary storage, and underwater transfer of HWR fuel. All Fuel Storage Area structures necessary to limit off-site

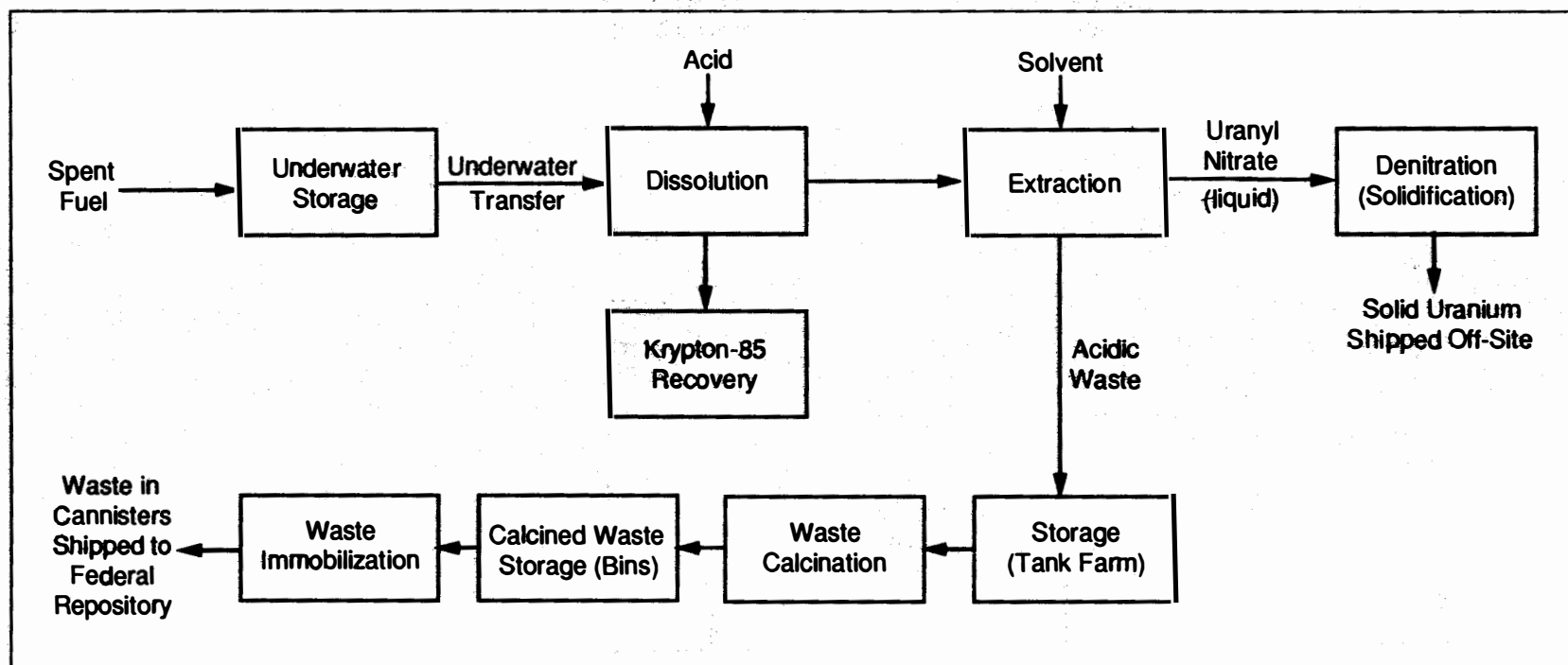


FIGURE A.20 Major Spent Fuel Processing Steps in the Idaho Chemical Processing Plant at INEL (Source: Modified from EG&G 1989)

doses to less than 10 CFR 100 limits are designed to withstand a design-basis tornado, a probable maximum flood, a design-basis earthquake, or an operating-basis earthquake. Off-gas processing systems would collect and process radioactive particulates and gases.

The current fuel receipt areas and storage pools generally handle highly enriched fuels and are capable of handling HWR fuels. However, actual receipt of HWR fuels would require additional equipment (e.g., storage racks) and further safety analysis.

The Headend Fuel Processing Facility would be constructed adjacent to the fuel storage basin at the Fluorinal Dissolution Process and Fuel Storage Facility to allow direct underwater transfer of fuel. The facility, and its location relative to other processing facilities, is shown in Figure A.21. The facility would be about 24 m by 66 m by 24 m high, with 18 m of the structure bermed with earth or located below grade. The high-level radioactivity processes would be located below grade and within shielded cells to provide radiation protection for personnel. Remote-maintenance features would include provisions for remote removal and replacement of valves, pumps, and equipment modules.

The HWR fuel would require about 40 shipments per year, assuming 15 assemblies could be loaded into a shipping cask. Three or four new shipping casks would be needed for the rail or truck shipments. Rail shipments would require the construction of a short railroad spur, leading from the Reactor Facility to the Fuel Dissolution Process and Fuel Storage Facility. The 40 shipments per year would require minimal additional work force. One unloading pool and two storage pools at CPP-666 were designed for handling 4.6-m-long fuel assemblies while maintaining 3-m water shielding and could therefore accommodate the HWR fuel.

Space for three dissolvers is provided in the new dissolution area, although only two dissolvers are required. The dissolution process could be run semicontinuously by allowing the nitric acid to overflow from the dissolver. The operating volume for each dissolver system is estimated to be 1 m³.

Construction of the Headend Fuel Processing Facility is under way and is expected to be completed by 1996. The following sections address only those impacts to the Headend Fuel Processing Facility that would result from specific support for HWR fuel.

A.4.5.2 Process Description

The primary functions of the existing Fuel Storage Facility are to receive, store, disassemble, and transfer various fuels at the Idaho Chemical Processing Plant for processing. The primary mission of the Headend Fuel Processing Facility would be to produce a uranyl nitrate solution, suitable for feed to the uranium extraction system in the Fuel Processing Facility. Headend fuel processing would consist of the following steps: fuel transfer from the fuel storage basin, fuel charging to the dissolver, dissolver product clarification, product accountability and storage, and product transfer to the Fluorinal Dissolution Process and Fuel Storage Facility or the Fuel Processing Facility.

The processing of the aluminum-can HWR fuel in the Fuel Processing Facility would be integrated with most of the Idaho Chemical Processing Plant fuel processing operations, which are based on zirconium fuel. Zirconium fuel is dissolved with hydrofluoric acid (the fluorinal process), which requires the addition of $\text{Al}(\text{NO}_3)_3$ to inhibit corrosion in the stainless steel, uranium purification equipment.

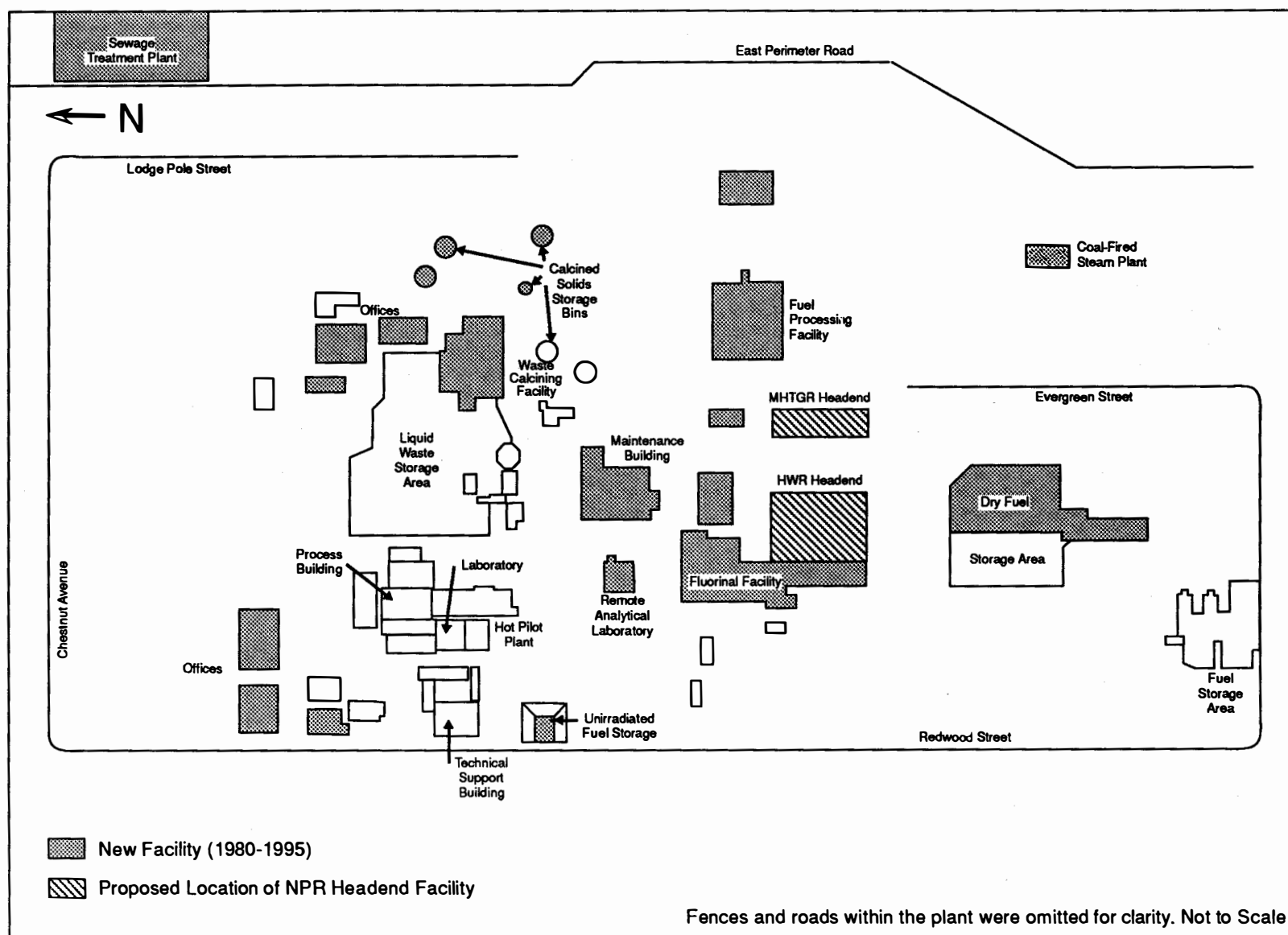


FIGURE A.21 Plan View of Idaho Chemical Processing Plant Facilities, Showing Location of New Headend Facility at INEL
(Source: Modified from EG&G 1989)

The HWR dissolver product would be coprocessed with the zirconium dissolver product, which would result in a 15% reduction in high-level waste. However, the impacts assumed no coprocessing to provide bounding values. Aluminum alloy fuel processing would be conducted during extended maintenance periods for the fluorinal dissolver system, which would enable better utilization of the entire facility. Approximately 20% of the total utility and work force of the Idaho Chemical Processing Plant Fuel Processing Facility would be required to support the HWR.

A.4.5.3 Process Effluents and Wastes

All gaseous wastes produced at the Fuel Storage Area are filtered by the building's ventilation system and released via the 50-m-high stack at the Fluorinal Dissolution Process and Fuel Storage Facility. In addition, off-gas from the fluorinal dissolution process is routed through the same exhaust system. All radioactive and nonradioactive gaseous effluents are routed through HEPA filters and are monitored for radioactive releases before discharge to the environment. Liquid wastes from the Fuel Storage Area would result from the rinsing and decontamination operations, the water treatment systems, and the nonradioactive waste systems. These wastes would include intermediate- and low-level radioactive wastes and nonradioactive wastes. All liquid wastes from the Fuel Storage Area are handled by the Idaho Chemical Processing Plant waste processing systems. Radioactive wastes are routed to the process equipment waste system; nonradioactive wastes are routed to the service waste system that discharges to the evaporation pond; hazardous chemical wastes are shipped off-site; and sanitary wastes are treated in a system that discharges to the ground.

Solid radioactive wastes are packaged in accordance with Radioactive Waste Management Complex criteria to ensure containment of radioactive material and are transferred to the complex for storage and ultimate disposal. Nonradioactive solid wastes are disposed of in an INEL sanitary landfill.

Gaseous effluents from the Headend Fuel Processing Facility would include process off-gases and releases from the ventilation system. Gaseous and particulate effluents in the process off-gases would include krypton, iodine, tritium, ruthenium, and some chemical compounds (e.g., NO_x). Process off-gases would be treated via an extensive gas cleanup system to reduce particulates and volatile effluents to levels that comply with DOE orders. The heating, ventilating, and air conditioning (HVAC) supply and exhaust air for the process cells would pass through a HEPA filter at the cell inlets and outlets. Clean off-gases would be combined with the HVAC exhaust and would pass through two more stages of HEPA filters before release to the environment.

Liquid wastes from the new headend facility would be transferred to existing waste treatment and disposal systems. Nonradioactive liquid wastes would include chemical wastes that would be shipped off-site for final disposal.

Radioactive solid wastes would include failed process equipment, acid-leached and dried HEPA filters, contaminated packaging and clothing, and other items. These wastes would be processed to reduce their volume and packaged to reduce the risk of spreading contamination. High-level waste would be sent to the Federal repository, and all other radioactive waste would be disposed of on-site. The bulk of the nonradioactive solid wastes would be office trash and shipping containers. These wastes would be disposed of in INEL landfills.

A.4.6 Tritium-Target Processing

A.4.6.1 Facility Description

The Tritium-Target Processing Facility receives irradiated tritium-target elements from the reactor, processes the targets to extract tritium, and stores and packages the tritium for shipment to SRS for purification and transfer to the Defense Program. These processes would be based on the technology being proposed for the new Replacement Extraction and Purification Facility at SRS (Section A.2.6.1). The information contained in Section A.2.6.1 is also suitable for the INEL facility.

A.4.6.2 Process Description

The Tritium-Target Processing Facility would include target cleaning and drying; tritium extraction; primary gas separation; isotopic separation; tritium packaging, storage, and shipping; hot-cell detritiation; and emissions reduction. The process flow for the Tritium-Target Processing Facility is shown in Figure A.22. The cleaning, drying, reduction, and tritium extraction process for the heavy-water reactor at INEL would be the same as the processes described for the heavy-water reactor at SRS (Section A.2.6.2).

A.4.6.3 Process Effluents and Wastes

Gaseous effluents from tritium processing would include purge air from the hot-cell detritiation system, NO_x treated off-gases from the tritium recovery system, and ventilation air. All gas streams would be continuously monitored and filtered with HEPA filters to ensure radioactivity releases are as low as reasonably achievable. The cell detritiation system would be designed to remove any tritium released to a cell.

The emissions reduction system would remove tritium from the glovebox effluents and processing waste streams in the target processing systems before they would be released to the atmosphere. The system can also be used with temporary enclosures to decontaminate airborne releases that occur when tritium containment systems are opened during maintenance.

The hot-cell detritiation system would remove tritium from the air purge stream of the hot cell to keep the cell atmosphere below the release limits for tritium ($5 \text{ Ci/m}^3 \cdot \text{s}$). The combination of the detritiation system and the furnace stripper should reduce tritium releases from the facility to much less than $5,000 \text{ Ci/yr}$. The system would function only when tritium was accidentally released in the cell.

Liquid high-level wastes would include pump oil, water from gas stream driers, confinement systems, and liquid wastes generated from any other "hot" process. The liquid wastes would be transferred to the packaging and disposal area by double-wall transfer lines or by individual containers. All operations would be performed in gloveboxes or fume hoods. The liquid would be mixed, sampled, and assayed for tritium. Water that contained tritium in sufficient concentration to be safely and economically recovered would be decanted and filtered, and after removal of organics, calorimetered, packaged, and shipped to the Heavy-Water Processing Facility.

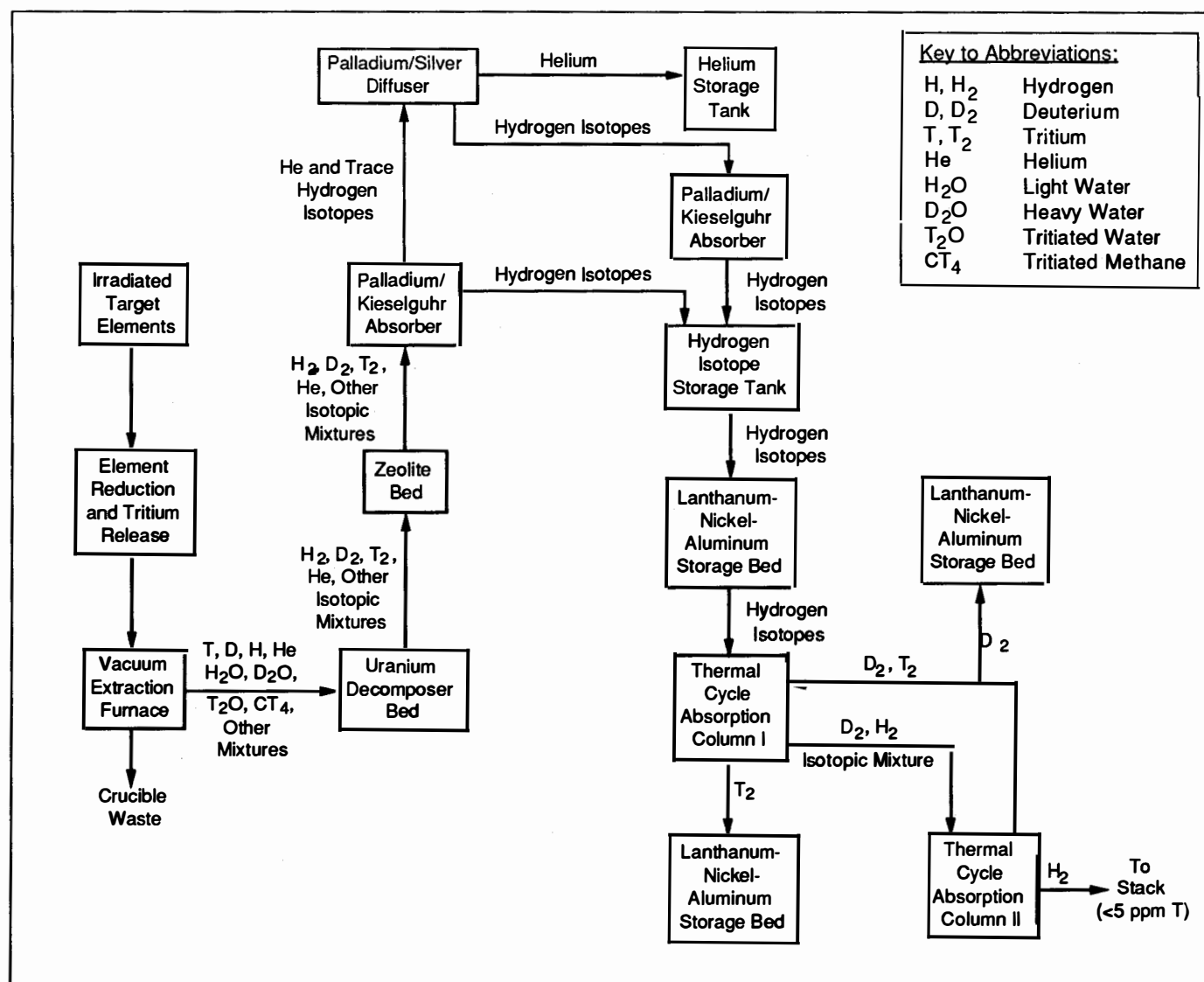


FIGURE A.22 Process Flow for the Tritium-Target Processing Facility at INEL (Source: Modified from EG&G 1989)

High-level wastewater in 0.025-m^3 batches would be solidified by mixing with cement in 0.10-m^3 plastic drum liners. Also, oil in 0.025-m^3 batches would be solidified by using attapulgite clay as an absorbing material in a 0.10-m^3 drum liner. The liner would be placed in a 0.114-m^3 open-head drum, the space between the liner and drum would be filled with nonhardening asphalt, and the drum lid would be bolted in place. This package would then be placed in a 0.21-m^3 (55-gal) steel drum, the new void volume would be filled with asphalt, and the drum lid would be bolted in place. These drums would then be transported to the Radioactive Waste Management Complex for disposal.

The liquid low-level waste would include mop water, water from equipment decontamination, and glassware cleaning solutions. It would not include shower and lavatory wastewater, which would be sent to the sanitary sewage system. Liquid low-level waste, at 0.025 m^3 per drum, would be mixed with diatomaceous earth and cement in 0.21-m^3 steel drums.

Residue from the extraction furnaces would consist of metals and lithium aluminate. The residue would be assayed, solidified, and packaged for transfer to the Radioactive Waste Management Complex. Other radioactive solid wastes would consist of such items as failed plant equipment, gloves, shoe covers, bubble suits, boots, tape, polyvinyl chloride materials, mop heads, glassware, and filter elements. These items would be sorted as compatible, combustible, or noncompatible.

Nonradioactive solid waste (e.g., office trash and empty chemical shipping containers) would be disposed of in an INEL landfill. Nonradioactive liquid wastes would be monitored and then discharged to the sanitary sewage system. Nonradioactive gaseous wastes would be monitored and exhausted through one-stage HEPA filters.

A.4.7 Fuel/Plutonium-Target Processing

A.4.7.1 Facility Description

The Plutonium-Target Processing Facility at INEL would recover plutonium produced in targets irradiated in the reactor. The facility would be designed to process about 400 t/yr of depleted uranium. Operating time would be 300 d/yr, at an average of 85% design capacity. The new facility would contain several shielded cells that would use remote handling and remote repair and replacement capabilities. High-level radioactivity processes would take place in below-grade shielded cells, which would provide radiation protection for personnel. Support equipment that did not contain radioactive materials would be in areas contiguous to the hot cells. The facility layout would be similar but not identical to the layout proposed for the modular high-temperature gas-cooled reactor Plutonium-Target Processing Facility (Appendix C, Section C.2.7.1). The principal differences would be the absence, in the modular high-temperature gas-cooled reactor case, of underwater target transfer into and out of the Fluorinal Dissolution Process and Fuel Storage Facility Fuel Storage Area and the absence of electrolytic dissolution, both of which are proposed in the HWR.

The Plutonium-Target Processing Facility would house the following principal process cells: an underwater target transfer channel; an electrolytic dissolver; feed clarification and solids packaging; process off-gas treatment; chemical adjustment and uranium and plutonium partitioning; low-level waste and acid recovery; low-enriched uranium salvage; denitrator feed

storage; low-enriched uranium denitration; interim storage plutonium feed; plutonium solidification and packaging; and a final product storage vault.

A.4.7.2 Process Description

The Plutonium-Target Processing Facility would have five major processing functions (Figure A.23): plutonium-target transfer from the reactor to the Fluorinal Dissolution Process and Fuel Storage Facility Fuel Storage Area (FAST FSA) for unloading and inspection, with a 30-day storage capacity underwater transfer from the FAST FSA to the headend facility, followed by electrolytic fuel dissolution; two cycles of tributyl phosphate extraction for uranium recovery and decontamination, along with plutonium partitioning in the first cycle, followed by uranium purification, denitration, and oxidation to produce uranium oxide for shipment off-site; plutonium recovery and decontamination in two cycles of tributyl phosphate extractions; and concentration and denitrations of the aqueous plutonium product. These major activities would be supported by such typical balance-of-plant features as uranium and plutonium salvage, solvent cleanup, utilities, waste disposal, chemical makeup, nitric acid regeneration and recycle, remote maintenance, analytical support, and research and development facilities.

A.4.7.3 Process Effluents and Wastes

Most radioactive fission product gases would be released as krypton-85 and, to a lesser extent, hydrogen-3. Other fission product gas releases would be limited to traces that escaped capture by upstream removal processing and filtering in submicron particulate filters. Figure A.23 indicates the flow of the Plutonium-Target Processing Facility off-gases.

The off-gas and ventilation air would pass through double HEPA filters and would be continuously monitored for radioactivity before being discharged to the atmosphere via the stack. High-efficiency particulate air filters would be protected by typical high-integrity design features (e.g., dampers, roughing filters, and fire protection sprays). The operating parameters of the facility would also be monitored. The exhaust stack would have state-of-the-art monitoring systems to continuously monitor the effluent streams for gaseous and particulate radioactivity. The systems would include velocity and static pressure probes, isokinetic probes, flow straighteners, and sample return probes. The systems would continuously draw samples of the effluent to monitor the level of gaseous radiation. Particulates would be collected to monitor radiation levels. Data would be transmitted to the radiation and environmental safety computer system for immediate analysis.

Nonradioactive gaseous releases would be discharged through double HEPA filters and continuously monitored for radioactivity. Releases of NO_x from the uranium denitration process would be reduced by the NO_x treatment system. Nitrogen oxides would be monitored before being discharged to the atmosphere through the Plutonium-Target Processing Facility stack.

The principal radioactive liquid effluent would be high-level waste from the first-cycle extraction system. The waste, primarily aluminum nitrate with most of the fission products, would be stored in the Idaho Chemical Processing Plant tank farm until it was used as a complexing solution in the Fluorinal Dissolution Process and Fuel Storage Facility. Aluminum nitrate is routinely used to complex the free fluoride that remains after zirconium fuels are dissolved with hydrofluoric acid. The availability of this "hot" aluminum nitrate would eliminate

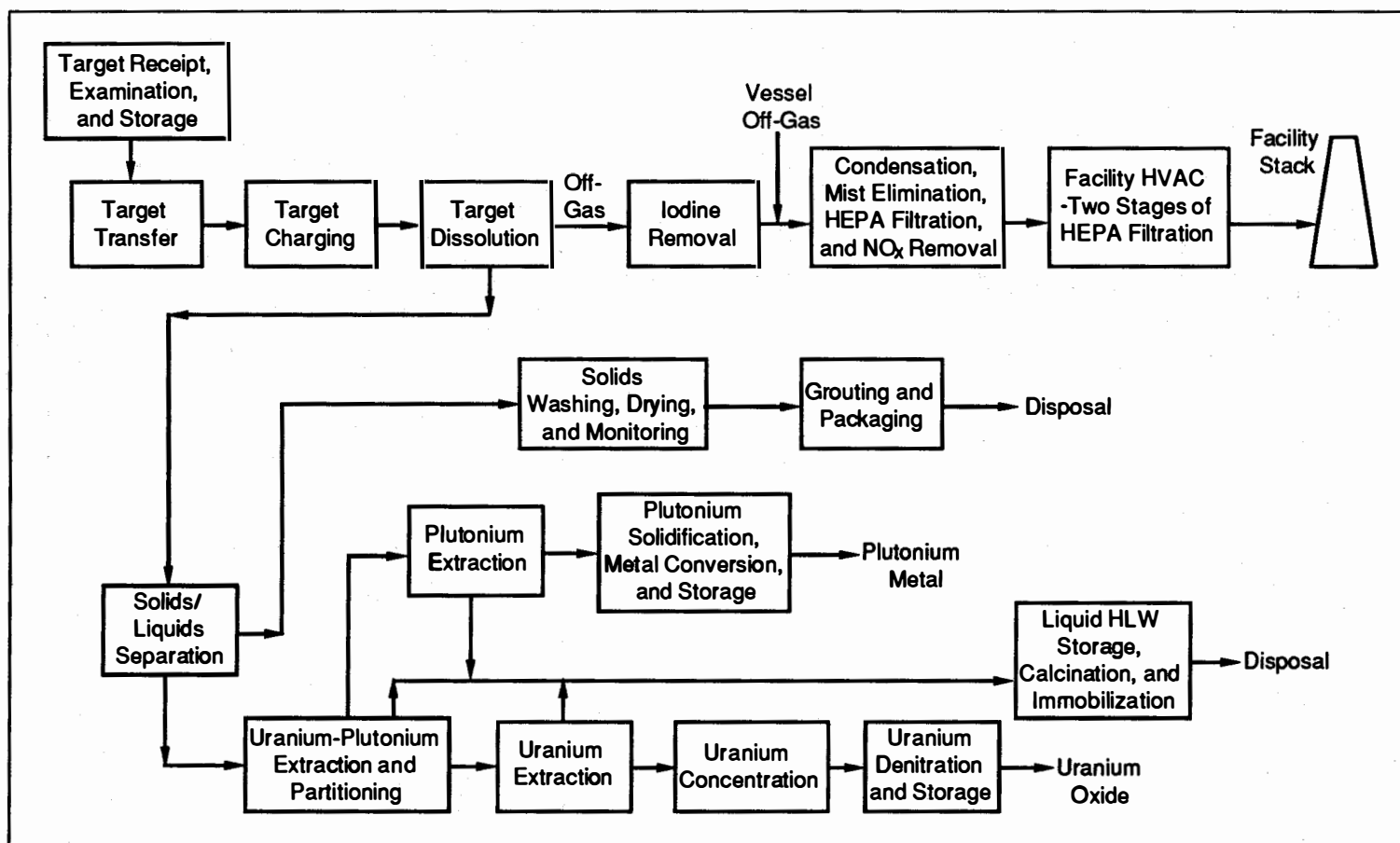


FIGURE A.23 Process Flow for the Plutonium-Target Processing Facility at INEL (Source: Modified from EG&G 1989)

the need to use "cold" chemicals for the complexing process and would reduce operating costs for the fluorinal dissolution process. The volume of high-level zirconium waste does not increase because hot aluminum would merely be substituted for cold aluminum; however, the fission product per unit volume would increase.

The radioactive aqueous low-level wastes would be collected in tanks in a 6-m by 6-m by 6-m-high cell. Herein, the aqueous waste would be accumulated, sampled, and concentrated in a thermosyphon evaporator. Concentrated wastes would be packaged and sent to the grouter for immobilization. The cell would also include a nitric acid regeneration system that would recover and concentrate the acid for recycle to the dissolution system. The nitric acid recovery and recycle system would reduce the release of NO_x to the environment. Unless radioactivity exceeded prescribed limits, the nonradioactive aqueous process wastes would be transferred to a new service waste pond for disposal by evaporation. Traces of radioactivity and hazardous materials contained in the process equipment waste evaporator condensate would be routinely discharged to the service waste stream.

Undissolved radioactive solids would accumulate in the dissolver product clarification system and would be converted to grout. Miscellaneous contaminated paper goods and equipment would also be generated.

The nonradioactive solid wastes from the Plutonium-Target Processing Facility would mainly be compactible solids (e.g., paper and boxes). The solids would, in general, be compacted and sent to an INEL landfill. There would be limited quantities of solid chemical wastes, and these would be disposed of as necessary via existing Idaho Chemical Processing Plant cold chemical waste disposal systems and procedures.

A.4.8 Plant Operation

Plant operation as described in Section A.2.8 is generally applicable to the heavy-water reactor at INEL with the following exceptions. Diesel fuel would be used to operate the diesel generators in a standby mode during reactor operation. Electricity would be obtained from the INEL grid, which obtains its power from the Federally owned Experimental Breeder Reactor-II on the INEL Site and from the Idaho Power Company.

The process and heating steam for the facilities at the HWR site would be generated using reactor heat supplemented by electricity. Steam for the fuel/plutonium-target processing facilities would be obtained from the Idaho Chemical Processing Plant steam supply system.

The bounding raw water makeup requirement would be about $4.3 \times 10^7 \text{ m}^3/\text{yr}$. Assuming five cycles of concentration of the cooling tower water, the peak blowdown to the evaporation pond would be about $0.21 \text{ m}^3/\text{s}$. Cooling, process, and potable water would be obtained from the Snake River Plain aquifer.

The resource requirements for normal operation of the reactor and its support facilities are summarized in Table A.3. The additional staffing requirements for operation of each of the facilities in support of NPR are shown in Table A.4.

A.4.9 Sitewide Waste Management

The primary radioactive waste management facilities at INEL are located at the Idaho Chemical Processing Plant and the Radioactive Waste Management Complex. The chemical composition and radioactivity levels of the heavy-water reactor wastes sent to the INEL waste treatment facilities would be within their design-basis operating envelopes. Flowcharts for wastes generated by the NPR are given in Appendix M.

A.4.9.1 Waste Management Facilities

The Idaho Chemical Processing Plant processes and stores liquid radioactive waste generated on-site and received from other INEL facilities. Its four principal waste management facilities for handling high-level wastes include the tank farm, the New Waste Calcining Facility, the Calcined Solids Storage Facility, and the Waste Immobilization Facility (to be constructed). In passing through these four facilities in series, high-level liquid wastes would be converted to a solid form for shipment to the Waste Isolation Pilot Plant or another appropriate facility.

The DOE's NPR operations will be conducted consistent with commitments DOE has made and will make in compliance agreements with state and Federal regulatory authorities. If it should become necessary, DOE will work with the regulators to incorporate NPR needs into existing agreements or to develop new agreements to ensure continued compliance. Under no circumstances will DOE's performance pursuant to any existing compliance agreement be compromised or diminished as a result of the NPR project. If there are discrepancies between the waste stream volume and waste treatment capacity figures in the DEIS and in existing compliance agreements, or those currently in negotiation, the figures in the compliance agreements will prevail.

Most low-level liquid wastes are treated in the process equipment waste evaporator and the liquid effluent treatment and disposal systems. The liquid wastes treated by evaporation yield a high-level waste that is sent to the tank farm and a low-level waste that is combined with other low-level wastes. These wastes are treated by ion exchange to produce an effluent that is disposed of in percolation ponds. The spent resins are stored at the Radioactive Waste Management Complex. The present liquid disposal method (discharge to a percolation pond) has been accepted by the state of Idaho as an interim method of disposal.

These systems are continuously maintained and periodically upgraded to ensure safe operations and to minimize environmental impacts. The additional waste management activity associated with processing HWR fuel would be well within these waste treatment system capabilities in terms of capacity and treatment requirements.

The Radioactive Waste Management Complex disposes of INEL-generated solid, low-level, beta/gamma contaminated wastes and also stores retrievable contact-handled and remote-handled transuranic waste. The solid waste inventories and forecasts from other INEL waste generators indicate the complex would be able to accept waste until the year 2093. Future facilities and procedures designed for waste processing and volume reduction should ensure that goal would be met.

The Radioactive Waste Management Complex consists of two main areas: a 36-ha Subsurface Disposal Area and a 22-ha Transuranic Waste Storage Area. Operations presently

consist of subsurface disposal of low-level waste. Contact-handled and remote-handled transuranic wastes are stored on asphalt pads under protective cover. Radioactive mixed wastes are no longer accepted for disposal at the complex and are stored at the Mixed Waste Storage Facility.

The Stored Waste Experimental Pilot Plant was constructed at INEL to enable the examination of various-sized transuranic waste containers and determine their acceptability for long-term storage in the Waste Isolation Pilot Plant or another appropriate facility. The existing Process Experimental Pilot Plant program demonstrates full-scale methods for processing transuranic waste into a form acceptable for disposal at the Waste Isolation Pilot Plant or another appropriate facility.

The existing Waste Experimental Reduction Facility conducts three low-level beta/gamma, waste volume reduction activities: waste sizing, waste melting, and waste incineration. The products are then shipped to the Radioactive Waste Management Complex for storage. Mixed low-level solid waste for reduction would not be accepted until receipt of an Environmental Protection Agency permit to process these materials.

A.4.9.2 Liquid Waste Processing

The high-level liquid wastes include first-cycle extraction waste streams, evaporator concentrates from the fuel processing extraction operations, and all other high-level wastes stored in stainless steel tanks located underground in concrete vaults, until solidified by calcining. After calcining, the solid wastes are placed in long-term, retrievable storage.

Liquid radioactive wastes processed at the Idaho Chemical Processing Plant are mainly wastes generated during nuclear fuel processing. The liquid wastes are classified as service wastes, low-level waste, and high-level waste, according to the source and radioactivity levels. Service wastes contain little or no radioactivity and are currently monitored and then discharged to a percolation pond. For NPR operation, these wastes would be discharged to a large evaporation pond at the Idaho Chemical Processing Plant.

Low-level wastes are generated by plant operation and equipment decontamination and are produced by evaporation and ion exchange. The waste produced by evaporation is concentrated to high-level waste. The ion-exchange effluent is low-level waste that is discharged to an evaporation pond. This low-level waste meets release criteria established in DOE Order 5480.4, *Environmental Protection, Safety and Health Protection Standards*.

The present liquid disposal method (discharge to a percolation pond) has been accepted by the state of Idaho as an interim disposal method. The state has been promised a final solution, representing the best approach, following a study of alternatives. An alternative disposal method, liquid effluent treatment and disposal, is currently in the design phase. This method will significantly reduce the use of percolation ponds for liquid disposal.

A.4.9.3 Solid Waste Processing

The Radioactive Waste Management Complex disposes INEL-generated solid, low-level, and beta/gamma contaminated wastes, and stores retrievable, contact-handled and

remote-handled transuranic wastes at the Transuranic Waste Storage Area. The solid waste inventories and forecasts from waste generators (Section 7.1.2) indicate the complex will be able to accept waste until the year 2093. Future Radioactive Waste Management Complex-related facilities and procedures designed for waste processing and volume reduction should ensure that the complex will meet that goal.

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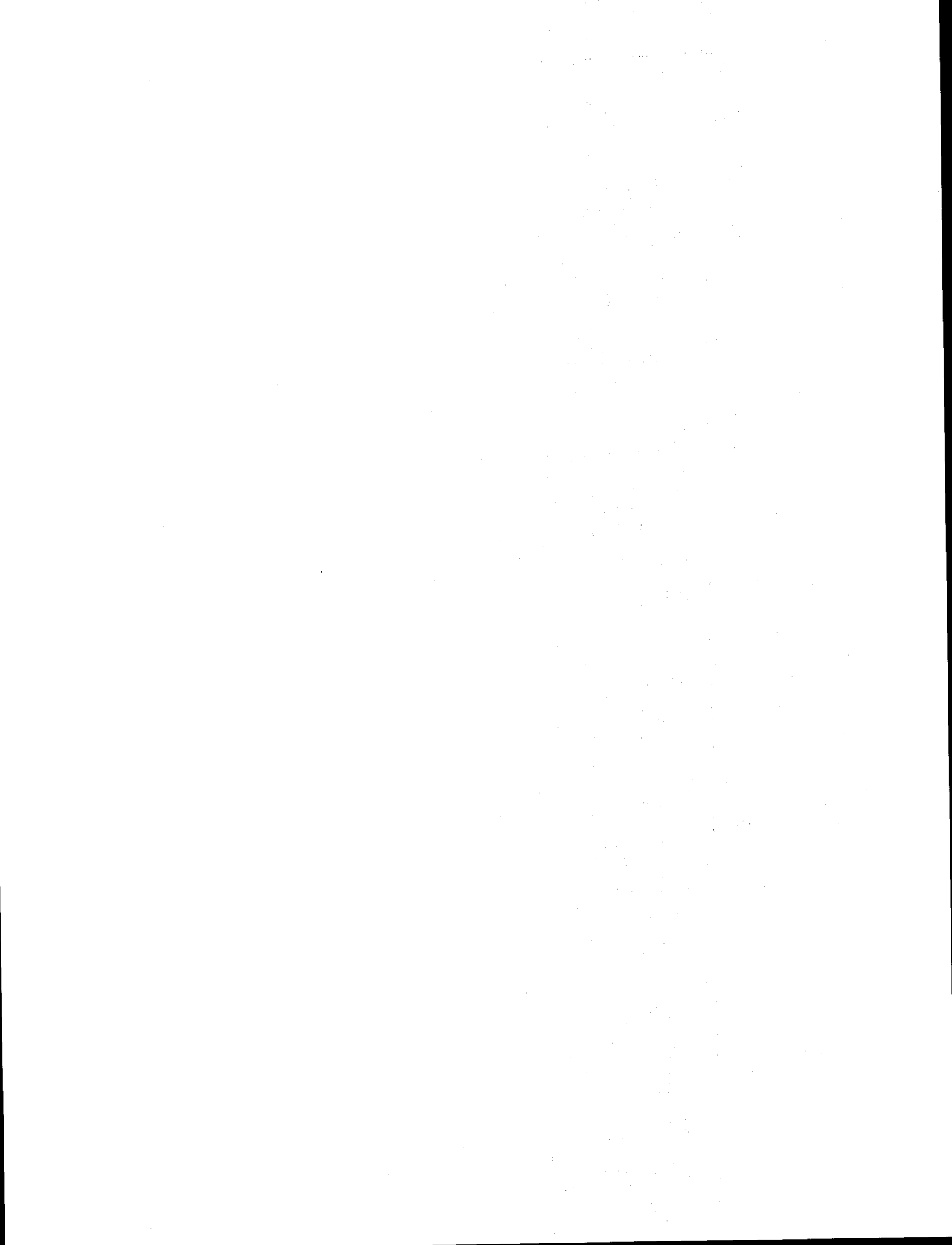
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APPENDIX B:
LIGHT-WATER REACTOR TECHNOLOGY



APPENDIX B: LIGHT-WATER REACTOR TECHNOLOGY

B.1 OVERVIEW

B.1.1 Introduction

Appendix B provides a summary description of the new production reactor (NPR) light-water reactor (LWR) technology and the location and operation of such a facility at each of three alternative DOE sites: the Hanford Site near Richland, Washington (Section B.2); the Idaho National Engineering Laboratory (INEL) Site near Idaho Falls, Idaho (Section B.3); and the Savannah River Site (SRS) near Aiken, South Carolina (Section B.4). The key assumptions for EIS analyses given in Appendix A, Section A.1.1 (on design capability, baseline conditions, high-level waste repository, decontamination and decommissioning, and so on), for a heavy-water reactor (HWR) also apply here.

The production complex at each site, as described in this appendix, would include the reactor, target and fuel fabrication, fuel and target processing, and appropriate waste management facilities. Facilities to support tritium production as well as spent fuel processing and plutonium production are included. Section 1 discusses the relationship of these activities to the proposed actions and alternatives available for the DOE Reconfiguration PEIS. Use of applicable existing facilities at the three alternative sites is assumed (Figures 3.4.5-1 through 3.4.5-3). The requirements for new support facilities and the use of existing facilities are discussed in Sections B.2.1.1, B.3.1.1, and B.4.1.1 for Hanford, INEL, and SRS, respectively. In addition, the cooling water requirements (Table B.1) at each site would be different.

B.1.2 Safety and Safety Assurance

Safety and safety assurance will be attained through compliance with applicable DOE orders and national consensus codes and standards. The approach used in the New Production Reactor Program described in Section A.1.2 for HWR technology also applies to LWR technology.

B.1.3 Light-Water Reactor Technology

B.1.3.1 Reactor

The LWR would contain one, multiple-coolant-loop, pressurized, light-water-moderated, light-water-cooled nuclear reactor. Because of the pressurization, the temperature of the coolant would be sufficiently high to allow generation of steam that could be used to produce electricity or for other purposes. In the proposed design, the steam would be used to power a 1,800-rpm turbine generator having a rated output of 1,339 MWe.

The major structures and components needed to operate the reactor would be contained in a Reactor Facility. The Reactor Facility would include a containment building to house the reactor and a nuclear steam supply system to generate steam to power the turbine generator.

B.1.3.2 Fuel and Tritium-Target Cycle

The LWR tritium production fuel cycle would use uranium dioxide (UO_2) fuel, enriched to 5-12 wt% uranium-235, for irradiation of lithium aluminate targets. The reactor assemblies would be composed of fuel and target rods. The fuel and target rods would be fabricated in new facilities adjacent to the Reactor Facility at INEL (Sections A.4.1.1 and B.3.1.3) and SRS (Section B.4.1.1), but in the existing Fuels and Materials Examination Facility at Hanford (Section B.2.1.1). The irradiated assemblies would be discharged to a water-filled storage basin. The target rods would be stored for at least 1 month to allow decay of short-lived radioisotopes. If there is a decision in the ROD for the Reconfiguration PEIS to process spent fuel, the target rods would be removed and packaged for transfer to the Tritium-Target Processing Facility for recovery and purification of tritium. The remainder of the assemblies (containing only the irradiated fuel rods) would be stored for at least 11 additional months before transfer to the Fuel Processing Facility for disassembly, uranium recovery, and waste treatment.

Figure B.1 shows the major facilities and interfaces associated with the LWR tritium production fuel cycle. Intrafacility transfers would be accomplished by a combination of rail, truck transport, and pipeline.

B.1.3.3 Fuel/Plutonium-239 Target Cycle

The plutonium-239 production fuel cycle would use fuel/target assemblies containing UO_2 enriched to approximately 1.7 wt% uranium-235. The fuel/target assemblies would serve as both fuel and target and would consist of Zircaloy tubes containing UO_2 pellets. The fuel/target assemblies would be fabricated at commercial facilities and shipped to the Reactor Facility. After irradiation, the assemblies would be discharged to a water-filled storage basin in the Reactor Facility. They would be stored for at least 1 year to allow for decay of short-lived isotopes. After this period, the assemblies would be transferred to a processing facility, where the plutonium and uranium in the irradiated fuel/target rods would be removed as product and for recycle, respectively. By-products would receive appropriate waste treatment. The plutonium product would be packaged and shipped to the Rocky Flats Plant in Golden, Colorado, or another appropriate facility, pending completion of the Reconfiguration PEIS. The reclaimed UO_2 would be packaged and shipped to the commercial supplier of the production assemblies for recycle. Figure B.2 shows the major facilities and interfaces associated with the LWR plutonium production fuel cycle. Intrafacility transfers are also noted.

Because plutonium production fuel/target assemblies would be commercially manufactured, the plutonium production facility would require only plutonium fuel/target and uranium processing facilities in addition to the Reactor Facility. Plutonium fuel/targets could be processed in the same building used for tritium fuel processing if selected equipment and process changes were made. Additional space and equipment would be necessary to accommodate the extra equipment and larger throughput of materials. The Fuel Processing Facility proposed by Hanford and INEL would be sized to accommodate the extra equipment and larger throughput.

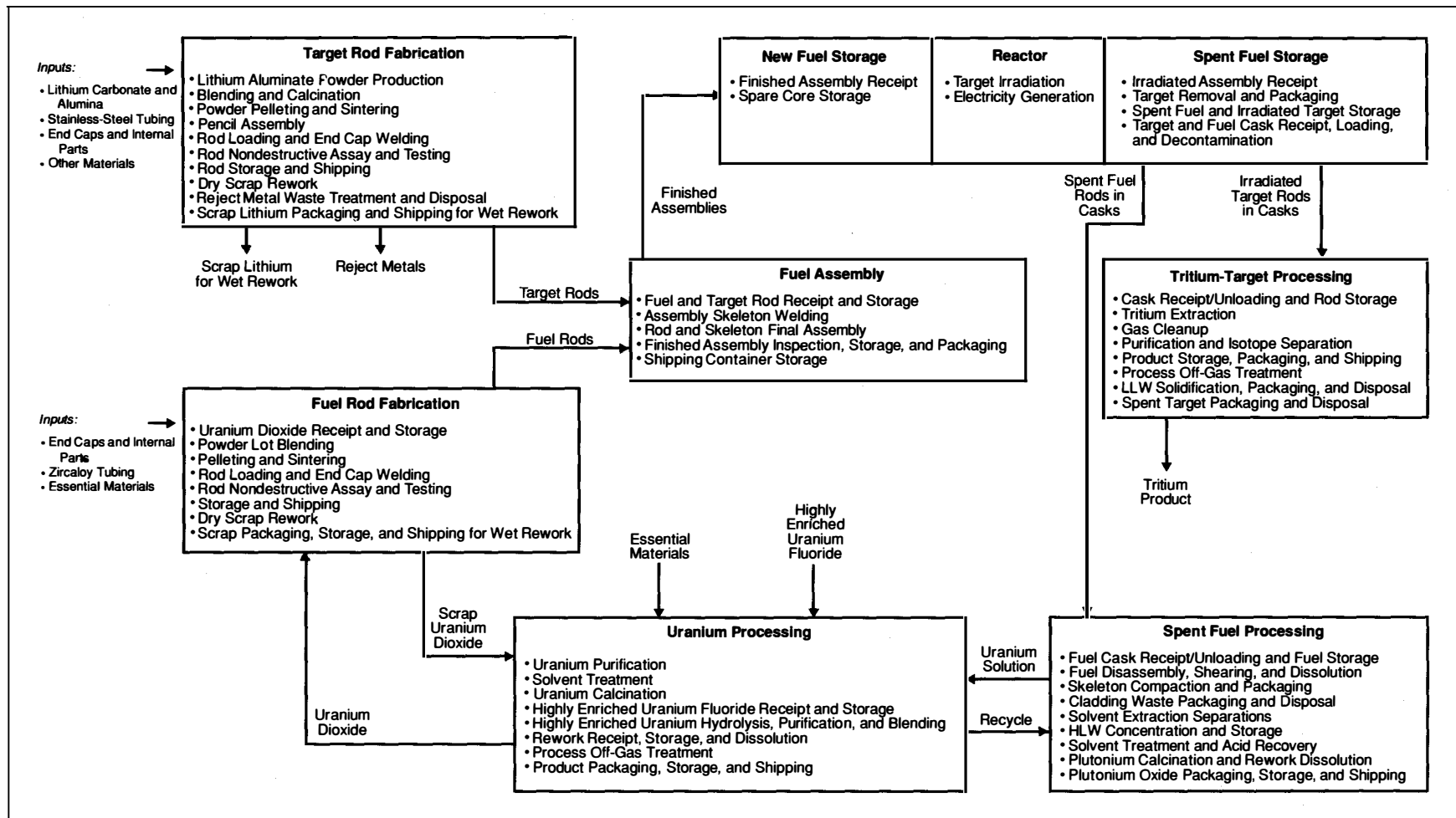


FIGURE B.1 LWR Tritium Production Fuel Cycle (Source: WHC 1990a, Fig. 3-1)

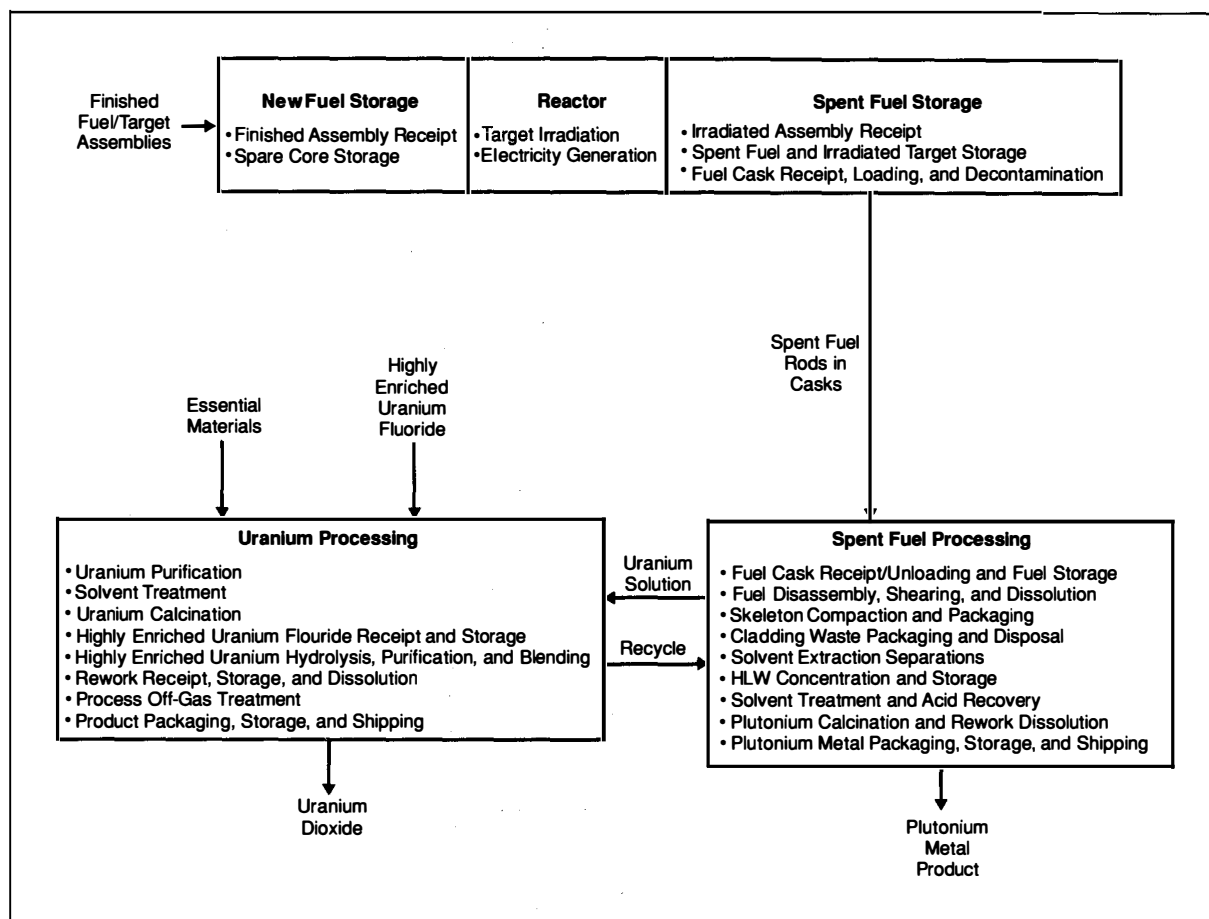


FIGURE B.2 LWR Plutonium Production Fuel Cycle (Source: WHC 1990a)

The EIS includes plutonium production to ensure that alternative is available to the Reconfiguration PEIS. Material flows would be based on processing four reactor cores per year. Plutonium would be processed to an oxide for on-site storage, but would be converted to a metal for shipment to the Rocky Flats Plant or another appropriate facility, pending completion of the DOE Reconfiguration PEIS. As described in Section 3.3.5.6, the LWR would also be capable of producing other isotopes.

B.1.3.4 Waste Management

The DOE conducts its environmental management activities at Hanford, INEL, SRS, and other DOE sites pursuant to compliance agreements with state and Federal regulatory authorities. These agreements guide DOE activities at the sites under applicable environmental laws, regulations, and other standards. Compliance with the terms of these negotiated agreements is one of the highest of DOE's priorities. The DOE's NPR operations will be conducted consistent with commitments DOE has made and will make in these agreements. If it should become necessary, DOE will work with the regulators to incorporate NPR needs into existing agreements or to develop new agreements to ensure continued compliance. Under no circumstances will DOE's performance pursuant to any existing compliance agreement be compromised or diminished as a result of the NPR project. If there are discrepancies between

the waste stream volume and waste treatment capacity figures in the DEIS and in existing compliance agreements, or those currently in negotiation, the figures in the compliance agreements will prevail.

Each facility would produce gaseous, liquid, and solid waste. Gaseous wastes would be treated within each facility to reduce the toxic and radioactive contents to acceptable levels before discharge to the atmosphere through stacks. Liquid wastes would be treated within each facility to reduce the toxic and radioactive contents either to a level that meets applicable Federal, state, and local regulations for discharge to the environment or to an acceptable state for receipt at the liquid waste treatment system existing on each proposed site. In either case, solid wastes would be produced. Solid wastes would generally be treated within each facility to a form that would be appropriate for further treatment, disposal, or storage within the waste management system existing at each alternative site. These waste management systems are described in Section A.3.9 for Hanford, Section A.4.9 for INEL, and Section A.2.9 for SRS. High-level and transuranic wastes would be stored only until they can be sent to the national high-level waste repository.

B.2 LIGHT-WATER REACTOR TECHNOLOGY AT HANFORD

B.2.1 Introduction

This section provides information on the conversion and operation of WNP-1 as a light-water production reactor and on the construction and operation of the required support facilities at Hanford. This section is organized to provide a description of potential facilities and operations. Impacts and policies associated with these facilities are discussed in Sections 1, 2, and 5. The information presented in this section is abstracted from Hanford reports describing the reactor (WHC 1990b) and its support facilities (WHC 1990a), except where otherwise referenced. Those reports and the EIS are based on design information available at the time of their preparation, which is referred to in this appendix as the "generic design." Since that time, a new stage of project design, the "conceptual design," has begun; however, the conceptual design is not considered here.

B.2.1.1 New and Existing Facilities Required for the NPR

An NPR using light-water reactor technology at Hanford would be based on conversion of the partially completed WNP-1 reactor. Institutional issues associated with this alternative are discussed in Section 5.2.11.2. Construction on WNP-1 was halted in April 1982 because of the uncertainty of electric power demand in northwestern United States. Civil and structural work is essentially complete; mechanical work is approximately 60% complete; electrical work is approximately 50% complete; and heating, ventilating, and air conditioning work is approximately 70% complete. The overall completion status of all construction-related activities is approximately 63%. The physical plant assets and supporting documentation are being preserved, and licenses are being maintained during the delay to enable future completion of WNP-1.

Nearly 95% of necessary plant equipment for WNP-1 has been procured and delivered. A formal preventive maintenance program has been instituted to ensure equipment and materials -- installed or warehoused -- are properly maintained.

The plant arrangement and select safety systems of WNP-1 would need to be modified for conversion to a nuclear materials production reactor. The core configurations for both tritium and weapons-grade plutonium production would also need to be modified. Other modifications would be required as a result of changes in regulatory requirements since the WNP-1 construction permit was issued and in consideration of the effects of the modified core configurations. The plant descriptions discussed in the following sections are based on a plant design that would satisfy current requirements.

The LWR support facility design is based on the use of the existing Fuels and Materials Examination Facility to house fuel and target fabrication and tritium-target processing activities. This design includes a new Fuel Processing Facility to be constructed within the existing 200-East Area, which would be near existing and planned waste management facilities.

B.2.1.2 Special Low-Exposure Tritium Production Scenario

The reference tritium and plutonium production fuel cycles identified in Sections B.1.3.2 and B.1.3.3, respectively, form the bases for the facility descriptions and the analyses in the EIS. Because the reference target (getter-barrier design) has not been verified yet, a special low-exposure tritium-target design concept (aluminum can design) might be used temporarily until the reference target development activities are completed (completion is scheduled for late 1993). The projected effluents associated with low-exposure tritium-target operations are presented in Section 9.4 of a Hanford report (WHC 1990a).

Support facility implications using a low-exposure tritium target would be identical to those discussed in Section B.2.1.1. The primary difference resulting from the two tritium-target design concepts is that the material flow through each support facility would be larger from the low-exposure scenario than from the reference scenario, which is the basis for the descriptions later in this appendix. Fuel and target assemblies for the low-exposure design would be changed three times per year instead of one time per year for the reference targets. For both tritium-target designs, normal operating release estimates would be based on a storage decay time of at least 1 month for targets and at least 12 months for the fuel and other assembly components.

B.2.1.3 Location

Currently owned by the Washington Public Power Supply System and licensed for construction by the U.S. Nuclear Regulatory Commission, WNP-1 is located on the Hanford Site in Benton County, Washington, on property leased from DOE. Its regional location is described in Section A.3.1.2. The relative locations of WNP-1, associated Hanford facilities, and roads are shown in Figure A.12.

B.2.1.4 Existing Facilities, Utilities, and On-site Transportation

Figure A.12 shows the general location of LWR support facilities with respect to major features of the Hanford Site. Existing utilities and on-site transportation are described in Section A.3.1.3.

B.2.2 Light-Water Reactor Facility

B.2.2.1 Plant Structures

Figure B.3 shows the WNP-1 facility, including the major buildings and the perimeter fence. The reactor containment building houses the WNP-1 reactor and the nuclear steam supply system. The general service building is adjacent to the containment building, but is physically separate for seismic design purposes. The general service building, which is a rectangular, reinforced-concrete structure 68 m wide, 111 m long, and 46.3 m high, contains auxiliary systems, control equipment, fuel and target storage areas, emergency diesel generators, plant support systems, and office space to support operation of the nuclear plant. Northeast of the containment is the turbine generator building, which houses the steam-powered turbine generator and associated equipment. Southeast and east of the turbine generator building are a circulating water pumphouse and three cooling towers that dissipate waste heat to the atmosphere. Each mechanical draft cooling tower is 18.7 m high by 72.8 m in diameter. Miscellaneous storage tanks are located in the plant yard.

A spray pond and pumphouse are located south of the general service building. The on-grade spray pond is the ultimate heat sink. It has a capacity of $4.5 \times 10^4 \text{ m}^3$ * of cooling water for emergency shutdown and at least 30-day cooling of the reactor. The spray pond pumphouse contains the emergency shutdown service water pumps and associated equipment.

A two-story alternate Steam Condensing Facility, approximately 46 m by 61 m by 38 m high, would be located between the turbine generator building and the circulating water pumphouse. Components in the facility would include high-pressure steam condensers, condensate drain tanks, condensate feed heaters, pumps, and condensate coolers. This facility would only be used if the main turbine generator was not available for power production, but reactor operation was required to meet production demands. The existing makeup water pumphouse, which would be used for the NPR, is located at the Columbia River, about 4 km northeast of WNP-1.

B.2.2.2 Nuclear Reactor Systems

The WNP-1 reactor is a pressurized light-water reactor, manufactured by the Babcock & Wilcox Company. The WNP-1 production reactor would be composed of the reactor vessel, the reactor internals including the fuel and target assemblies, and control rod drives. The reactor core would consist of 205 assemblies arranged in a cylindrical lattice.

*Scientific notation: $4.5 \times 10^4 = 45,000$.

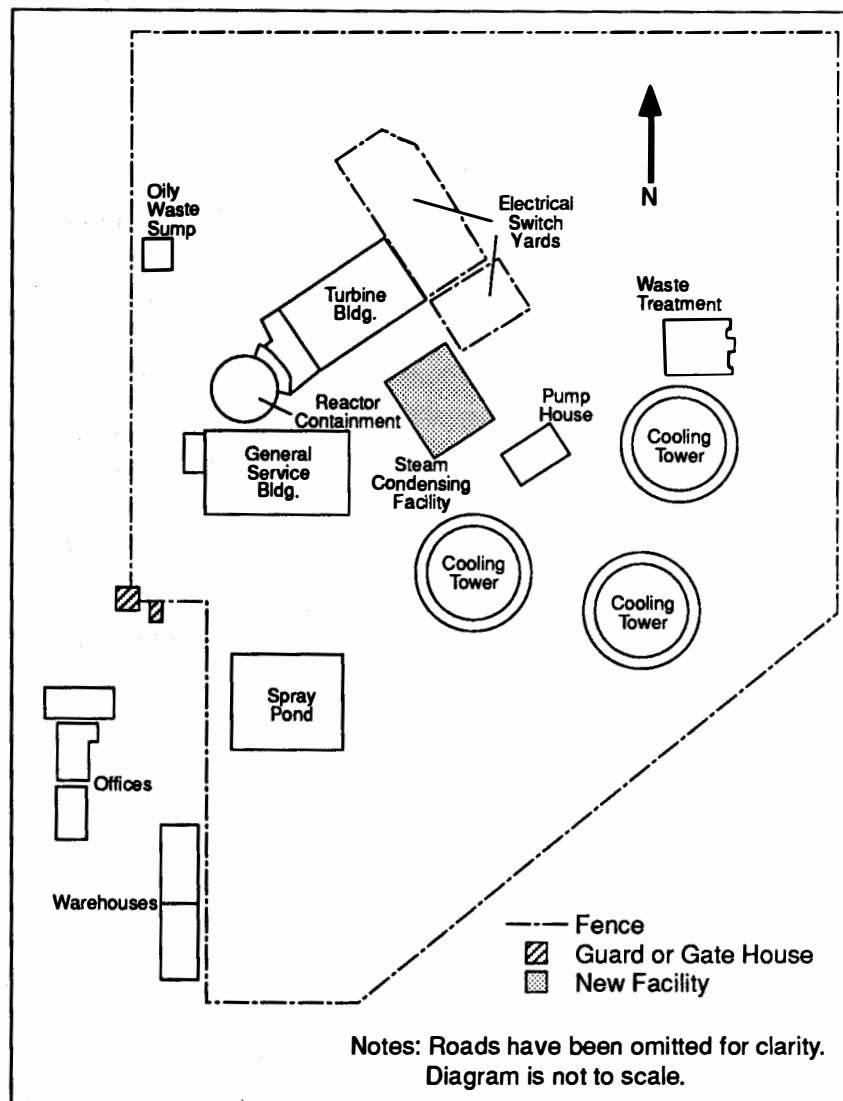


FIGURE B.3 WNP-1 Facility at Hanford (Source: Modified from WHC 1990b)

The core design power level would be 3,800 MWt. The rated power of the reactor would be 3,760 MWt, and the net plant electrical output for 3,760 MWt would be 1,259 MWe.

The reactor design allows operation between 25% and 103% of design power (with corresponding levels of tritium or plutonium production), which makes it possible to respond to varying levels of demand for electricity. When electricity is not being generated, the alternate steam condensing mode of operation would enable full-power operation and corresponding full tritium or plutonium production.

The nuclear steam supply system consists of the reactor, the reactor coolant system (two closed coolant loops connected in parallel to the reactor vessel), and associated auxiliary fluid systems. Each loop contains two reactor coolant pumps and a once-through steam generator with a pressurizer connected to one loop.

The reactor vessel and reactor internals contain and support the fuel and control rods and direct the reactor coolant through the core. The reactor vessel, which is made of low-alloy steel clad with stainless steel, is cylindrical, with hemispherical upper and lower heads. Control rod drive mechanisms, which position the control rods vertically in the reactor core, are mounted on the upper head.

The steam generators are vertical, straight-tube, tube-and-shell design heat exchangers. The hot high-pressure primary coolant from the reactor would flow through the tubes. The secondary-side feedwater to be converted to steam would flow through the shell side, outside the tubes. The reactor coolant pumps would be vertical, single-stage, centrifugal pumps equipped with controlled leakage shaft seals.

The reactor coolant system would contain and circulate reactor coolant at pressures and flows necessary to transfer the reactor heat to the steam generators. In addition to providing heat transport, the light-water coolant would serve as a neutron moderator and reflector. The reactor would be controlled by a coordinated combination of chemical shim in the form of soluble boron and mechanical control rods. Figures B.4 and B.5 present an elevation view and a schematic of the reactor coolant system, respectively. A decay heat removal system would cool the reactor during plant shutdown or reactor refueling and provide emergency cooling when required during off-normal operation.

B.2.2.3 Engineered Safety Features

The engineered safety features consist of systems that cool the core or maintain it in a coolable geometry in the event of a postulated design-basis accident. Cooling would be accomplished using the emergency core cooling systems. Coupled with the thermal-hydraulic and blowdown characteristics of the reactor, these systems would prevent excessive metal-water reactions (or changes in core geometry) that could prevent cooling and cause reactor core degradation. The engineered safety features would limit the potential radiation dose to the general public from a design-basis accident to below-guideline values of Title 10, *Code of Federal Regulations*, Part 100 (10 CFR 100).

B.2.2.4 Reactor Containment

The WNP-1 containment building is a 46-m inside diameter, 79-m-high, reinforced-concrete, cylindrical structure with a hemispherical dome and a circular, flat, reinforced-concrete base mat foundation. The free volume within the containment is 87,500 m³. The containment isolates those systems that penetrate the containment, but that are not essential to mitigate the consequences of an accident, thereby reducing the risk to public health and safety. The containment is also designed to resist various combinations of seismic loads, winds, pressures, temperatures, and tornado forces during normal and accident conditions. The containment has been designed, constructed, and certified in accordance with the American Society of Mechanical Engineers Boiler and Pressure Vessel Code, Section III, Division 2, and has been pressurized to 60 psig to test its structural integrity. Access to the containment is provided by a personnel airlock and an equipment hatch with an emergency airlock.

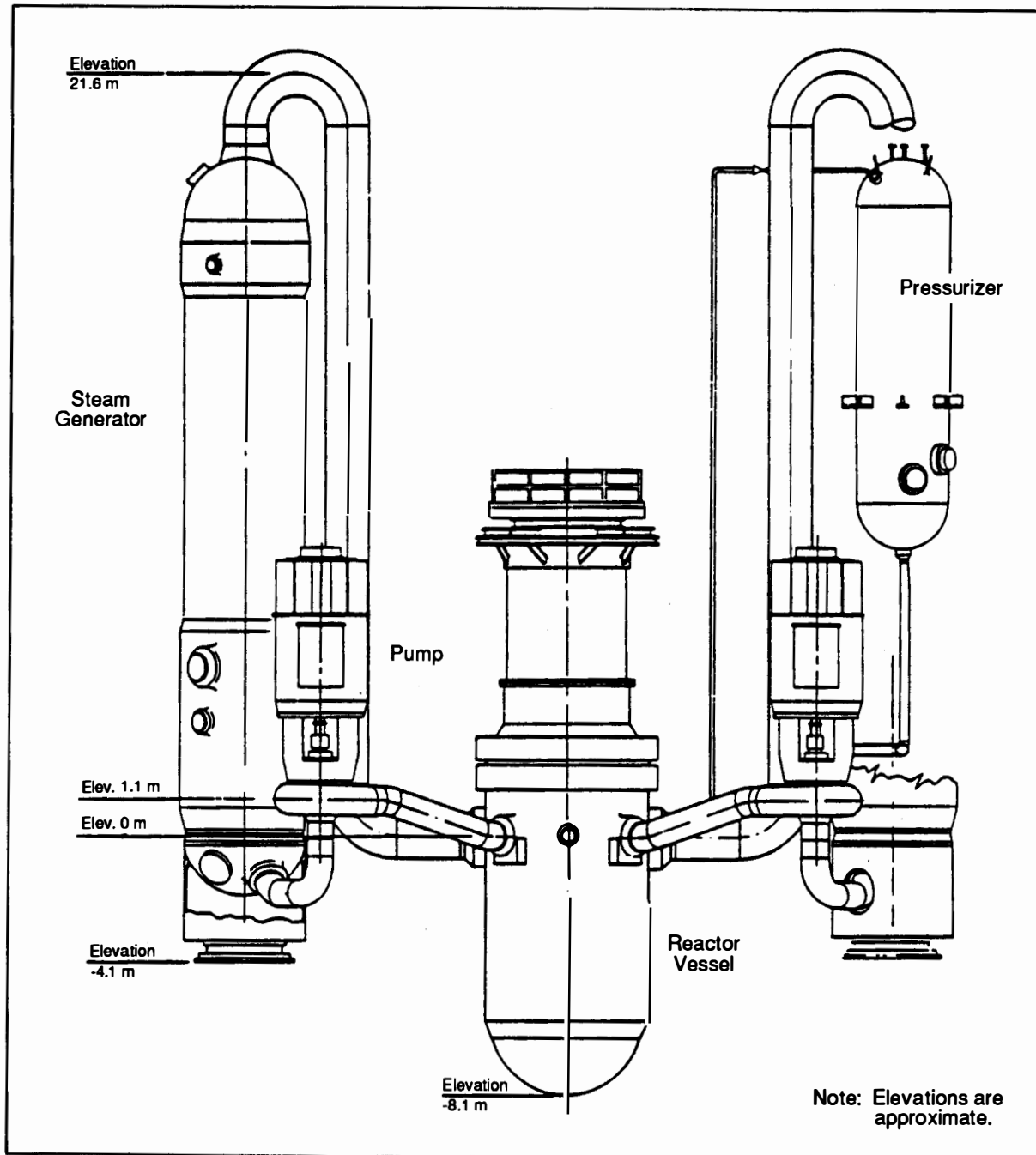


FIGURE B.4 LWR Reactor Coolant System Arrangement at Hanford (Elevation View; Based on WNP-1) (Source: WHC 1990b)

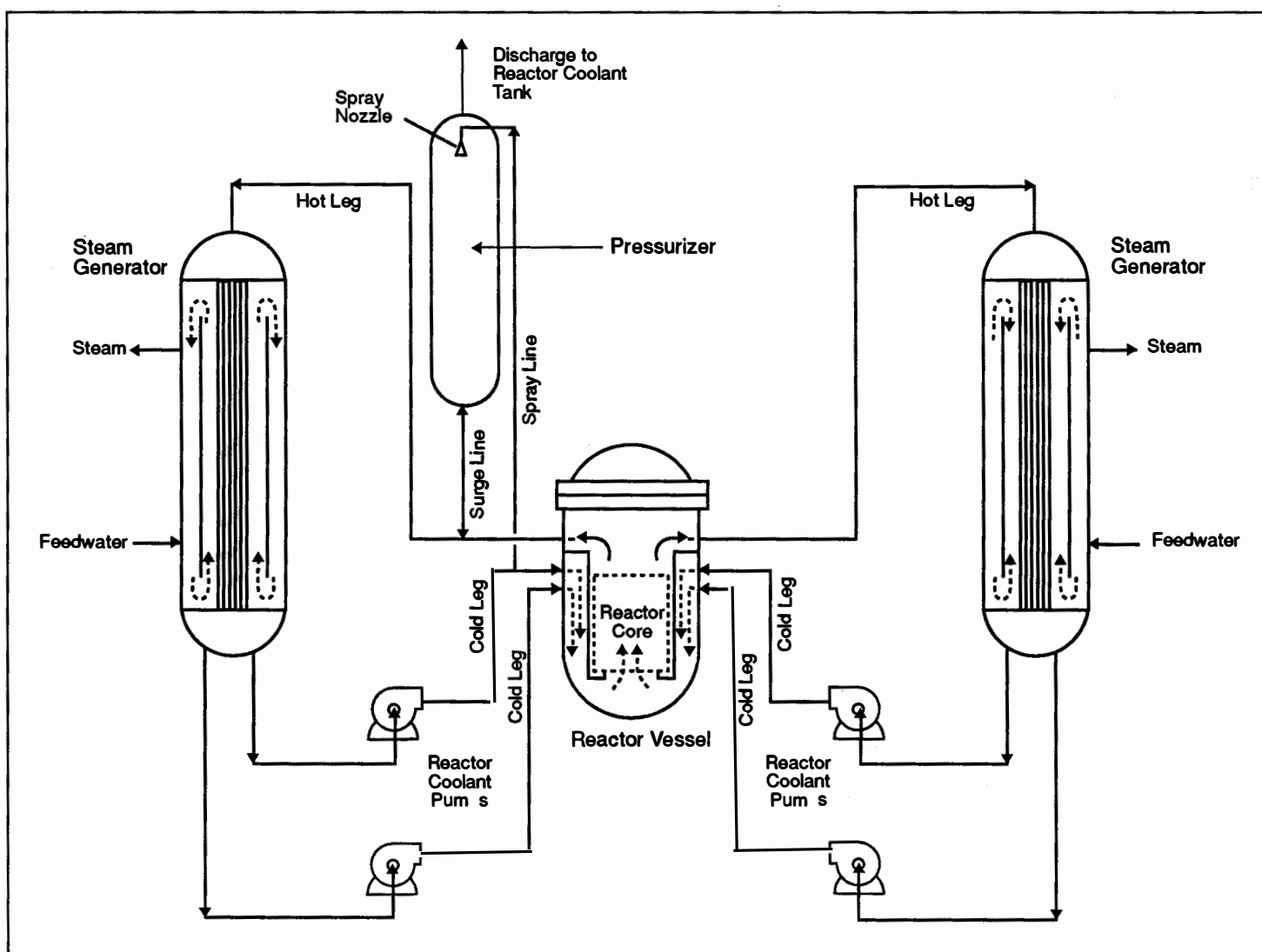


FIGURE B.5 LWR Reactor Coolant System Piping at Hanford (Based on WNP-1) (Source: WHC 1990b)

B.2.2.5 Fuel and Target Handling

The reactor would be refueled with equipment capable of handling spent fuel and target assemblies underwater from the time the fuel and target assembly is removed from the core until it is placed in a cask for shipment from the reactor site. Underwater transfer provides an optically transparent shield as well as a reliable source of coolant for removal of decay heat. The use of borated water would ensure subcritical conditions during refueling.

A spent fuel and target assembly would be removed from the core using a pneumatically operated fuel grapple. It would then be inserted into a transfer basket, moved through the fuel transfer tube to the spent fuel storage pool, removed from the basket, and placed in storage racks in the pool.

The tritium targets would be removed from the assemblies and packaged for transport to the Tritium-Target Processing Facility. The remaining fuel assemblies would be packaged for transport to the fuel processing facilities. For the plutonium production mode, the fuel/target assembly would not need to be disassembled. The complete assembly would be packaged in certified casks for transport to the Spent Fuel Processing Complex. This procedure would be reversed to move the fuel/target assemblies from the storage vault into the core.

B.2.2.6 Power Conversion System

During normal operation, steam would flow from the steam generator outlet nozzles through the steam piping, the main steam isolation valves, the main steam throttle valves, and the control valves into the high-pressure end of the turbine. During normal operation, steam would also be supplied to the main feedwater pump turbines, to the reheaters of the moisture separator-reheater system, and to the turbine glands for sealing. Steam would also be supplied to auxiliary feedwater pump turbines during certain abnormal conditions.

The turbine generator is a single-shaft, 1,800-rpm, tandem-compound, impulse-reaction turbine with one stage of external moisture removal and two stages of steam reheat. A hydrogen-cooled electric generator with water-cooled stator conductors and a direct-connected, brushless excitation system form the generator section. Turbine exhaust steam would be reconverted to water in the turbine condenser and recycled to the steam generators.

The turbine plant's electric system and its associated equipment are designed to generate and deliver power to a high-voltage transmission network. This system includes facilities for providing power to and controlling the operation of electrically driven station auxiliary power equipment and instrumentation. The electricity from the plant would be fed into the transmission network of the Bonneville Power Administration's power system. Figure B.6 is a schematic of the power conversion system, i.e., the turbine generator plant.

When the turbine generator is not operational, the alternate heat dissipation system, also referred to as the steam condensing system, would take over. This system would be a closed-cycle system with separate condensers and pumps that feed water to the steam generators. The existing cooling towers would also provide cooling to these condensers.

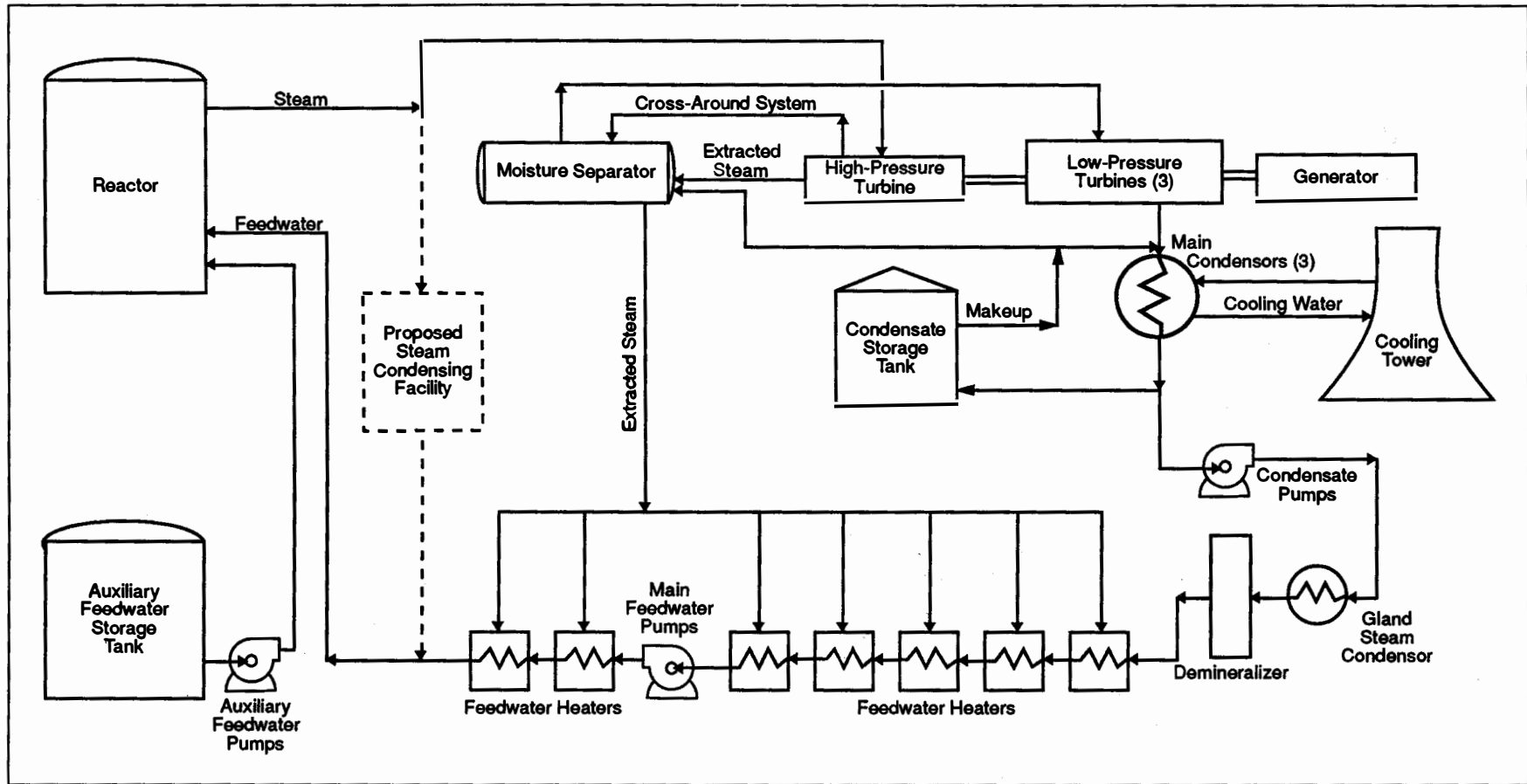


FIGURE B.6 Power Conversion System at Hanford (Source: WHC 1990b)

The auxiliary feedwater system is a safety system. When needed, this system would supply feedwater to the steam generators to remove residual heat for safe reactor cooldown. The system consists of four feed pumps; two pumps would be driven by steam tapped from a main steam line from each steam generator, and two pumps would be electrically driven. All four pumps, one steam and one electric in each of the two trains, are designed to operate when an engineered safety features actuation signal is received.

B.2.2.7 Electric System

The reactor plant is supplied by two electric systems, one from the turbine generator and the other from two off-site sources, consisting of a 500-kV and a 230-kV system. The 500-kV tieline would be a dual-purpose installation. When the generator is off-line, it would carry power to the auxiliary boiler and station auxiliary transformers. When the generator is on-line, it would carry power from the generator to the H.J. Ashe switchyard. The generator would also provide power for station auxiliary loads.

While generating, all auxiliary power would be supplied from the turbine generator. When the generator is off-line, appropriate interconnections through either the 500-kV or the 230-kV off-site tieline would ensure continued power to vital equipment. Two diesel generators (each 7,000 kWe) would serve as standby emergency on-site power sources in the event of a complete loss of off-site power and loss of the turbine generator.

B.2.2.8 Heat Dissipation Systems

Heat dissipation for the NPR would be based on the existing facilities constructed for WNP-1. These facilities use Columbia River water as a medium for disposing heat to the atmosphere via wet cooling towers; a small amount of heat is disposed to the Columbia River via cooling tower blowdown. This river water would mostly be used for cooling either the turbine condenser during electricity generation or the alternate steam bypass heat dissipation system condenser during operation. The Columbia River would also supply water for other cooling systems and serve as the source of potable and process water for the Reactor Facility.

Turbine Condenser Cooling System

The turbine condenser cooling system includes the condensers, cooling towers, cooling water pumps and piping, makeup water intake structure on the Columbia River, and discharge system to the river. In addition to providing cooling water to the main turbine condensers, the system provides cooling water to the alternate heat dissipation system condensers and also rejects small amounts of heat from auxiliary equipment.

Cooling water from the cooling towers circulates through the tube side of the condensers, and heated water returns to the cooling tower. The cooling tower rejects heat to the atmosphere, cooling the water for recirculation to the condensers. During this process, water is lost into the atmosphere by evaporation and drift. The WNP-1 reactor would use evaporative mechanical draft cooling towers for this purpose. A small portion of the circulating water (blowdown) is continuously discharged to the river to control buildup of dissolved solids in the

cooling water. Makeup water would be added continuously to compensate for evaporation, drift, and blowdown.

The peak water loss from evaporation and drift during power production is $0.98 \text{ m}^3/\text{s}$, assuming 100% reactor power. Water loss from evaporation and drift is estimated at $2.45 \times 10^7 \text{ m}^3/\text{yr}$, if the unit operates continuously at 100% power. These cooling tower losses are calculated on the basis of 30 years (1950-1980) of meteorological data taken at Hanford. Three 0.9-m-diameter intake lines are currently installed from the pumphouse to the river intake located 219 m to the east. Details of the makeup water inlet structure are presented in Figure B.7.

Cooling tower blowdown water ($5.27 \times 10^6 \text{ m}^3/\text{yr}$) is removed from the circulating water system at the point of discharge from the circulating water pumps. A cooling tower blowdown line that runs parallel to and downstream of the buried makeup water intake lines discharges to the Columbia River. The blowdown line is buried under the riverbed and emerges about 7.6 m downstream of the makeup water inlets and 219 m from the pumphouse. At low-river stage, the discharge port is about 91 m from the shoreline. A schematic of the blowdown discharge piping is presented in Figure B.8. Riprap is placed around the outfall to prevent erosion of the riverbed.

The peak water loss in the steam bypass condensing mode would be approximately $1.43 \text{ m}^3/\text{s}$ if the plant were operated at maximum. The maximum blowdown rate would be approximately $0.31 \text{ m}^3/\text{s}$, using the design conditions of five cycles of concentration of cooling water (Table B.1). The makeup water required in this mode would be $4.5 \times 10^7 \text{ m}^3/\text{yr}$.

The intake and discharge systems provide the increased makeup and blowdown requirements in the steam condensing mode. Three makeup pumps would provide makeup water for evaporation, drift, and blowdown at 100% power in the steam condensing mode. The maximum expected blowdown temperature would be 31.7°C . Other aspects of the cooling water, intake, and discharge systems would remain unchanged during the steam condensing operation.

Water Treatment Systems

Water treatment for the turbine condenser cooling system would have two purposes. To control buildup of scale in the system, sulfuric acid would be added continuously to maintain pH and alkalinity. To control biological fouling in the system, chlorine would be added intermittently for 30-minute periods. Chlorination would take place a maximum of three times per day during the summer months when biological activity would be at its peak. To ensure that no chlorine would be discharged to the river, blowdown would be terminated during chlorination. The chemical composition of the cooling tower blowdown at five cycles of concentration (average values) and ten cycles of concentration (maximum values) is discussed in Section 4.1.3.

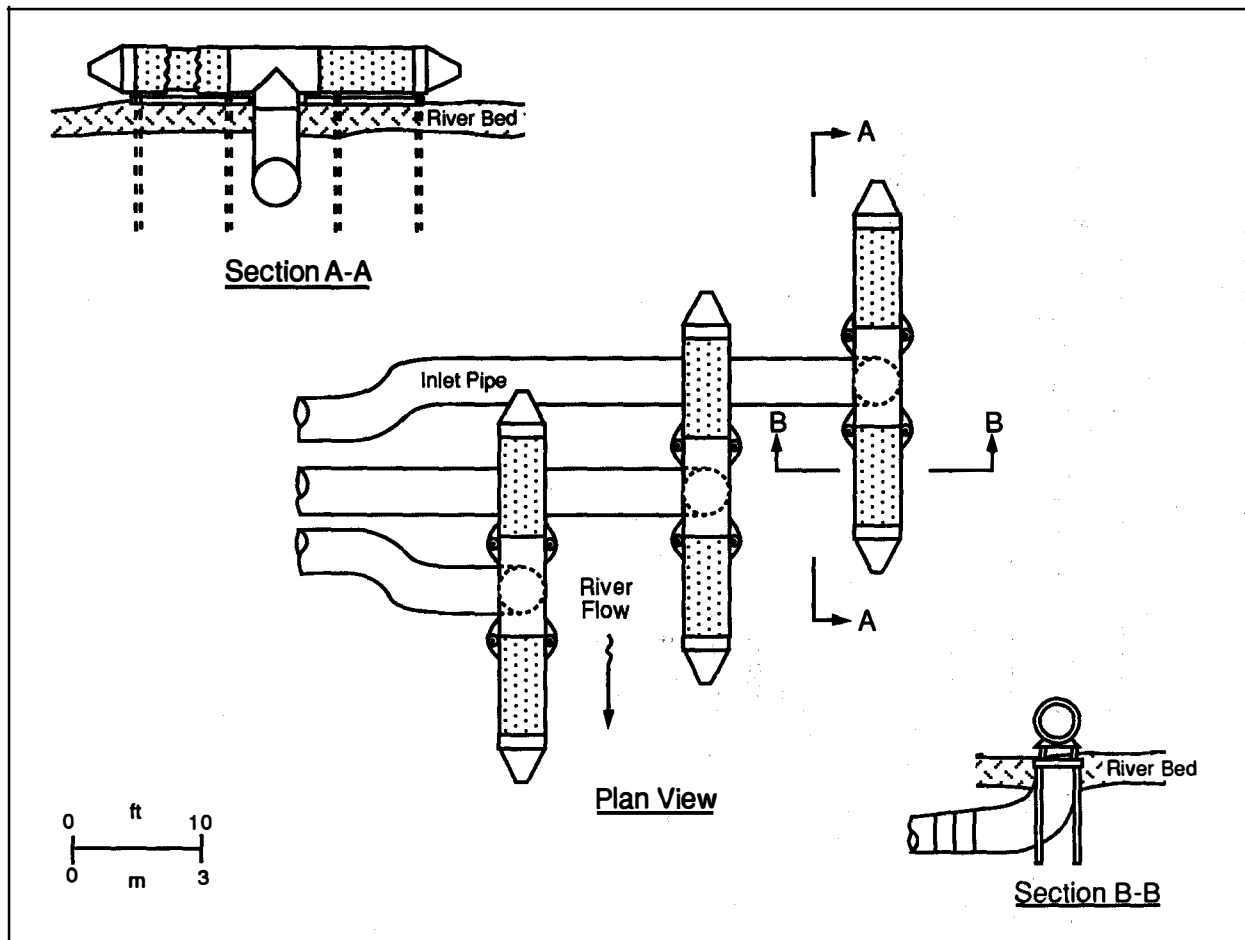


FIGURE B.7 Details of the Makeup Water Inlet Structure at Hanford (Source: WHC 1990b)

A second water treatment system installed at WNP-1 would condition Columbia River water for use as potable and process water. The second water treatment system consists of three distinct physical and chemical process systems: the pretreatment system, which includes disinfection, clarification, and filtration; the demineralization system, which includes activated carbon adsorption, mechanical degasification, and demineralization by ion exchange; and the potable water system, which includes activated carbon adsorption and disinfection. The capacity of the pretreatment system is $5.7 \times 10^{-2} \text{ m}^3/\text{s}$. An average of about 4.5 kg/d, 50 kg/d maximum, of solids would be removed by the pretreatment system, about equally divided between clarifier sludge and gravity filter backwash.

Other Reactor Cooling Water Systems

The WNP-1 turbine condenser cooling systems would provide balance-of-plant service water, component cooling water, nuclear service water, and emergency shutdown service water. A diagram of the plant cooling water system flow is shown in Figure B.9.

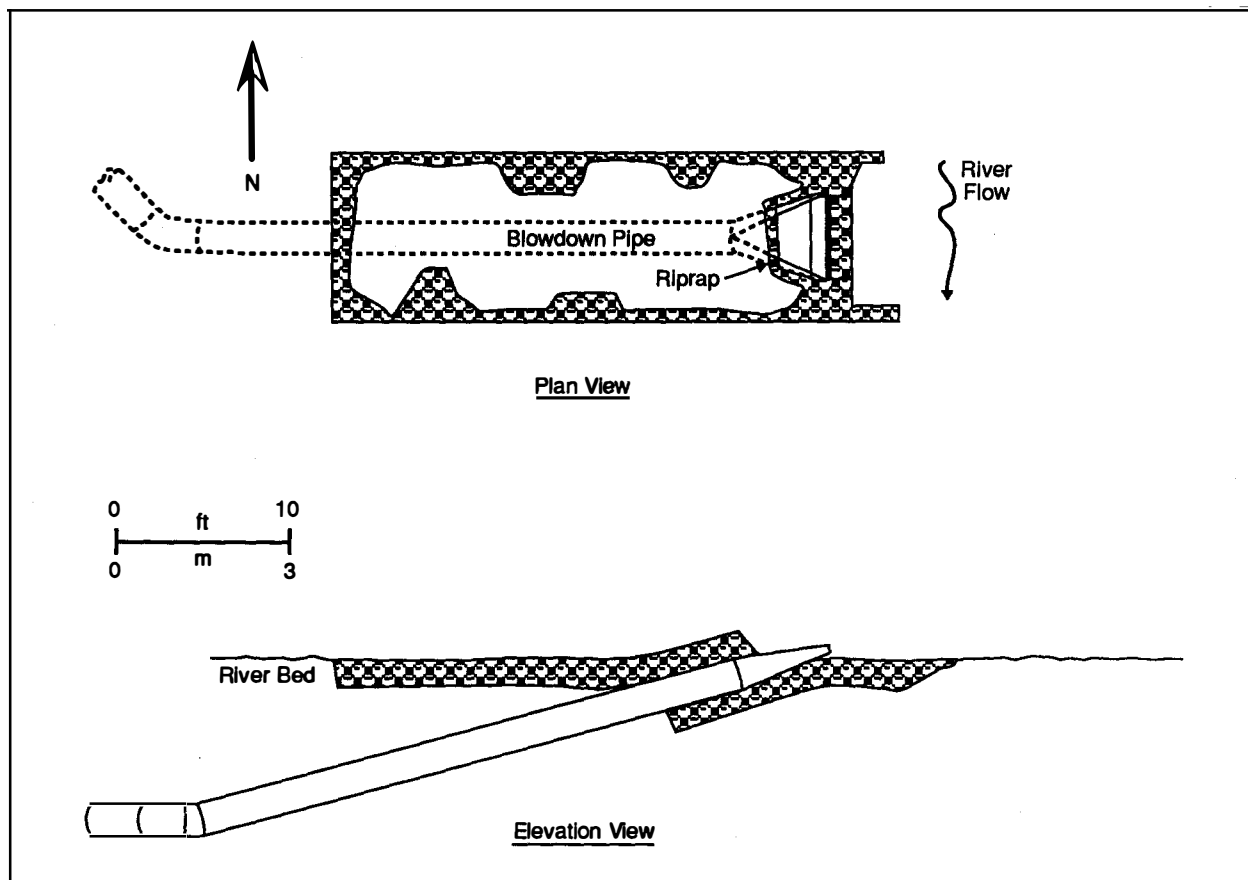


FIGURE B.8 Schematic of Blowdown Discharge Piping at Hanford (Source: WHC 1990b)

During an emergency or an accident, when the normal water system might not be available, cooling water would be provided from the emergency shutdown service water system, which is a closed-loop cooling system that would reject the plant heat to the ultimate heat sink. The ultimate heat sink consists of a single, concrete-lined pond with redundant pumping and spray facilities. The pond and pumphouse are designed to Reactor Safety Class 1 criteria. The spray pond is sized to provide emergency cooling water for 30 days without makeup.

B.2.2.9 Waste Management

For the purpose of this EIS, it is assumed that spent fuel would ultimately be disposed of in a Federal repository. Spent fuel processing is analyzed in this EIS as part of the original mission of NPR, which included the production of virgin plutonium-239. However, plutonium production is no longer part of the NPR proposed action. The Waste Management PEIS will assess the impacts of wastes from reprocessing of spent fuel from DOE reactors.

The quantities and types of wastes to be managed depend on whether spent fuel is reprocessed and whether plutonium is produced. Estimates in this appendix were prepared on the basis that it is reasonably foreseeable that spent fuel could be reprocessed and plutonium produced. If it is decided not to continue those activities, the impacts upon waste management systems, from NPR operations, would be less than shown here.

TABLE B.1 Estimated Water Use for LWR Cooling Towers at 3,800-MWt Reactor Power (Bounding Case; Steam Bypass Mode)^a

Type of Water Use	Hanford	INEL	SRS
Evaporation			
Peak (m ³ /s)	1.43	1.27	1.27
Annual (10 ⁶ m ³)	36.8	36.0	37.8
Drift			
Peak (m ³ /s)	0.008	0.008	0.008
Annual (10 ⁶ m ³)	0.254	0.254	0.254
Blowdown			
Peak (m ³ /s)	0.31	0.31	0.83
Annual (10 ⁶ m ³)	7.87	8.71	24.5
Concentration factor	5	5	2.5 ^c
Makeup			
Peak (m ³ /s)	1.75	1.59	2.11
Annual (10 ⁶ m ³)	44.9	45.0	62.6
Temperature control			
Peak (m ³ /s)	NR ^b	NR	1.30
Annual (10 ⁶ m ³)	--	--	38.2

^aPeak values are based on the month of greatest water use. Annual values are based on the averages of 12 months.

^bNR = not required.

^cThe concentration factor is limited to 2.5 at SRS to meet discharge requirements for dissolved solids.

Conversion factors: 1 m³ = 264.2 gal;
1 m³/s = 15,850 gal/min.

Sources: WHC 1990b for Hanford data; UE&C 1990 for INEL and SRS data.

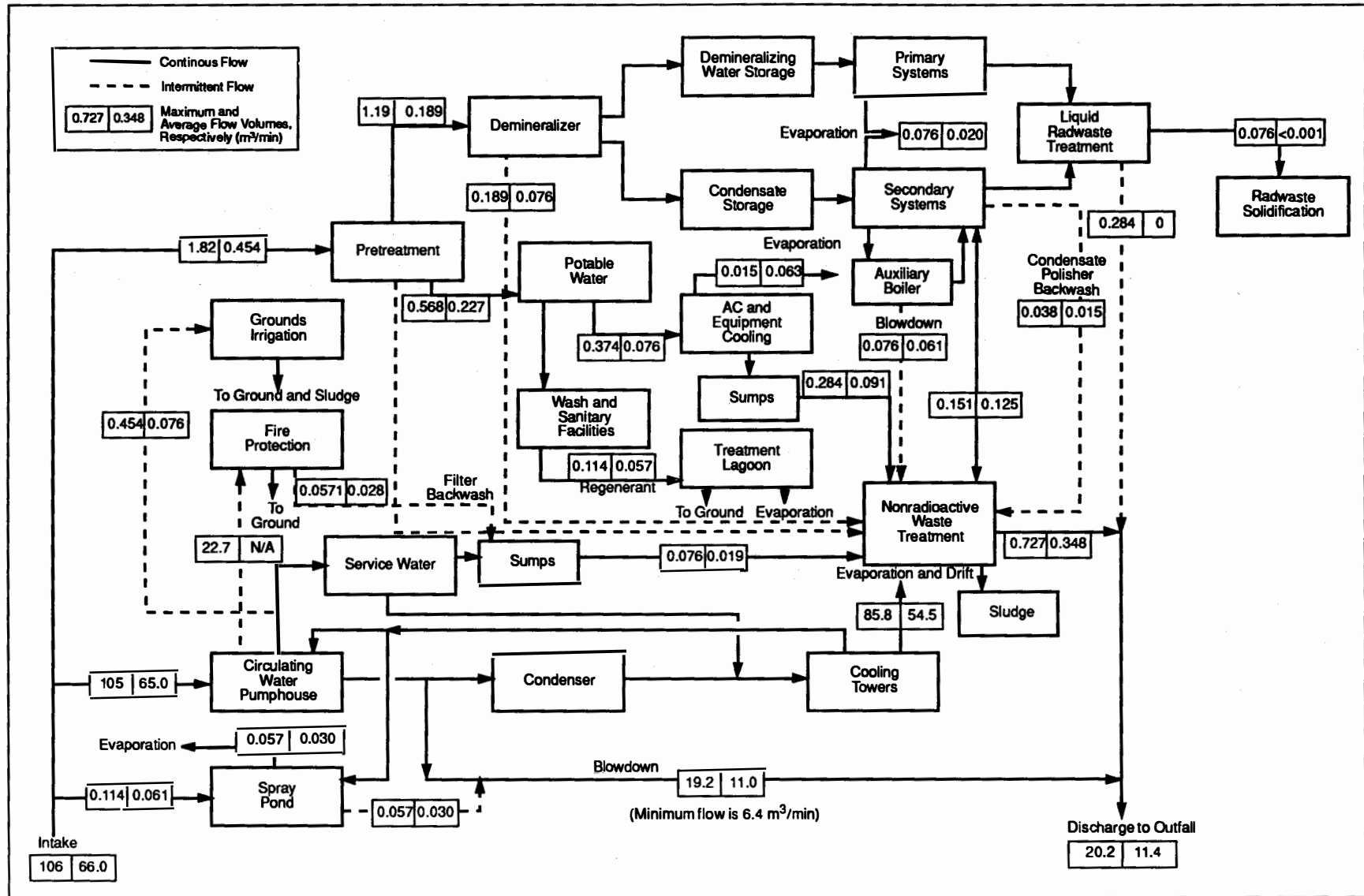


FIGURE B.9 LWR Cooling Water System Flow at Hanford (Based on WNP-1) (Source: WHC 1990b)

There are six categories of wastes: high-level waste, low-level waste, mixed (radioactive and hazardous) waste, hazardous waste, transuranic (TRU) waste, and other waste (see Appendix M for definitions of wastes). During normal operation, no high-level or TRU wastes would be produced at the reactor, although subsequent processing of the irradiated fuel would result in such wastes at the processing facilities. Low-level, mixed, hazardous, and other effluents and wastes are produced at the reactor, and their processing is summarized in the following sections.

Gaseous Waste Processing

The radioactive gaseous waste system receives, processes, and holds radioactive off-gases. The system consists of two parallel, redundant processing trains, four parallel gas decay tanks, and one release high-efficiency particulate air (HEPA) filter assembly. Gases directed to the system would be diluted by a recirculating nitrogen gas flow to maintain hydrogen concentration below the point of flammability. The gases would then be compressed and sent through a hydrogen recombiner unit. The gaseous waste stream would be directed to one of four waste gas decay tanks. The tank contents would be held for decay of the short-lived isotopes until analysis of the contents indicates release limits would not be exceeded. The gas would be filtered through a HEPA filter and monitored during discharge with the building exhaust. Spent HEPA filters would be processed in the radioactive solid waste system (see Solid Waste Processing discussion that follows). The reactor coolant bleed degasifiers would be the largest contributors to the radioactive gaseous waste system. The components of the radioactive gaseous waste system are cross-connected to provide operational flexibility and to allow operation following equipment malfunctions.

The detritiation system, if required, would keep the tritium releases from the liquid and gaseous effluents at or below the amount released for a typical LWR power plant. The most direct method for accomplishing this would be to detritiate the reactor coolant. The final selection of a detritiation process has not been made, but it is likely to be based on the distillation principle.

Drift of water droplets from the cooling towers would constitute about 0.02% of the circulating water flow rate. The chemical composition of the drift would be the same as that of the cooling tower blowdown. During chlorination, the cooling tower drift would contain residual chlorine. At the maximum chlorination rate, discharge of chlorine to the atmosphere would be about 0.5 kg/d.

Under normal operating conditions, the Reactor Facility would not burn any fossil fuels; however, the standby diesel generators would burn fossil fuel and emit gaseous wastes to the environment intermittently during testing.

Liquid Waste Processing

During normal operation of WNP-1, low-level liquid wastes would be generated from the sumps of the reactor containment building and the general service building, from the backflushing of demineralized beds, and from small leakages within the Reactor Facility. These wastes are processed in the radioactive liquid waste system located in the general service building. The system consists of three collection tanks, two identical processing trains, four

holdup tanks, and the associated piping. Each processing train is provided with filters, a forced circulation evaporator package, and mixed-bed demineralizers. The system is designed to continuously collect and treat batches of radioactive and potentially radioactive liquid wastes generated during normal reactor operation, including anticipated operational occurrences. The collection tanks are designed to provide 30 days of holdup capacity at the maximum flow rates.

Batches of waste are collected in the three tanks according to activity level. The contents of one tank are high-level wastes, mainly evaporator concentrates, which are sent to the radioactive solid waste system for solidification and subsequent transfer to the sitewide waste management system (Section A.3.9). The contents of the other two lower activity level tanks would first be processed through the processing trains to concentrate. Then these lower activity wastes would be recycled to the high-level waste tank, or passed through filters and demineralizers and discharged as treated waste, or sent to holding tanks to allow short-lived isotopes to decay to acceptable levels.

Treated waste (i.e., waste that has been processed through filters, forced circulation evaporators, and mixed-bed demineralizers to reduce activity levels to below discharge limits) would be discharged via the cooling tower blowdown line to the Columbia River. Treated waste would be isolated from the cooling tower blowdown line by a valve controlled by radiation monitoring equipment, followed by a manually operated valve. Solid wastes produced during low-level liquid waste processing would be processed in the radioactive solid waste system (see Solid Waste Processing discussion that follows).

During the operation of WNP-1, wastewater streams would be produced from a number of sources. These waste sources include low-volume waste, backwash, and regenerant from the water treatment plant; blowdown from plant air conditioning systems and from equipment cooling water; waste from equipment and floor drains, including bearing and seal leakage and oily wastes; waste from the radioactive liquid waste treatment system; backwash from the condensate polishing system; preoperational fluid system cleanliness verification flush; metal-cleaning waste; auxiliary boiler blowdown; and circulating water system waste.

These waste streams would be collected and directed to the nonradioactive waste treatment system. The treated wastewater would be discharged to the cooling tower blowdown line after pH adjustment. The wastewater treatment system settling basins would be periodically drained, and accumulated solids would be removed for landfill disposal.

Chemicals used to treat water and wastes are detailed in Table 3-17 of a Hanford report (WHC 1990b). A schematic of the water flow at WNP-1 is shown in Figure B.9. The maximum anticipated plant water use for the electric power production mode for full-power production, 25% electric power production, and normal shutdown is discussed in Section B.2.8.2. Discharge compositions and volumes of the waste streams are discussed in Section 4.2.3.

The treatment of the solid wastes generated in this nonradioactive liquid treatment system is described in the Solid Waste Processing discussion that follows. The treatment of hazardous and mixed wastes within the sitewide waste management system is described in Section A.3.9.

Corrosion or erosion of the condenser and miscellaneous heat exchanger tubes could contribute small amounts of corrosion products to the blowdown. The seismically qualified

spray pond that serves as the ultimate heat sink would be blown down occasionally to control solids buildup, but the discharge would be insignificant.

The sanitary waste treatment system would use aerated lagoons together with lined stabilization ponds. Flow from the ponds would be alternately directed to four percolation and evaporation ponds with a combined area of about 1 ha. The percolation ponds are located above the water table, and there would be no discharge to a surface water course. Wastes would be delivered to the sanitary treatment plant via a gravity collection system.

Solid Waste Processing

The radioactive solid waste system is designed to solidify various liquid wastes and to process solid radioactive wastes for safe shipment to a Federal repository. The process flow diagram of the LWR radioactive solid waste system is shown in Figure B.10.

The wastes handled by the radioactive solid waste system (all low-level wastes) include dry, lightweight, compactible items such as clothing, paper, and glassware; spent resin beads from various plant demineralizers; spent powdered resin from the condensate polishing system; spent filter cartridges containing resin fines, corrosion products, and particulates from various plant process systems; highly concentrated liquid wastes (e.g., boron recovery system evaporator concentrates, radioactive liquid waste system evaporator concentrates, radioactive liquid waste system filter backflush tank contents, and radioactive vent and drain system chemical drain tank contents); and dry, noncompactible wastes, HEPA filters, wood, and steel.

Liquid wastes would be solidified in stainless steel vessel liners by mixing with a Portland cement/sodium silicate solidification agent. Resin beads and powdered resins would be dewatered and mixed with the concentrated wastes before solidification. Spent resin beads might be dewatered as an alternative to solidification. Solidified waste containers might be stored to allow for decay before off-site disposal.

Dry wastes to be compacted would be bulky, but light. A standard industrial ram device would compact the material in containers to save space in shipping. When a container is full, the materials would be placed in the compactor and compacted into 0.21-m³ (55-gal) steel drums. The container would be capped, monitored, decontaminated (if necessary), and held for off-site shipment. In addition, U.S. Department of Transportation-approved cartons could be used.

Radioactive waste would either be stored in a shielded storage room in the radwaste area or in the radioactive material storage area of the general service building. The containers could be stored for approximately 4 months to allow decay of radionuclides before shipping, assuming a solidification system would process one 3-m³ container every 5 days. At that design rate, waste could be stored for approximately 2 weeks. If the system were operated at maximum throughput, approximately 3 days of storage would be available. These storage times assume no shipments would occur until the storage room is filled to capacity.



Hazardous, mixed, and other wastes would be treated within the sitewide management system (Section A.3.9).

B.2.3 Fuel and Tritium-Target Fabrication

The designated location for fuel and tritium-target fabrication and for tritium-target processing is the Fuels and Materials Examination Facility, which was completed in 1984. This facility was built to support irradiation testing of fuels and materials for liquid-metal fast breeder reactors and is currently uncontaminated because no radioactive material has been processed in the facility. The only planned operation is the assembly of thermoelectric generators containing encapsulated plutonium-238. A proposal has been made to use the facility for assembly of fuel for the Fast Flux Test Facility starting in 1994. If this activity or other plutonium-238 operations are added, use of the facility for NPR fuel and target fabrication and tritium-target processing may be precluded; in that case, these NPR facilities would be located in the 200-East Area.

B.2.3.1 Facility Description

The processing building at the Fuels and Materials Examination Facility is a 79-m-long, 46-m-wide concrete structure that extends 11 m below grade to 27 m above grade at the roof level. The building has seven floors, a floor area of 15,800 m², and four annexes (the entry wing, the fuel assembly area, the mechanical equipment wing, and the emergency wing). Offices, safeguards and security computers, laboratory space, maintenance, and emergency support equipment are included.

The Fuels and Materials Examination Facility is a Class A facility for handling Category 1 special nuclear materials and meets or exceeds current seismic, safeguards, and security requirements for a facility of this type. The facility is designed to control the spread of contamination within the facility and to prevent uncontrolled releases of radioactive materials to the environment.

Final assembly of the tritium production assemblies would take place in the assembly area. Target processing would use the main hot cell in the central portion of the processing building and in adjacent rooms on multiple floors.

B.2.3.2 Fuel and Target Description

The proposed tritium production assembly (Figure B.11) would be composed of a square array of UO₂ and lithium aluminate-filled rods connected by end nozzles and a series of spacer grids. The fuel rods would consist of Zircaloy-4 tubes containing pellets of 8-12 wt% uranium-235 enriched UO₂. A range of enrichments would promote uniform neutron flux fields in the reactor. The target rods would be composed of stainless steel tubes filled with lithium aluminate pellets.

Each fuel assembly would consist of 288 prepressurized fuel rods, 40 target rods, 32 control rod guide tubes, 1 instrument tube, 8 spacer grids, and 2 end fittings. The guide tubes, spacer grids, and end fittings would form a structural cage to hold the rods and tubes in a 19 by 19 array.

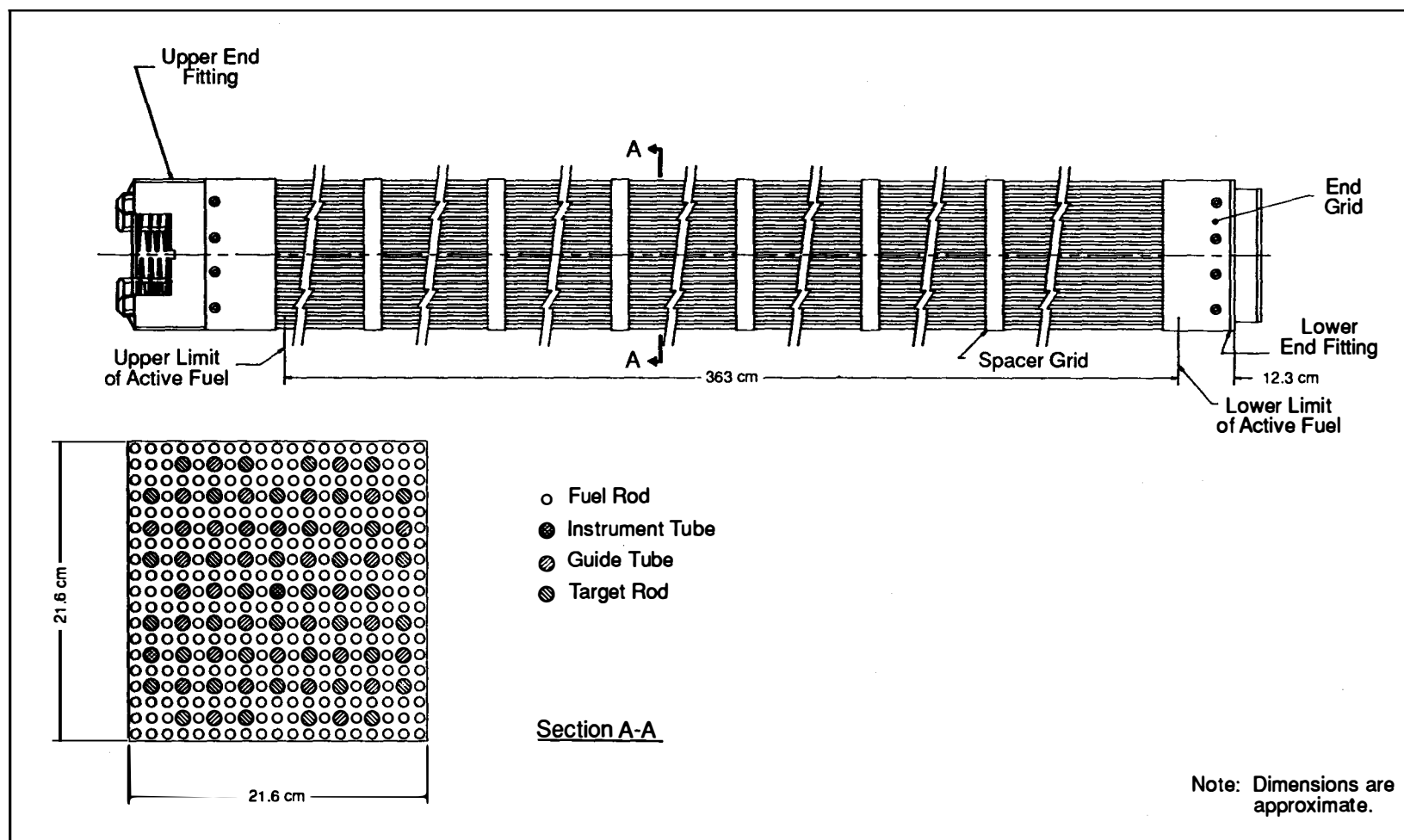


FIGURE B.11 Proposed Tritium Production Assembly at Hanford (Source: WHC 1990b)

B.2.3.3 Process Description

A simplified block flow diagram of the fuel fabrication process is shown in Figure B.12. Uranium dioxide powder would be received from the uranium plant located in the Spent Fuel Processing Complex. The powder would be blended, pressed into pellets, and sintered. Strings of pellets would be pushed into an empty Zircaloy tube previously welded shut at one end. Loaded tubes would be outgassed, backfilled with helium, and welded shut.

A simplified process flow diagram for tritium-target rod fabrication is shown in Figure B.13. The process would begin with lithium carbonate and aluminum oxide, which would be blended, calcined, pressed into thin, annular, ceramic pellets, and sintered. The pellets would then be ground to size, inspected, preassembled with the getter, and loaded into individual stainless steel tubes. The tubes would be dried, backfilled with helium, and welded shut. Fully inspected tubes would be placed in containers and transported to the bundle assembly area where the target tubes, driver-fuel tubes, and associated hardware would be assembled into a bundle before shipping to the reactor.

B.2.3.4 Process Effluents and Wastes

The existing facility exhaust stack is 35.7 m high and is located on the north side of the Fuels and Materials Examination Facility. The estimated off-gas flow is 37.7 m³/s. Flow sheets for off-gas treatment systems would be developed during the conceptual design stage. This ventilation system would need to be modified to provide for fuel and target fabrication and target processing in the building (Figure B.14). Off-gas from most of the fuel fabrication area would pass through one stage of HEPA filtration and then through two additional HEPA filters before leaving the main exhaust blowers. Off-gas from some of the fuel assembly areas might only pass through the final two stages. No filtration would be required for off-gas from the target pin fabrication area; however, this off-gas would pass through the final two stages of HEPA filters.

No fume or particulate scrubber requirements are anticipated for the fuel and target pin fabrication areas. Off-gas flows from the pellet sintering furnaces would be oxidized to ensure explosive mixtures are not released.

The Fuels and Materials Examination Facility contains a complex liquid waste system designed to segregate radioactive from nonradioactive wastes. This system would be modified to segregate wastes from NPR fuel and target fabrication and target processing. Liquid wastes from fuel and target fabrication and target processing would consist of sanitary wastes, process wastewater, chemical wastes (some of which may be hazardous), and potentially low-level radioactive wastes. Radioactive liquids from fuel fabrication operations would be collected and transported by truck to the 200-East Area for disposal following concentration and solidification. Radioactive liquids from target processing operations would be solidified in the Fuels and Materials Examination Facility, and the resulting low-level solid waste would be disposed of within the sitewide waste management system.

Chemical wastes would be generated by demineralizer regeneration, spent X-ray film development chemicals, target fabrication laboratory analyses, pellet grinding, and stainless steel tubing passivation. Spent plating wastes might also be generated by target fabrication operations

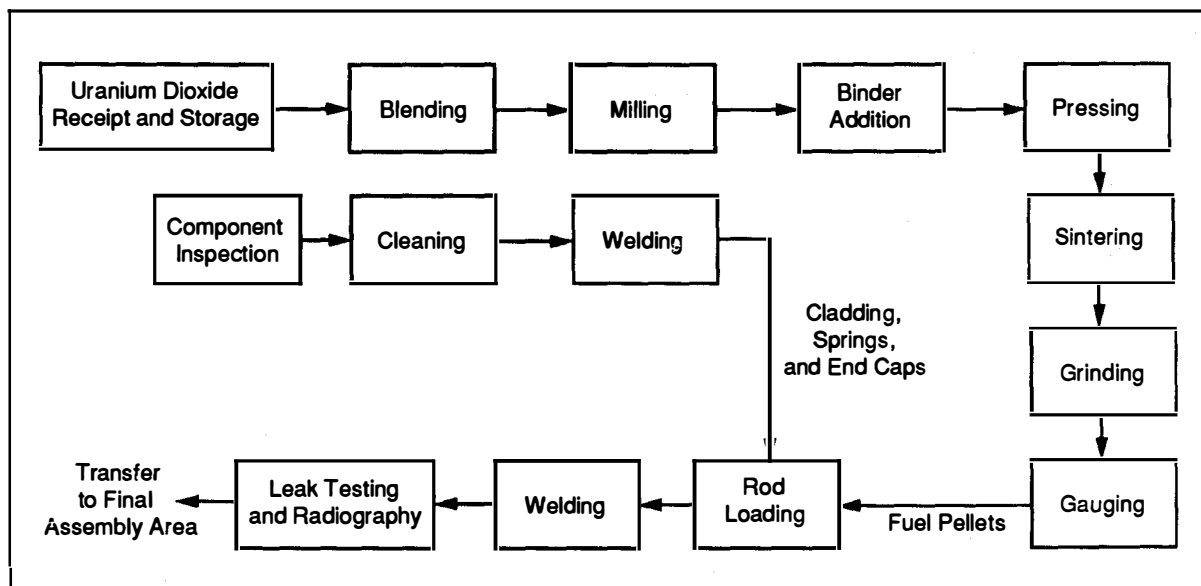


FIGURE B.12 Tritium Fuel Rod Fabrication Process at Hanford (Source: WHC 1990a)

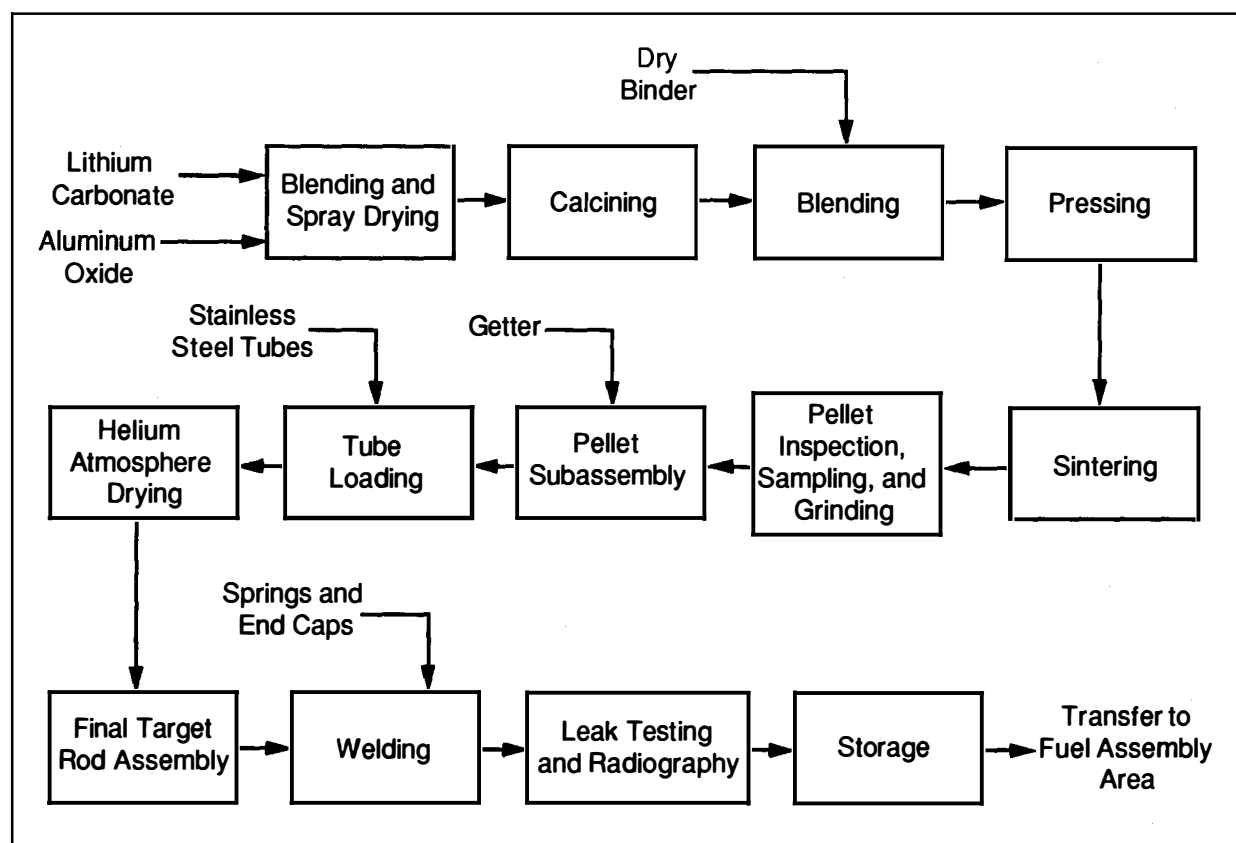


FIGURE B.13 Tritium-Target Fabrication Process at Hanford (Source: WHC 1990a)

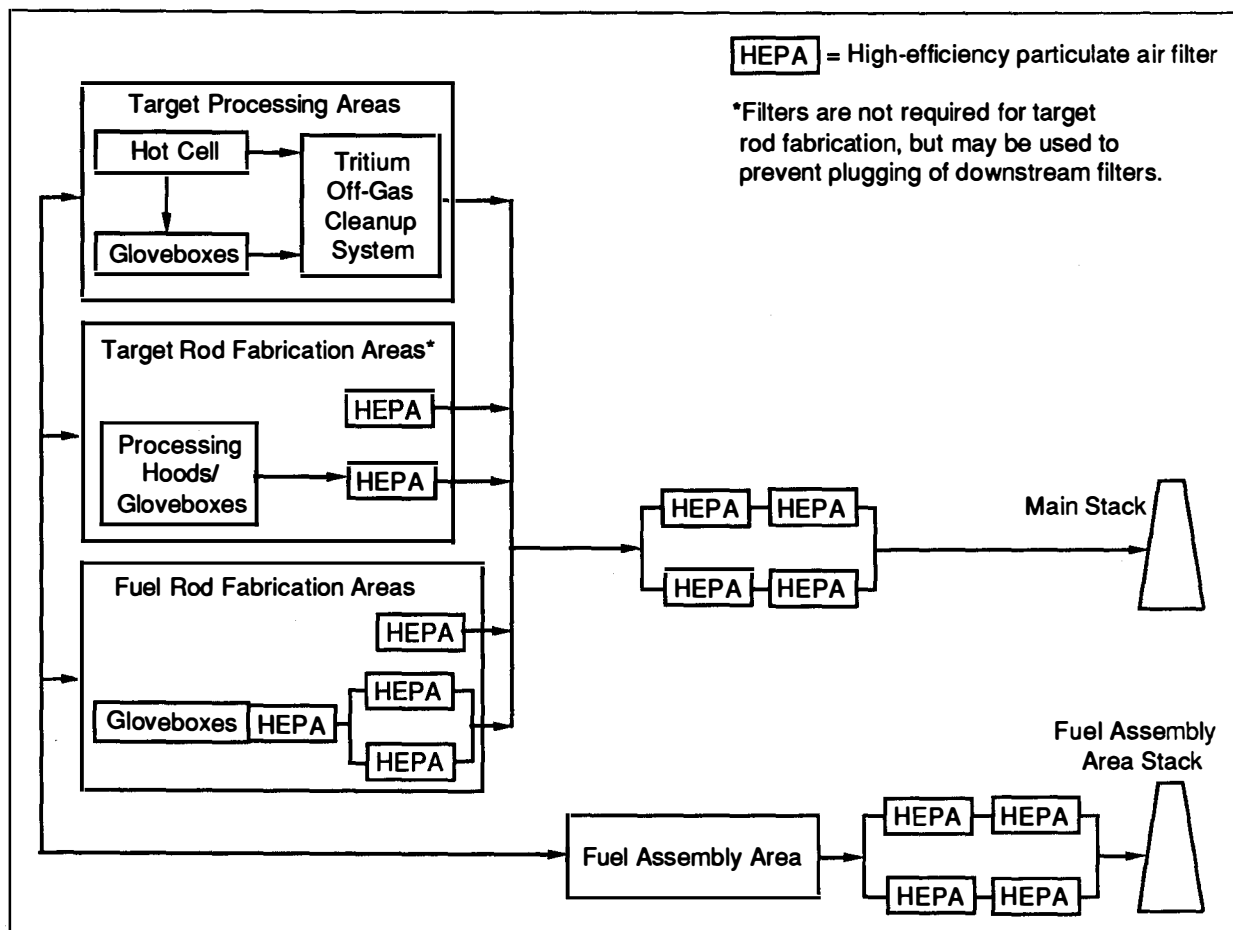


FIGURE B.14 Airflow for Fuel and Target Fabrication and Target Processing at Hanford
(Source: WHC 1990a)

if parts cannot be procured from commercial sources. These wastes would be collected and disposed of with process wastewater or handled separately, depending on sample analyses. Hazardous wastes would be handled within the sitewide waste management system (Section A.3.9). No radioactive liquids would be generated by target fabrication operations.

The estimated amounts of uranium in the fuel fabrication wastes and lithium aluminate in the target fabrication wastes are small. Wastes containing economically recoverable amounts of material would be recycled to the supplier.

The nonradioactive solid wastes would be disposed of in the existing on-site landfill. All low-level radioactive wastes would be disposed of in burial trenches in the 200 areas. No transuranic wastes are expected to be generated in the Fuels and Materials Examination Facility from fuel and target fabrication and target processing activities.

No mixed waste would be generated by target fabrication operations, and none is anticipated from target processing. Minor quantities of radioactive solutions (uranium mixed with various laboratory chemicals) would be generated routinely in the laboratory during normal

analytical procedures. These solutions would be mixed with uranium-containing wastes from other fuel fabrication operations and handled as radioactive or mixed waste. Less than 0.4 m³/yr of uranium and chemical solutions (before dilution) would be generated in the laboratory.

B.2.4 Fuel/Plutonium-239 Target Fabrication

Because the plutonium-239 production fuel assembly is nearly identical to a typical LWR fuel assembly, and because the fuel enrichment is within the licensing envelope for nuclear materials that can be produced by a commercial manufacturer, plutonium production assemblies would be procured from an off-site commercial manufacturer of nuclear power plant fuel. Analyses of environmental emissions associated with commercial fuel production are to be covered by the vendor's application for operating permits from applicable regulatory agencies and are beyond the scope of the EIS.

The plutonium production assembly would be similar in appearance to the tritium production assembly and very similar to an LWR fuel assembly in a commercial power plant. The assembly would be composed of a square array of rods connected by end nozzles and a series of spacer grids. The fuel, which would also be the target, would be composed of 1.7 wt% uranium-235 enriched UO₂ pellets in Zircaloy-4 tubes (rods). The tubes would be slightly larger in diameter than the rods in a tritium production assembly, but would be the same length.

B.2.5 Spent Fuel Processing

For the purpose of this EIS, it is assumed that spent fuel would ultimately be disposed of in a Federal repository. Spent fuel processing is analyzed in this EIS as part of the original mission of NPR, which included the production of virgin plutonium-239. However, plutonium production is no longer part of the NPR proposed action. The Waste Management PEIS will assess the impacts of wastes from reprocessing of spent fuel from DOE reactors.

Spent fuel processing at Hanford would take place in the new Spent Fuel Processing Complex to be constructed in the 200-East Area. The proposed location is indicated in Figure A.15.

The Spent Fuel Processing Complex would consist of a fuel processing building and a uranium recovery building. The complex would recover uranium and plutonium from irradiated fuel assemblies by chemical separation of the uranium and plutonium from each other and from undesired actinides, fission products, and waste.

B.2.5.1 Facility Description

The Spent Fuel Processing Complex is described in Section A.3.5.1.

B.2.5.2 Process Description

Tritium production mode spent fuel processing is described in Section A.2.5.2, and that description is applicable here, except for the headend process and the separation of neptunium. The LWR fuel assemblies, from which target rods have been removed, would be disassembled, sheared into about 5-cm lengths, and fed to the dissolver. Nitric acid would dissolve the fuel leaving the cladding hulls, which would be disposed of in the sitewide waste management system (Section A.3.9).

B.2.5.3 Process Effluents and Wastes

Process effluents and wastes in all six categories (high-level, low-level, mixed, hazardous, transuranic, and other wastes) would be generated from spent LWR fuel processing at Hanford. These wastes would be similar to those described for spent HWR fuel processing (Section A.3.5.3). Effluents from fuel combustion would be derived from testing backup diesel generators, general material delivery vehicles, and spent fuel deliveries. Approximately 10% of the fuel combustion emissions would be from stationary sources.

B.2.6 Tritium-Target Processing

B.2.6.1 Facility Description

At Hanford, the Fuels and Materials Examination Facility would house the Tritium-Target Processing Facility. Tritium-target processing would be carried out in the main hot cell and in adjacent rooms on multiple floors. Most of the process operations and hot laboratory analyses would be carried out in gloveboxes to ensure tritium containment. The hot cell would contain two or more vacuum furnaces for extracting tritium from the irradiated targets.

B.2.6.2 Process Description

Irradiated target tubes would be removed from the tritium production assemblies in the spent fuel pool and loaded into a target canister for shipment from the reactor to the Tritium-Target Processing Facility. Except for higher extraction temperatures, the tritium extraction process for LWR targets would be similar to the tritium extraction process for HWR targets (Section A.2.6.2). The tritium would be shipped to SRS for final purification, blending, and loading.

B.2.6.3 Process Effluents and Wastes

The process effluents and wastes from tritium-target processing are discussed in Section B.2.3.4, except for the special off-gas system related to the tritium extraction. Only that system is discussed here.

A schematic of the target processing ventilation and off-gas cleanup system is shown in Figure B.15. Parts of the process system would be evacuated. The gases would include mixtures of argon and nitrogen with hydrogen isotopes, including tritium. These gases would be sent to one of two collection tanks, depending on the composition of the gas. Spent HEPA filters would be handled within the sitewide waste management system.

B.2.7 Fuel/Plutonium-239 Target Processing

Fuel/plutonium-239 target processing would require the same basic processing facilities as described in Section A.2.5 for recovery of uranium and plutonium from spent fuel. Consequently, fuel/plutonium-target processing would take place in the main processing and uranium recovery buildings. The processing equipment and flow sheets would need to be modified to cope with the higher throughput and criticality differences of the materials to be processed. Additional equipment would be added to the plutonium processing room in the main processing building to convert the plutonium oxide to plutonium metal.

B.2.7.1 Facility Description

The buildings described in Section A.3.5.1 would contain sufficient contingency space to accommodate the equipment changes required for fuel/plutonium-target processing.

B.2.7.2 Process Description

The processes used for fuel/plutonium-target processing would be generally identical to the processes described in Section B.2.5.2, except process modifications would be required to support the increased material throughput associated with plutonium production and to convert the plutonium product to metal. Figure B.16 provides a general process description for operation of the Spent Fuel Processing Complex in support of the plutonium production mode.

B.2.7.3 Process Effluents and Wastes

During fuel/plutonium-target processing, the ventilation flow paths would remain unchanged from the HVAC system (Figure A.18). Estimates of the revised airflow quantities for the main processing and uranium recovery buildings are presented in Figures B.17 and B.18, respectively. Release points would be identical to those described for the tritium production mode.

Liquid and solid wastes would be similar to those described for spent fuel processing for tritium production (Section B.2.5.3). In addition, salt and crucible waste would be generated from plutonium metal production operations. The salt and crucible waste would be 0.002% magnesium chloride, 0.1% plutonium (as plutonium trichloride and plutonium dioxide), 0.4% silicon dioxide, 1% calcium, 3% sodium chloride, 4% potassium chloride, 5% calcium oxide, 22% magnesium oxide, and 64% calcium chloride. This waste, which would be a transuranic waste, would be handled within the sitewide waste management system (Section A.3.9).

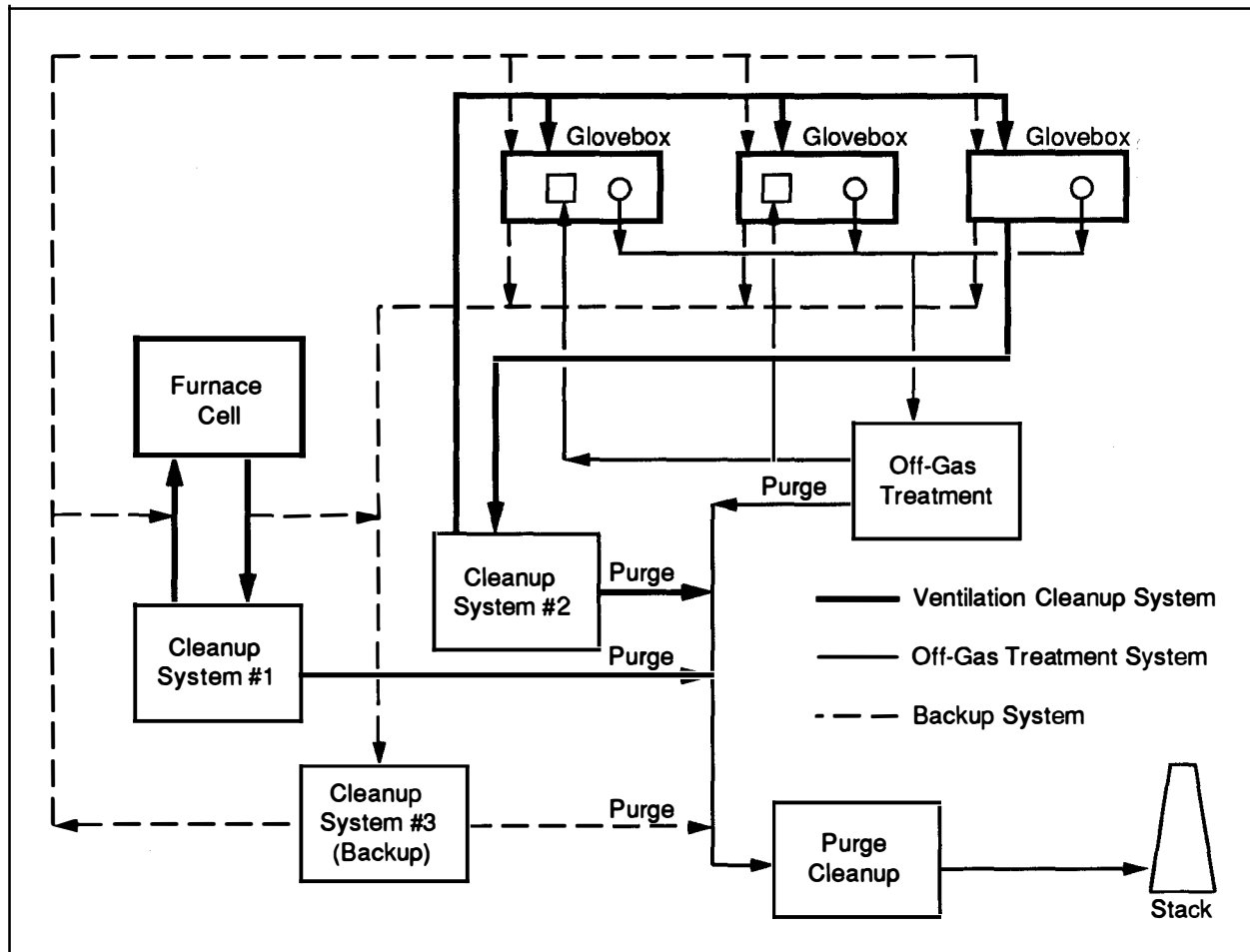


FIGURE B.15 Target Processing Ventilation and Off-Gas Cleanup System at Hanford
(Source: WHC 1990a)

B.2.8 Plant Operation

The requirements for normal NPR operation at Hanford are summarized in Table B.2.

B.2.8.1 Energy Requirements

Under normal operating conditions, WNP-1 would burn no fossil fuels; however, several emergency diesel generator units would burn fossil fuels and emit attendant gaseous and particulate wastes to the environment when tested intermittently. During normal operation, two principal emergency diesel generators would be tested for 2 hours each month to certify their operability, for a total operating time of 24 h/yr. These units would use No. 2 diesel fuel, and each unit would burn fuel at a rate of about 1.9 m³/h.

The Reactor Facility (WNP-1) would also use one 1,200-kW diesel generator for balance-of-plant power, one 150-kW diesel pump for fire protection, and one 250-kW diesel for backup reactor coolant pump seal injection. These three smaller diesel units would use No. 2 diesel fuel

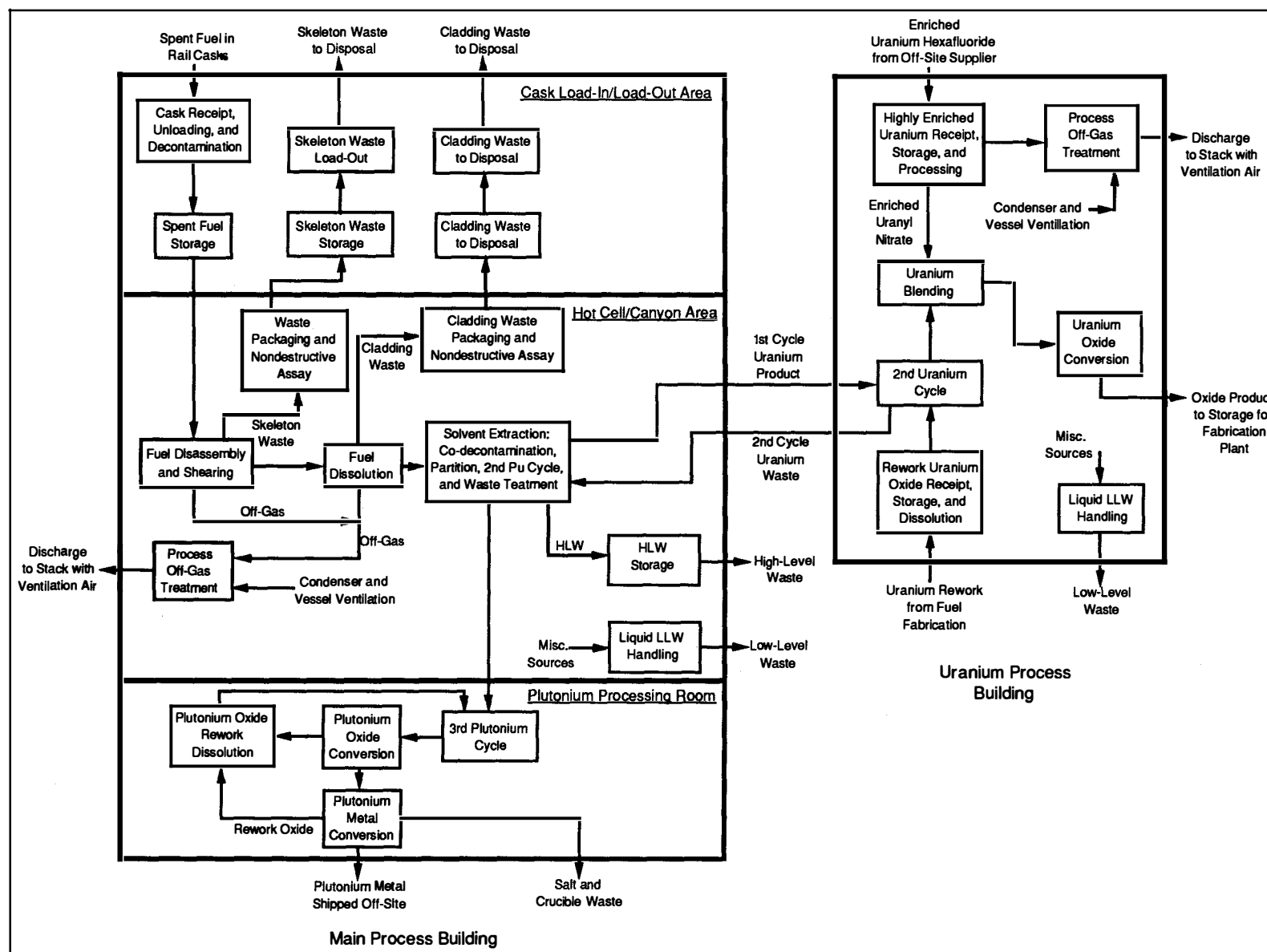


FIGURE B.16 Process Flow Diagram of the Spent Fuel Processing Complex at Hanford (Source: WHC 1990a)

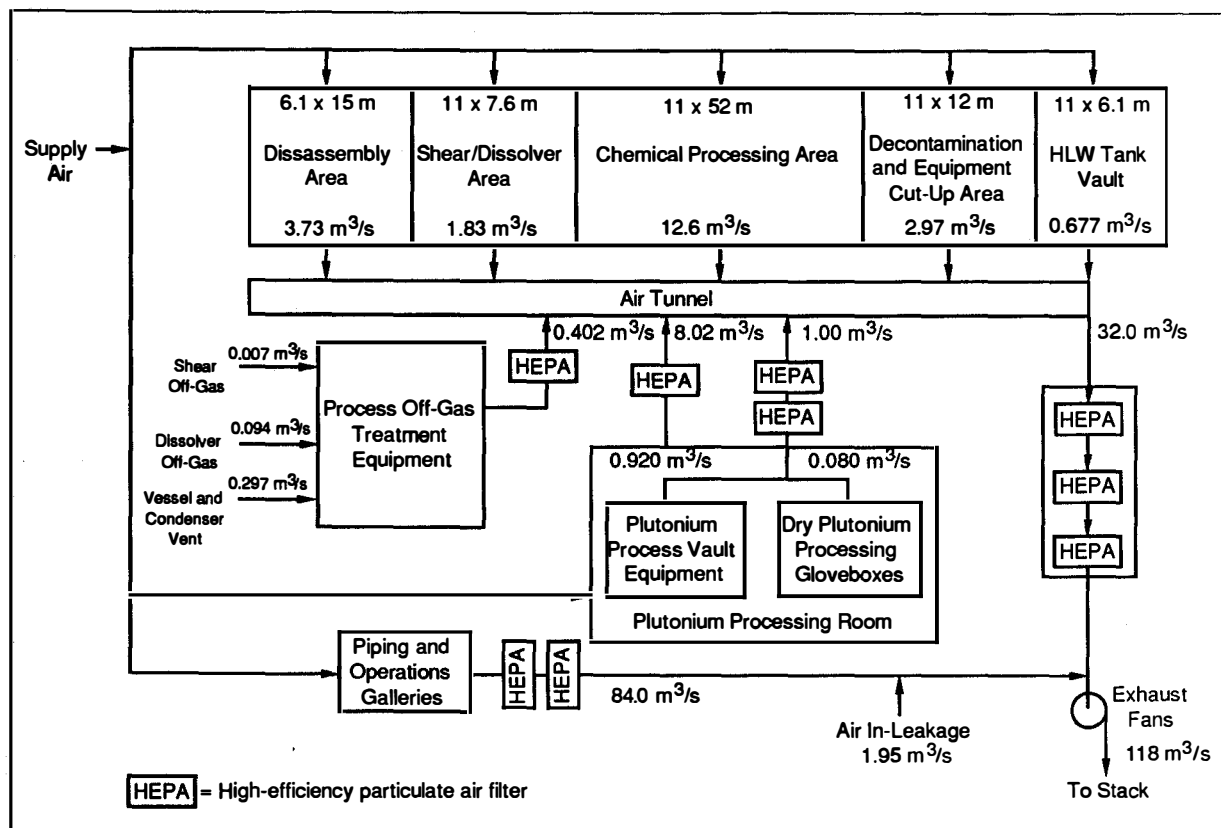


FIGURE B.17 Airflow in the Main Processing Building during Plutonium Production at Hanford (Source: WHC 1990a)

at rates of 0.4, 0.09, and 0.05 m³/h, respectively. Because these units would be standby units, they would only emit gases and particulate wastes intermittently.

Electricity would be supplied by the plant turbine generator during plant operation. This would result in a reduction in the net output to the grid of about 100 MWe. During reactor shutdown, the maximum anticipated electricity requirement would be 15 MW, which would be supplied from the regional power grid via the H.J. Ashe Substation. During operation in the bypass steam condensing mode, approximately 100 MW of electricity would be required from the same source. The regional power grid is adequate to supply the power for the foreseeable future.

The WNP-1 would generate 1,259 MW of electricity at 25 kV, 60 Hz. The generated power less plant requirements would be transferred to Bonneville Power Administration's 500-kV grid via three-phase, step-up transformers at the plant. The electric system for on-site, off-site, and emergency power is described in Section B.2.2.7.

The Fuels and Materials Examination Facility currently has a relatively small, electrically heated steam boiler. Because of its small capacity, this boiler would not be able to provide all the steam needed for processing operations and general plant support. The size and type of replacement steam boiler would be determined during the conceptual design stage.

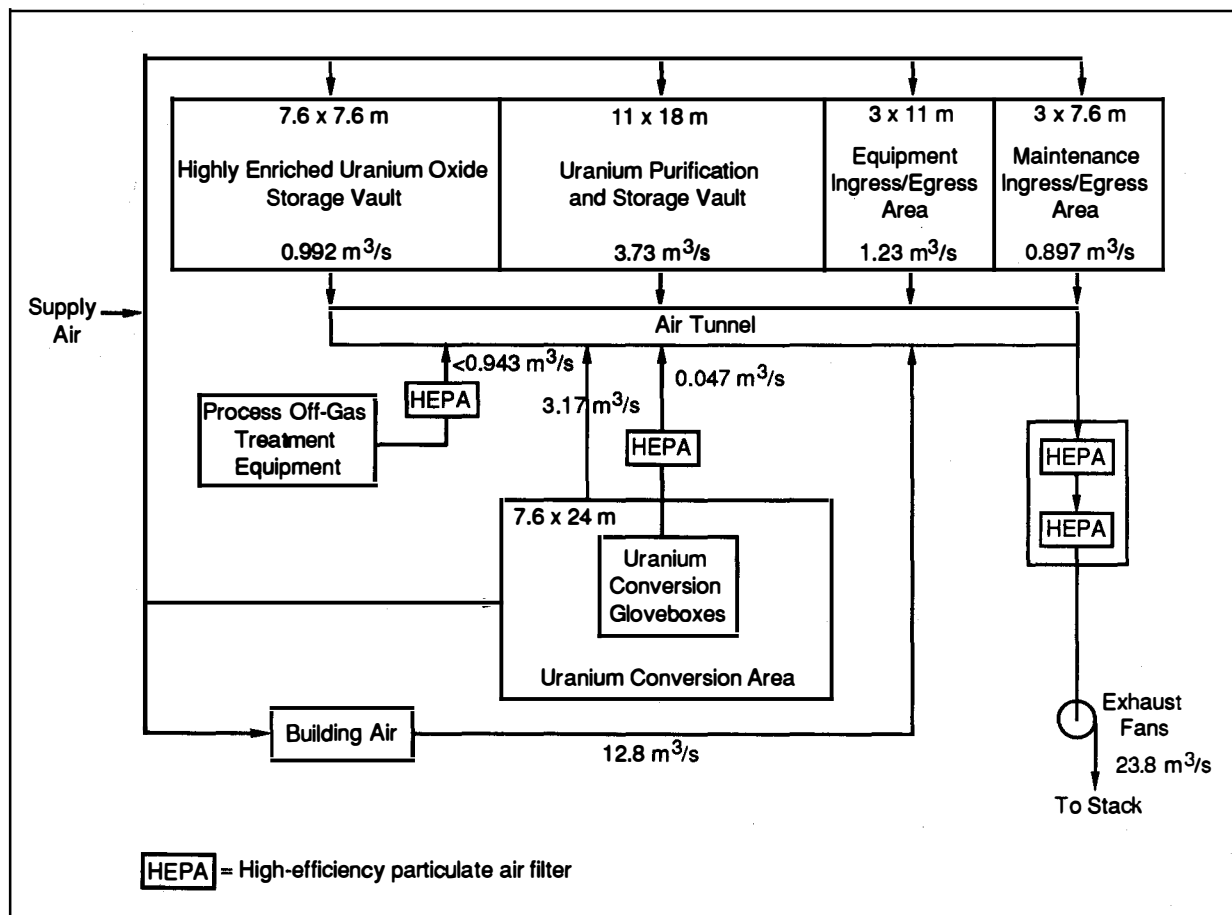


FIGURE B.18 Airflow in the Uranium Recovery Building during Plutonium Production at Hanford (Source: WHC 1990a)

B.2.8.2 Water Requirements

The support facilities would need to have process water, potable water, and cooling water. The Spent Fuel Processing Complex would use a closed-loop cooling system with cooling towers for process and heating, ventilating, and air conditioning heat removal. The estimated maximum and average water flow rates for WNP-1 are presented in Figure B.9. The data pertain to operation in the electric power production mode, which would be the predominant expected operational mode.

Consumptive water use includes cooling tower evaporation and drift, irrigation, evaporative cooling of air conditioning and plant equipment, main steam relief, sanitary wastewater, and waste solidification. The maximum anticipated water use for WNP-1 would be about 1 m³/s during the power production mode; the minimum regulated Columbia River flow is 1,000 m³/s. Table B.3 compares the anticipated plant water use for full-power production, 25% electric power production, and for normal shutdown.

TABLE B.2 Estimated Annual Commodity Requirements for Operation of the LWR Complex

Commodity	Unit	Hanford		INEL		SRS	
		Tritium Mode	Plutonium Mode	Tritium Mode	Plutonium Mode	Tritium Mode	Plutonium Mode
Energy							
Electric	MWh	633,000	655,000	671,000	655,000	650,000	641,000
Fuel (diesel, gasoline, kerosene)	L	254,000	235,000	240,000	235,000	240,000	235,000
Steam	kg	4.15×10^7	1.15×10^8	4.15×10^7	1.13×10^8	4.95×10^7	1.99×10^8
Steam, coal	t	3,200	9,200	Electric	Electric	5,444	21,854
Materials							
Metals							
Aluminum oxide	t	1.60	0	1.60	0	1.60	0
HEU as UO ₂ ^a		47.1	560	47.1	560	47.1	560
Inconel metal	t	0.30	5.2	1.30	5.2	1.30	5.2
Lithium carbonate (Li-6 enriched)	t	1.18	0	1.18	0	1.18	0
Plutonium							
Fuel/target assemblies	Each	0	820	0	820	0	820
Fuel/target rods	Each	0	285,000	0	285,000	0	285,000
Stainless steel	t	7.70	4	7.70	4	7.70	4
Zircaloy metal	t	20.9	138	20.9	138	20.9	138
Chemicals/cleaners/dissolvers							
Al. nitrate nonanhydrate (50 wt%)	L	144,000	2.01×10^6	144,000	2.01×10^6	144,000	2.01×10^6
Ammonia (28 vol%)	t	3.60	3.60	3.60	3.60	3.60	3.60
Boric acid	t	54	54	54	54	54	54
Calcium hydroxide	t	63.5	63.5	63.5	63.5	63.5	63.5
Hydrozlamine nitrate (19 wt%)	L	41	48	41	48	41	48

TABLE B.2 (Cont'd)

Commodity	Unit	Hanford		INEL		SRS	
		Tritium Mode	Plutonium Mode	Tritium Mode	Plutonium Mode	Tritium Mode	Plutonium Mode
Chemicals/cleaners/ dissolvers (cont'd)							
Hydrazine (35 vol%)	t	13.3	17.6	13.3	17.6	13.3	17.6
Nitric acid, fresh		693,000	1.26×10^6	693,000	1.26×10^6	693,000	1.26×10^6
Sulfuric acid	t	1,800	1,800	1,800	1,800	1,800	1,800
Sodium aluminate	t	104	104	104	104	104	104
Sodium carbonate	t	11.8	15.9	11.8	15.9	11.8	15.9
Sodium hydroxide (50 wt%)	t	183	580	183	580	184	580
Sodium nitrite	t	5.91	25.8	5.91	25.8	5.91	25.8
Gases							
Ammonia	t	22.7	181	22.7	181	22.7	181
Chlorine	t	50	50	50	50	50	50
Hydrogen	m ³	12,600	6,800	12,600	6,800	12,600	6,800
Water							
Cooling system	L	4.3×10^7	4.3×10^7	4.51×10^7	4.52×10^7	6.26×10^7	6.26×10^7
Process and other	L	364,000	572,000	360,000	570,000	293,000	498,000
Work force ^b	Workers	1,808	1,463	1,808	1,463	1,519	1,326

^aHEU = highly enriched uranium; tritium mode enrichment: 8-12 wt%; plutonium mode enrichment: 1.7 wt%.

^bOperation at SRS assumes concurrent operation of existing K, L, and P reactors. Waste management workers are included.

Source: Roman 1991.

TABLE B.3 Anticipated Plant Water Use at WNP-1

System	Full-Power Production Operation		25% Electric Power Normal Shutdown		Normal Shutdown	
	Intake Rate (m ³ /s)	Outlet Rate (m ³ /s)	Intake Rate (m ³ /s)	Outlet Rate (m ³ /s)	Intake Rate (m ³ /s)	Outlet Rate (m ³ /s)
Cooling tower makeup water	1.09	0.91 evaporation and drift 0.18 blowdown	0.28	0.23 evaporation and drift 0.05 blowdown	0	0
Fire protection water	0.38 ^a	NA ^b	0.38 ^a	NA	0.38 ^a	NA
Demineralized water	0.02	NA	0.02	NA	0.02	NA
Potable and sanitary water	0.01	0.003 to ground (and evaporated)	0.01	0.003 to ground	0.01	0.003 to ground
Liquid waste treatment	NA	0.012	NA	0.012	0	0
Radwaste treatment	NA	0.005	NA	0.005	NA	0.005
Auxiliary boiler	NA	0.0001	NA	0.0001	NA	0.001

^aWhen needed.^bNA = not applicable.Conversion factor: 1 m³/s = 15,850 gal/min.

Sources: WHC 1990a, 1990b.

Figures B.19 and B.20 provide water distribution diagrams for the Spent Fuel Processing Complex during tritium and plutonium production, respectively. Water for the complex would be obtained from the water supply systems in the Hanford 200-East Area. The water quantities presented in the figures would be the bounding values for water withdrawal. Heating steam and cooling water supplies are based on using closed-loop systems. The process would use steam on once-through flow, resulting in large uncontaminated water flows for steam supply and steam quenching. Future design modifications would likely recycle primary steam condensate to the steam plant, thereby eliminating quench water requirements, reducing water withdrawals, and reducing steam plant effluents. The return of uncontaminated condensates to the Columbia River represents another option currently under consideration. Future evaluations of the 200-East Area utility system, which would operate independent of a decision to locate an NPR at Hanford, may result in different configurations for uncontaminated water disposal than are presented in Figures B.19 and B.20.

B.2.8.3 Materials Requirements

Uranium would be irretrievably consumed by WNP-1 operation. Other materials consumed would be fuel-cladding materials, reactor control elements, reactor core components, process chemicals such as water treatment and ion-exchange chemicals and resins, and the minor quantities of materials used for maintenance and operation. Except for the uranium isotopes, uranium-235 and uranium-238, the consumed materials have widespread use. The primary use of the natural isotopes of uranium would be for production of useful energy.

After use in WNP-1, the fuel elements would still contain uranium-235 above the natural fraction. Once the enriched uranium was separated from plutonium and other radioactive materials, it could be used as feedstock for a uranium enrichment plant. Scrap material containing valuable quantities of uranium could also be recycled in the fuel processing and fabrication processes. Material resources, such as gasoline, diesel fuel, nitrogen, sulfuric acid, sodium hydroxide, and others, would be consumed during plant operation.

The detailed reactor core design is incomplete; however, preliminary designs have been developed. Two types of tritium production cores have been conceptualized: the getter-barrier type and the aluminum can (low-exposure) type. The former is the current reference design.

B.2.8.4 Staffing Requirements

The on-site staffing requirements for normal operation of WNP-1 and its support facilities are given in Table B.4. Variations in the staffing requirements among sites is due to the existence and use of existing facilities and staffs to accomplish some of the NPR tasks.

B.2.9 Sitewide Waste Management

Waste generated by NPR operation would be processed and prepared for disposal at the generating facility or at the existing Hanford waste management facilities. These sitewide waste management facilities are described in Section A.3.9.

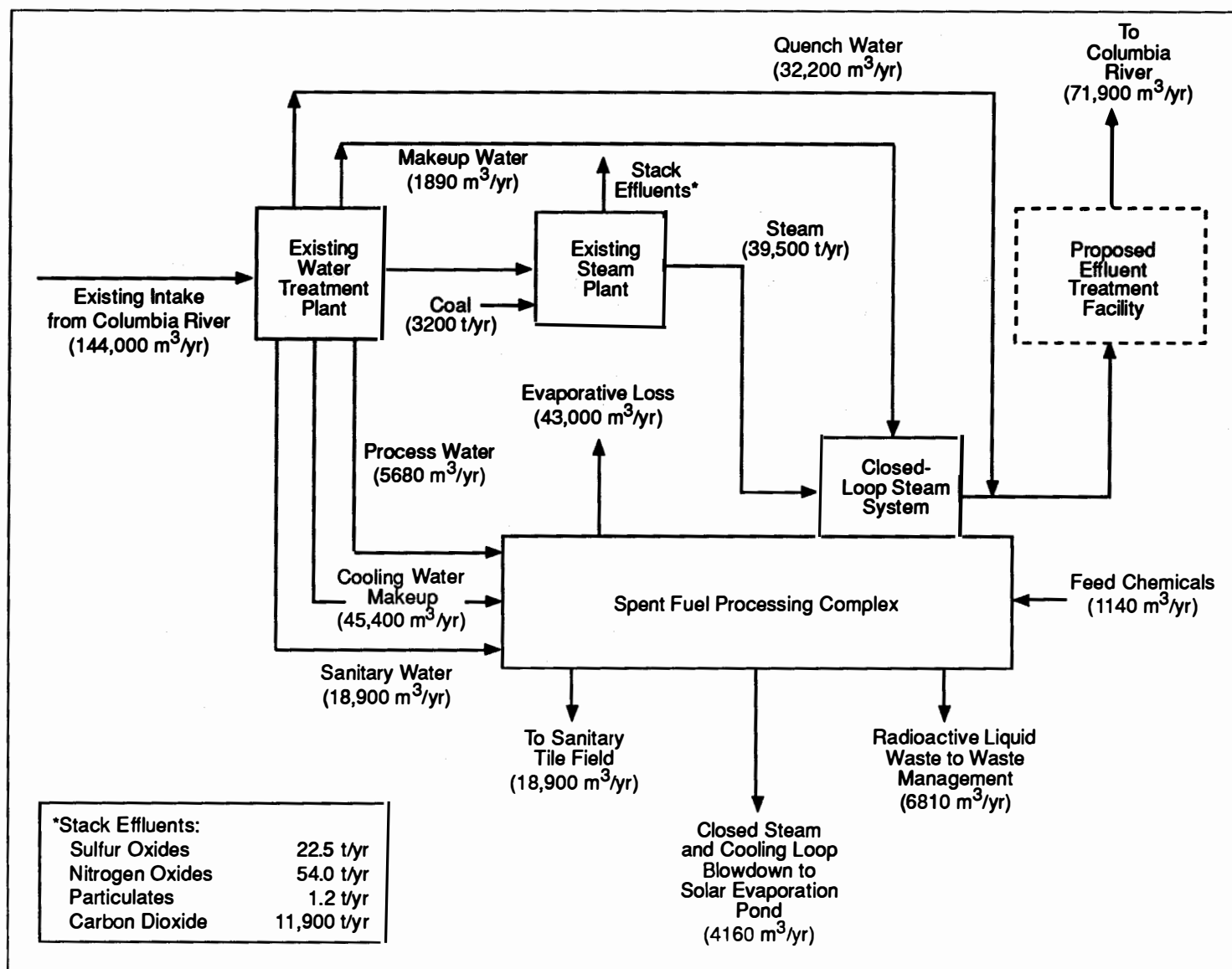


FIGURE B.19 Water Distribution and Utility Effluents for the LWR Spent Fuel Processing Complex for Reference Tritium Fuel Cycle Support at Hanford (Source: WHC 1990a)

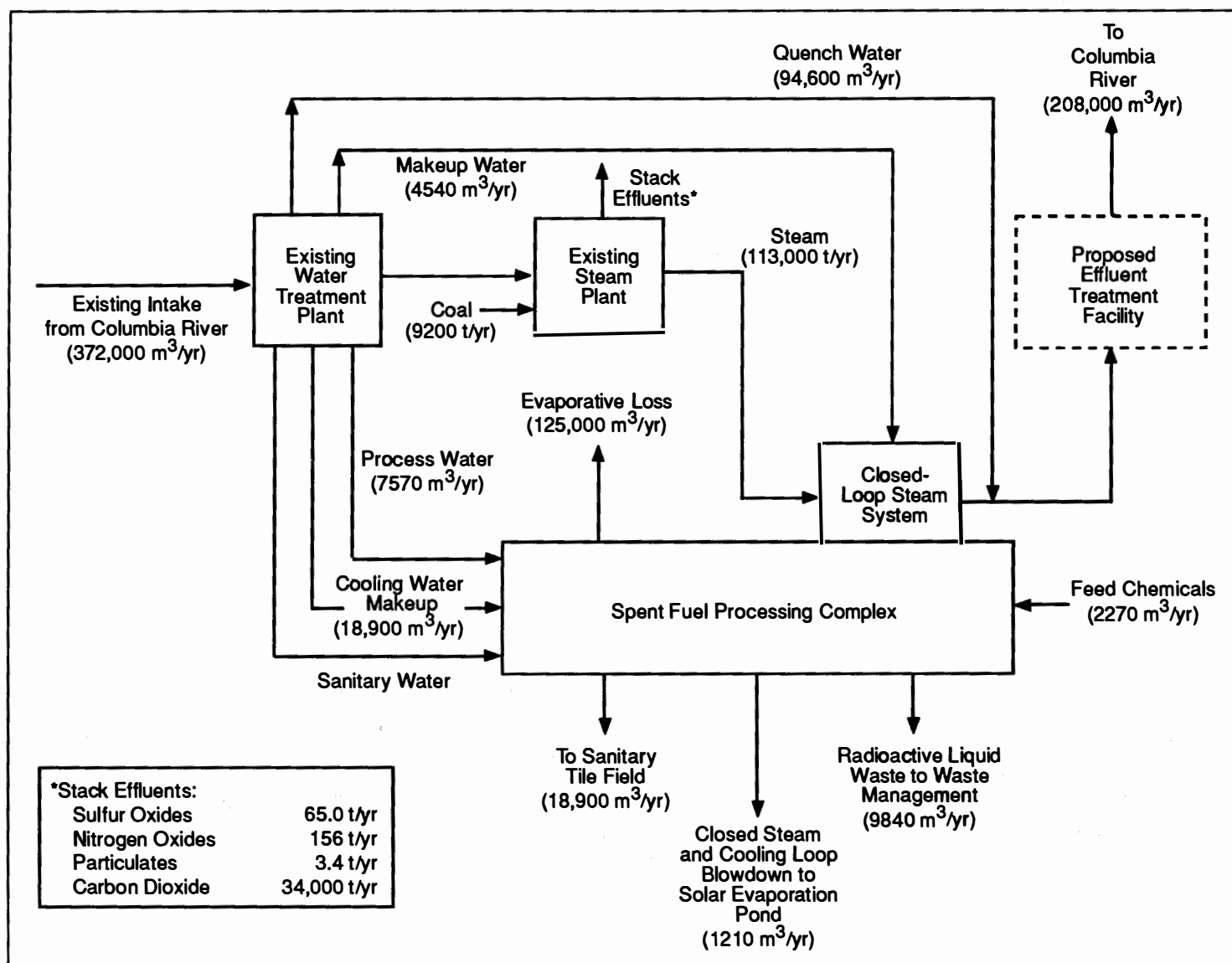


FIGURE B.20 Water Distribution and Utility Effluents for the LWR Spent Fuel Processing Complex for Plutonium Production Fuel Cycle Support at Hanford (Source: WHC 1990a)

TABLE B.4 LWR Operations Staffing Requirements (Number of Employees)

Facility	Hanford	INEL	SRS ^a
1. Reactor Facility and subfacilities ^b	810	810	810
2. Tritium-Target Fabrication	85	85	85
3. Plutonium-Target Fabrication	0	0	0
4. Fuel Fabrication (tritium only)	130	130	130
5. Tritium-Target Processing	130	130	26
6. Spent Fuel Processing	575	575	259
7. Plutonium-Target Processing	575	575	307
8. Waste Management	78	78	209
Total			
Tritium mode ^c	1,808	1,808	1,519
Plutonium mode ^d	1,463	1,463	1,326

^aAssumes operation of existing K, L, and P reactors.

^bExcludes 22 persons for operation of the Energy Conversion Area.

^cStaffing requirements for the tritium mode include elements 1, 2, 4, 5, 6, and 8.

^dStaffing requirements for the plutonium mode include elements 1, 6 or 7, and 8 for Hanford and INEL, and elements 1, 6, 7, and 8 for SRS.

Sources: Bean 1990; Bowman 1990; Evans 1990.

The DOE's NPR operations will be conducted consistent with commitments DOE has made and will make in compliance agreements with state and Federal regulatory authorities. If it should become necessary, DOE will work with the regulators to incorporate NPR needs into existing agreements or to develop new agreements to ensure continued compliance. Under no circumstances will DOE's performance pursuant to any existing compliance agreement be compromised or diminished as a result of the NPR project. If there are discrepancies between the waste stream volume and waste treatment capacity figures in the DEIS and in existing compliance agreements, or those currently in negotiation, the figures in the compliance agreements will prevail.

B.3 LIGHT-WATER REACTOR TECHNOLOGY AT INEL

B.3.1 Introduction

This section defines the modifications required to adapt the light-water reactor to the Idaho National Engineering Laboratory (INEL) Site. The information in this section is largely abstracted from an EG&G report (EG&G 1989), except where otherwise referenced. The EG&G

document was largely abstracted from Hanford reports describing the LWR facility (WHC 1990b) and support facilities (WHC 1990a). These reports are abstracted in Section A.2.2.

B.3.1.1 New and Existing Facilities Required for the NPR

For the light-water reactor at INEL, a new Reactor Facility would be required. The description given in Section B.2.2 is adequate here, except for modifications to the cooling tower design for operation in the INEL meteorological setting and a complete revision of the description of the raw water intake and blowdown systems. Most of the other plant characteristics, performance data, and emissions would be virtually unaffected.

The light-water reactor at INEL would be a stand-alone facility. The waste management facilities would need to be modified to ensure acceptable waste forms for transfer to existing and planned waste management facilities. New facilities would be constructed for fuel and target fabrication for the tritium production mode, for fuel processing, and for tritium-target processing. The new Fuel Processing Facility would also be used for plutonium-target processing. Fuel/plutonium-target assemblies would be procured from a commercial manufacturer of nuclear power plant fuel assemblies.

B.3.1.2 Location

The proposed NPR site is described in Section A.4.1.2. However, the area of the evaporation pond for the LWR would be about 8.4 km². This feature is discussed in Section B.3.2.3.

B.3.1.3 Existing Facilities, Utilities, and On-site Transportation

The INEL facilities are described in Section A.4.1.3 in association with the siting of the heavy-water reactor at INEL. The waste management facilities described therein would be used in the LWR alternative. Existing utilities and on-site transportation are also described in Section A.4.1.3.

B.3.2 Light-Water Reactor Facility

B.3.2.1 Plant Structures

The generic description of an LWR facility is provided in Section B.2.2. The facility layout for INEL (excluding the blowdown pond) is shown in Figure A.19. The descriptive information for the LWR is applicable for the INEL adaptation, except as discussed in the following sections.

B.3.2.2 Electric System

The existing electric power transmission grid would be used for the NPR. Suitable voltage-reducing power transformers would be incorporated into the LWR design to ensure compatibility among the existing 138-kV INEL transmission grid and the LWR facilities. Two power transmission lines, each connected to an independent power supply, would be constructed between the existing grid and the Reactor Facility to supply power to the facility when the turbine generator is inoperative. One of these lines would also transmit power generated at the LWR facility to the regional power supply system when the generators were operating.

B.3.2.3 Heat Dissipation Systems

Turbine Condenser Cooling System

Deep wells into the Snake River Plain aquifer would provide all water supplies, including cooling water makeup. Mechanical draft cooling towers similar to those described in Section B.2.2 for the LWR at Hanford, would reject heat. The cooling tower evaporation, drift, and blowdown values for INEL are included in Table B.1. The maximum cooling tower water use at INEL would be 1.59 m³/s for evaporation, drift, and blowdown, assuming five cycles of concentration and steam bypass operation.

Cooling tower blowdown would go into a liquid evaporation pond that would be heated in the winter by reactor heat to ensure a high evaporation rate. The evaporation pond would have a surface area of 855 ha. The average depth of the pond would be about 1.3 m.

Both cooling tower blowdown and drift would contain chemicals from cooling tower chemistry adjustments. Assuming five cycles of concentration of cooling tower water, the approximate quantities of chemicals released would be as listed in Table 4.1 of an EG&G report (EG&G 1989).

Water Treatment System

At INEL, the water supply would contain significantly more chemicals, dissolved solids, and suspended solids than at Hanford. Consequently, INEL would treat water to be used in processing by pumping the raw water from the Snake River Plain aquifer through ion-exchange resins. Periodically, the resins would be backflushed, with output going to a retention pond. Acid or base would be added to the outflow to adjust its pH. The wastewater released to the environment would meet or exceed the quality of water initially removed from the aquifer.

B.3.2.4 Waste Management

Gaseous Waste Processing

The gaseous waste system described for Hanford would be suitable for the INEL adaptation (see Gaseous Waste Processing discussion in Section B.2.2.9).

Liquid Waste Processing

Facilities generating liquid waste would control, collect, store, and segregate that waste in appropriate waste collection tanks. Segregation of the wastes would allow efficient processing of liquid radwaste batches that differ in chemical and radioactivity content. Several types of waste collection tanks would be used: radioactive according to activity level, chemical, laundry, and decontamination solution. None would be expected to contain high-level or transuranic solutions.

Laboratory wastes would be collected in the chemical waste tank for sampling and neutralization. Laundry wastes, which would be collected in the laundry waste tank, would normally be very low activity wastes that might be suitable for direct discharge. Decontamination waste would be sampled in the sump, and if it was suitable for processing and release, it would be transferred to the chemical waste tank for appropriate treatment. If it was not suitable for processing and release, this waste would be sent to the decontamination solution waste tank for ultimate solidification.

If the nonradioactive wastewater quality meets the regulatory requirements for release, the contents of the collection tank would be discharged directly to an evaporation pond. If radioactivity is present, the waste would be transferred to one of two decay tanks where the radioactivity level would be allowed to decay before release. The use of decay is optional, however, and further treatment through ion-exchange and filtration systems could be performed before discharge to the environment. Wastewater that does not meet discharge requirements would be either returned to the decay tanks or solidified. After solidification, the solid waste would be sent to the Radioactive Waste Management Complex.

At INEL, sewage from the NPR site would be disposed of via a Sewage Treatment Facility and a septic field in compliance with appropriate DOE and Idaho state operating permits. The field would be sized to operate at least 40 years and be able to handle reactor, fuel fabrication, tritium-target fabrication, and tritium-target processing wastes.

Hazardous and mixed wastes resulting from liquid waste processing would be treated within the sitewide waste management system (Section A.3.9).

Solid Waste Processing

At INEL, solid waste would be packaged by each individual facility. If the waste meets prescribed INEL criteria for low-level radioactive waste, it would be taken to the Waste Experimental Reduction Facility for reduction. About 45% of the waste would be compactible. This waste could be routed to the beta/gamma incinerators at the Waste Experimental Reduction Facility. Higher levels of radioactive combustible waste and some portions of the noncombustible waste would be compacted. Some forms of the waste would need special treatment (e.g., deionizer resins, irradiated reactor scrap metal filters, filter cartridges). These special materials would contain many of the heavy long-lived isotopes.

Waste would be segregated into a low-activity fraction that would be disposed of by shallow land burial at the Radioactive Waste Management Complex, and a high-activity fraction that would be subject to processing and storage in soil vaults. A radioactivity level greater than 500 mrem/h at 1 m from the surface would trigger disposal of the waste into the soil vaults.

Deionizer resins would be stabilized in cement or other materials and packaged in drums. The stabilizing process would be similar to the process currently used in commercial nuclear power plants. The drums containing the resin would be transported by shielded carrier for on-site storage. Depending on the regulations in place at the time, the drums would either be stored or transported and disposed of at a geological repository. These resins might be suitable for disposal at a central solidification facility if one were available.

Reactor scrap metal would be compacted using remote-handling equipment. The containers of compacted metal pieces would be placed in a top-loading, bottom-unloading shielded cask for transport to and disposal in the Radioactive Waste Management Complex.

The mixed waste would be treated at the Waste Experimental Reduction Facility. Any untreatable mixed waste would be packaged and stored on-site at the Radioactive Mixed Waste Storage Facility according to the regulations governing that facility. No off-site storage and disposal facilities are licensed to accept mixed waste, so off-site shipment is not currently a viable option. The Radioactive Waste Management Complex would not be used for disposal because the chemical component of the waste is potentially hazardous. Typical mixed wastes generated by reactor operation would be oily rags and pump seals.

Hazardous wastes would include oils, solvents, acids, plastics, gloves, rag stock, and other materials associated with plant operation and maintenance. Collection and interim storage of such wastes would be needed. Segregation of wastes among hazardous and other waste types would be maintained. Treatment and disposal of nonradioactive hazardous wastes for the LWR would meet all requirements of DOE and Federal, state, and local agencies.

Hazardous waste would be stored at the Hazardous Waste Storage Facility until sufficient containers accumulate for shipment to an approved off-site treatment, storage, and disposal facility. Other wastes (trash, treated sanitary wastewater, and solids) would be handled in compliance with all applicable DOE, Federal, state, and local regulations. Trash would be compacted at the generating facility and disposed of in an INEL sanitary landfill.

B.3.3 Fuel and Tritium-Target Fabrication

B.3.3.1 Facility Description

Two new buildings, one for fuel fabrication and the other for target fabrication, would be built in close proximity so that common facilities such as associated service and office buildings could be shared. These buildings would be typical industrial buildings, consisting of windowless, steel or prefabricated concrete-slab structures. They would be designed to withstand loadings from earthquakes, tornados, and extreme wind forces and also to control the spread of contamination within the facility and prevent the uncontrolled release of radioactive material to the environment. The Fuel Fabrication Facility would be about 5,600 m². The Tritium-Target Fabrication Facility would be about 460 m².

B.3.3.2 Fuel and Target Description

The physical descriptions of the LWR fuel and target for tritium production in Section B.2.3.2 are generally applicable for the INEL adaptation.

B.3.3.3 Process Description

The process description for fabrication of the fuel and target assemblies given in Section B.2.3.3 is generally applicable for the INEL adaptation.

B.3.3.4 Process Effluents and Wastes

Generally, the gaseous wastes from the Fuel Fabrication Facility would be nonhazardous. Preliminary calculations indicate that the airflow to the stack would be about $16.5 \text{ m}^3/\text{s}$. All potentially contaminated airflows would be exhausted through a double set of HEPA filters. The principal chemicals released to the atmosphere would be carbon dioxide (CO_2) and nitrogen oxides (NO_x). At INEL, the off-gas cleanup systems would be similar to the systems shown in Figure B.19.

Liquid releases from the Fuel Fabrication Facility would include potentially low-level radioactive waste and other wastes such as sanitary waste, process water, and chemical waste (some of which might be hazardous). No radioactive materials would be discharged to groundwater. During fuel fabrication, both process wastes and condensates would be generated. Process wastes, which would contain hazardous waste, would be packaged and sent to the Waste Experimental Reduction Facility for incineration. Condensate wastes would be reduced and grouted for burial at the Radioactive Waste Management Complex.

Generally, the gaseous wastes from the Tritium-Target Fabrication Facility would be nonhazardous. Preliminary calculations indicate that the airflow to the stack would be about $12 \text{ m}^3/\text{s}$. All potentially contaminated airflows would be exhausted through a double set of HEPA filters. No radionuclides would be released to the atmosphere. The principal chemicals released to the atmosphere would be CO_2 and NO_x . At INEL, the off-gas cleanup system would be similar to that for the Tritium-Target Fabrication Facility at Hanford (Section B.2.3).

Liquid releases from the Tritium-Target Fabrication Facility would include process water, chemical wastes, and sanitary wastes. The chemical wastes would contain hazardous waste material that would be packaged and sent to the Waste Experimental Reduction Facility. Any condensate wastes would be reduced and grouted for burial at the Radioactive Waste Management Complex.

Solid wastes would mainly consist of nonradioactive compactible material. Some solid hazardous waste might be produced in the form of oily rags and pump packings.

B.3.4 Fuel/Plutonium-Target Fabrication

The fuel/plutonium-target assemblies would be procured from a commercial manufacturer of nuclear power plant fuel assemblies. Environmental emissions associated with

commercial production are assumed to be within the envelope of the vendor's environmental documentation, which supports applications for operating permits and licenses, and are not included in the EIS.

B.3.5 Spent Fuel Processing

A new facility for processing low-enriched fuel would be constructed adjacent to the Fluorinal and Dissolution Process and Fuel Storage Facility at the Idaho Chemical Processing Plant. This new facility would house the dissolution, extraction, and solidification systems for uranium and plutonium. Processing of plutonium targets and conversion of plutonium oxide to metal would also take place at this facility.

A new facility would be required for fuel processing because the processing requirements for low-enriched uranium dioxide fuel for the NPR would not be compatible with those of the existing facility at the Idaho Chemical Processing Plant; e.g., the uranium enrichment of LWR fuel is too low, its uranium mass is too high, there are no plutonium recovery systems, and a chop-leach headend does not exist.

The facility for processing low-enriched fuel would be equivalent to the Hanford Spent Fuel Processing Complex and would take the place of the Headend Fuel Processing Facility and the Fuel Processing Facility described for the heavy-water reactor at INEL (Section A.4.5.1).

B.3.5.1 Facility Description

The basic process description, equipment list, and balance-of-plant features of the Low-Enriched Fuel Processing Facility would be patterned directly after the description of the Fuel Processing Facility at Hanford (Section A.3.5.1).

B.3.5.2 Process Description

Underwater receipt of the fuel assemblies (without the tritium targets) and underwater storage would be provided by the Fluorinal and Dissolution Process and Fuel Storage Facility Fuel Storage Area. From there, the cooled spent fuel would be transferred underwater to the Low-Enriched Fuel Processing Facility, where it would be processed as described in Section A.3.5.2 for spent LWR fuel processing at Hanford.

B.3.5.3 Process Effluents and Wastes

Effluents and wastes would be similar to those described in Section B.2.5.3. Processing of these effluents and wastes would be modified so that they would be accepted within the sitewide waste management system at INEL.

B.3.6 Tritium-Target Processing

B.3.6.1 Facility Description

A new approximately 2,790-m² facility would be constructed for tritium-target rod processing. At INEL, the Tritium-Target Processing Facility would be similar to the facility defined for a modular high-temperature gas-cooled reactor (Section C.2.6.1).

B.3.6.2 Process Description

At INEL, tritium-target processing would be performed as described for the light-water reactor at Hanford (Section B.2.6.2).

B.3.6.3 Process Effluents and Wastes

Effluents and wastes would be similar to those described in Section B.2.6.3. Processing of these effluents and wastes would be modified so that they would be accepted within the sitewide waste management system at INEL (Section A.4.9).

B.3.7 Fuel/Plutonium-Target Processing

The processing of the irradiated fuel/target assemblies would be essentially the same as the processing of spent fuel for tritium production (Section B.3.5).

B.3.8 Plant Operation

The requirements for normal NPR operation at INEL are summarized in Table B.2.

B.3.8.1 Energy Requirements

At INEL, the light-water reactor would use fossil fuels for operation of the diesel generators in a standby mode whenever the reactor is operated. These engines would consume about 94 m³/yr of diesel fuel. The LWR would require about 100-MWe power from the power grid whenever the Reactor Facility was operated but the turbine generators were inoperative. The existing INEL grid would need to be altered to supply this load. During full-power operation in the power-generating mode, however, the net electricity transferred from the turbine generator to the grid would be 1,250 MW. The 500-kV tieline from the Reactor Facility to the power grid would be used to transfer the power to the grid.

B.3.8.2 Water Requirements

The primary water requirement for operation of the LWR is makeup water for the heat dissipation systems. Preliminary estimates of the cooling tower water requirements for five

cycles of concentration during the steam bypass mode are provided in Table B.1. Other water uses are auxiliary coolant makeup; fire water; heating, ventilating, and air conditioning system water; and potable water. The projected maximum demand for raw water is 1.66 m³/s.

B.3.8.3 Staffing Requirements

The number of additional staff required for operation of the light-water reactor facilities at INEL is included in Table B.4.

B.3.9 Sitewide Waste Management

Waste generated by NPR operation would be processed and prepared for disposal at the generating facility or at the existing INEL waste management facilities. These sitewide waste management facilities are described in Section A.4.9.

The DOE's NPR operations will be conducted consistent with commitments DOE has made and will make in compliance agreements with state and Federal regulatory authorities. If it should become necessary, DOE will work with the regulators to incorporate NPR needs into existing agreements or to develop new agreements to ensure continued compliance. Under no circumstances will DOE's performance pursuant to any existing compliance agreement be compromised or diminished as a result of the NPR project. If there are discrepancies between the waste stream volume and waste treatment capacity figures in the DEIS and in existing compliance agreements, or those currently in negotiation, the figures in the compliance agreements will prevail.

B.4 LIGHT-WATER REACTOR TECHNOLOGY AT SRS

B.4.1 Introduction

The purpose of this section is to define the adaptation of a light-water reactor to the Savannah River Site (SRS). The description of the light-water reactor is largely abstracted from an SRS report (WSRC 1991a), which in turn refers to a Hanford report (WHC 1990b). The descriptions of the support facilities for the light-water reactor at SRS are largely abstracted from an SRS report (WSRC 1991b), which in turn refers to a Hanford report (WHC 1990a).

B.4.1.1 New and Existing Facilities Required for the NPR

The SRS is an integrated site that uses heavy-water reactor technology for the production of tritium and plutonium. For siting of the light-water reactor at SRS, the facility design described in Section B.2.2 would require minor performance modifications to the cooling tower design for operation in SRS meteorological conditions, resulting in modified raw water intake requirements and evaporative loss and blowdown rates from the cooling towers. Most other plant characteristics, performance data, and emissions would be unaffected.

Some existing facilities could be used directly to support the operation of a light-water reactor at SRS, some would have to be modified, and some new facilities would have to be built. New tritium production fuel and target fabrication facilities would have to be built to support the LWR in the tritium production mode. No fuel/target fabrication facilities would have to be constructed for the plutonium production mode because the fuel assemblies would be purchased from a commercial manufacturer. Processing of spent fuel from the tritium production mode would require the construction of a new Headend Fuel Processing Facility adjacent to the existing H-Canyon and a new uranium recovery building near the H-Canyon. Tritium targets would be processed in the Replacement Extraction and Purification Facility, which has been proposed in support of the existing tritium production activities. Processing of plutonium targets would require construction of a new Headend Plutonium-Target Processing Facility for F-Canyon and a new UO_3 reduction line in F-Canyon.

Because the LWR would include the option to generate electricity, the site would require a 49-m-wide corridor for the outgoing transmission lines. This would be in addition to the two independent power lines that would be required when the turbine generator is inoperative.

B.4.1.2 Location

The reference site for the light-water reactor at SRS is the same as described in Section A.2.1.2 for a new heavy-water reactor at SRS.

B.4.1.3 Existing Facilities, Utilities, and On-site Transportation

The existing services at SRS are discussed in Section A.2.1.3.

B.4.2 Light-Water Reactor Facility

The facility description provided in Section B.2.2 is applicable for the light-water reactor at SRS, with the additional clarifications and exceptions noted in the following sections.

B.4.2.1 Electric System

The LWR plant electric system described in Section B.2.2.7 would be compatible with the existing 230-kV electric grid.

B.4.2.2 Heat Dissipation Systems

Turbine Condenser Cooling System

The design of the cooling towers would be adapted to SRS meteorological and climatic conditions. This would be reflected in the water required for evaporation, drift, and blowdown. At SRS, total makeup for a light-water reactor is assumed to be bounded by the data given in Table B.1.

The raw water intake structure described in Section A.2.2 for the heavy-water reactor at SRS is assumed to be sufficient for raw water intake for the light-water reactor at SRS.

Thermal discharge standards limit blowdown temperatures to 32°C. In addition, the difference between the blowdown temperature and the temperature of the receiving open waters is limited to 2.8°C. As a result, the blowdown would likely need to be mixed with additional raw river water.

The effluent water discharge point (see Secondary Cooling System discussion in Section A.2.2.9) for the heavy-water reactor at SRS would be used as the discharge point for the cooling tower blowdown water, sanitary water, and treated liquid radwaste effluent.

Water Treatment System

The description of the treatment of the turbine condenser cooling water for a light-water reactor at Hanford (see Other Reactor Cooling Water Systems discussion in Section B.2.2.8) would generally be applicable to SRS. However, more flocculants and chlorine would be required at SRS than at Hanford because the suspended solids and biological activity would be higher in the Savannah River than in the Columbia River.

B.4.2.3 Waste Management

The types of waste, their activity levels, and their annual volumes defined for a light-water reactor at Hanford would also be applicable to SRS, except that suspended solids and biological activity would be higher in the Savannah River than in the Columbia River. Consequently, as a result of the turbine condenser water treatment, a greater volume of wastes would be generated at SRS than at Hanford.

No modifications would be required in the SRS waste disposal infrastructure for handling either the solid radioactive waste from an LWR or the liquid wastes that would be solidified (Section B.2.2.9).

B.4.3 Fuel and Tritium-Target Fabrication

B.4.3.1 Facility Description

Two new facilities would be constructed for fuel and tritium-target fabrication. They would be similar to the INEL facilities described in Section B.3.3.1.

B.4.3.2 Fuel and Target Description

The fuel and targets would be the same as those described for the LWR at Hanford (Section B.2.3.2).

B.4.3.3 Process Description

A detailed description of the processes is given in Section B.2.3.3 for the LWR at Hanford.

B.4.3.4 Process Effluents and Wastes

The off-gas from the fuel and target facilities would be filtered through HEPA filters before being discharged to the atmosphere. The fuel and target fabrication facilities would have a chemical liquid waste stream and a potentially radioactive liquid waste stream. It is assumed that the waste streams would be processed together through the Effluent Treatment Facility at SRS.

Low-level radioactive solid waste would be generated from fuel and target fabrication and stored in on-site vaults. No mixed waste is expected from the Tritium-Target Fabrication Facility.

Chemical wastes regulated by RCRA would be generated in both the fuel and target fabrication facilities. Some of the chemicals of the liquid waste stream may be classified as hazardous waste (silver oxide), but, because of the small quantities involved (4 kg/yr), it is assumed the facility would be classified as a small-scale generator, and the stream would not be classified as a hazardous waste.

B.4.4 Fuel/Plutonium-Target Fabrication

In the plutonium production mode, the fuel would be procured from commercial suppliers. Therefore, there would be no fuel/plutonium-target fabrication activities on-site.

B.4.5 Spent Fuel Processing

The spent fuel from the existing heavy-water reactors at SRS is highly enriched metallic uranium fuel. The spent fuel is processed in Building 221-H (H-Canyon) to recover uranium.

The processing of existing HWR fuel would continue, but a new Headend Fuel Processing Facility would be built. This new facility would chop and leach the irradiated LWR fuel and would use nitric acid to dissolve the uranium (UO_2) to produce a uranyl nitrate solution for solvent extraction in the H-Canyon. A new uranium recovery building would also be added to convert the recovered uranium to an oxide for recycle to the Fuel Fabrication Facility. The proposed LWR fuel and existing HWR fuel would be processed at different times so that highly enriched uranium from existing HWRs would not be degraded by the moderately enriched uranium of the proposed LWR.

B.4.5.1 Facility Description

As envisioned at the generic design stage, the new H-Canyon headend facility would consist of a multilevel structure adjacent to existing Building 221-H (Section A.2.5.1). The

process building would be seismic- and tornado-resistant (hardened). The headend facility would consist of a reinforced-concrete structure designed to contain high-level radioactivity. The overall dimensions of the building would be approximately 55 m by 30 m by 37 m high, with about 23 m below grade. The structure and the inaccessible or nonreplaceable components for radioactive processes would have a design life of 40 years. Equipment, other than dissolvers, would have a design life of 20 years; renovation could extend the lifetime to 40 years.

A support building would adjoin the headend facility. This building, which would be a one-story, semidetached 24-m by 30-m clear-span metal building, would contain offices, clothes-changing rooms, a lunchroom, a conference room, toilet and shower facilities, laundry storage facilities, and mechanical equipment. Personnel entering or leaving the headend facility would pass through the main entrance of the support building.

The headend facility would include a cask receipt and decontamination area capable of handling incoming fuel casks. It would also contain cells for remote (manipulator-operated) fuel disassembly, fuel chopping, and waste packaging. Other functional areas for dissolution, feed processing, interim storage, and off-gas treatment would be serviced by a remote crane. These areas would be supported by adjoining operating and service galleries and by areas for supporting mechanical equipment, electrical switchgear, control booms, clothes-changing rooms, and offices. Radioactive liquid waste from the LWR H-Canyon headend would be transferred to Building 221-H for processing or disposal.

A new two-story uranium recovery building, 30 m by 14 m by 14 m high, would be built near Building 221-H. One level of the structure would be below grade. The building would have areas for reduction of the H-Canyon-produced UO_3 to UO_2 , which would then be recycled to the Fuel Fabrication Facility; storage of highly enriched uranium from off-site, which would be blended with the uranium recovered from processing the LWR fuel; and storage areas for feed materials (UO_3), products (UO_2), and process chemicals (primarily ammonia).

B.4.5.2 Process Description

The H-Canyon headend facility would receive fuel assemblies without the tritium-target rods from the Reactor Facility and would disassemble, chop, dissolve the fuel to feed specifications, and store the solution for transfer to the H-Canyon for processing. The H-Canyon would use the processes described in Section A.2.5 to separate uranium, neptunium, and fission products and to convert the uranium to the UO_2 form, after receiving dissolver solution from the Headend Fuel Processing Facility.

B.4.5.3 Process Effluents and Wastes

The gaseous wastes would primarily be those associated with the dissolution of the spent driver fuels. These gaseous wastes would be released to the atmosphere after treatment for iodine adsorption and filtering through high-efficiency particulate air filters.

Actual tritium releases from the H-Canyon chemical separation areas are classified, but an upper-bound estimate of the amount of tritium released from the H-Canyon is 5.5×10^4 Ci/yr. Because this is an upper-bound estimate, an estimate of the incremental tritium

release from H-Canyon for LWR tritium production fuel processing is not made; i.e., H-Canyon release will still be less than the upper bound.

The high-level aqueous waste from 221-H Canyon processes contains most of the fission products. The waste is concentrated and neutralized before being sent to waste storage tanks. The nitric acid from the overheads is recovered for reuse.

The low-level liquid wastes come from evaporator overheads and steam condensates. The radioisotopes released with the low-level liquid waste during the processing of irradiated fuel are processed through the F and H areas Effluent Treatment Facility. This facility processes the liquid waste to remove most of the chemical and radioactive material so that the treated water meets the prescribed limits for release to on-site streams.

Radioactive solid waste, transuranic waste, mixed waste, and hazardous waste produced by processing irradiated LWR tritium production fuel would be disposed of appropriately in a Federal repository, in on-site vaults, in the Waste Isolation Pilot Plant or another appropriate facility, and at mixed and hazardous waste storage sites in compliance with applicable Federal, state, and local regulations.

B.4.6 Tritium-Target Processing

B.4.6.1 Facility Description

A new Replacement Extraction and Purification Facility is being planned to support the existing HWRs, and it would be functional when NPR operations begin. The portion of that facility devoted to tritium extraction is described in Section A.2.6 for the HWR.

Modifications would be needed to accommodate LWR tritium targets; i.e., a new extraction cell would be constructed to recover tritium from the LWR tritium targets and to store this material until it could be transferred to the HWR tritium extraction facility for purification of the tritium.

B.4.6.2 Process Description

Tritium would be extracted by heating the target in a vacuum furnace. Diffusion barriers and a thermal cycling adsorption process would be used for purification. A more detailed description is given in Section A.2.6.2.

B.4.6.3 Process Effluents and Wastes

Tritium is the only radionuclide that would be released to the atmosphere from the LWR Tritium-Target Processing Facility. Actual tritium releases from existing processing facilities are classified, but releases from the new extraction facility would be less than 5,000 Ci/yr for its maximum throughput. The processing of the LWR tritium-target process would not increase this upper limit.

Low-level liquid waste, primarily tritiated liquids, would be treated in the facility by solidification into grout. Additional solid low-level waste would be produced by the tritium-target processing operation. Most of that volume would be spent targets, and most of its activity would be due to chromium-51, manganese-54, cobalt-58, and cobalt-60 in the irradiated target materials.

No mixed waste or hazardous waste has been identified from the tritium-target processing operation; however, other wastes (i.e., trash and sanitary wastes) would be produced as part of tritium-target processing.

B.4.7 Fuel/Plutonium-Target Processing

The irradiated depleted uranium targets from existing HWRs are processed through Building 221-F (F-Canyon) and its associated facilities. These facilities would be used, with some modifications, to process the irradiated LWR fuel and target materials from operation in the plutonium production mode. To use the existing facility, a Headend Plutonium-Target Processing Facility would be constructed adjacent to the F-Canyon, and a uranium recovery building would be constructed near the F-Canyon.

B.4.7.1 Facility Description

Building 221-F is a 35,000-m³, massive-resistance, reinforced-concrete structure, 255 m by 40 m by 20 m high, designed to withstand external blast pressures of 47,900 Pa. It is a double-canyon structure and is similar in design to the H-Canyon (Section A.2.5) for an HWR.

The new headend facility (Section B.4.5) would receive the fuel/target rods and chop and dissolve them to prepare a nitrate solution for processing in the F-Canyon. The uranium recovery building (Section B.4.5) would be used to convert the UO₃ normally produced in F-Canyon processing to UO₂.

B.4.7.2 Process Description

The F-Canyon facility uses the Plutonium-Uranium Extraction (PUREX) process to separate uranium, neptunium, plutonium, and fission products contained in the irradiated targets. The existing process (Section A.2.7) would be used, except for the headend chop and leach steps and the final uranium conversion step.

B.4.7.3 Process Effluents and Wastes

The operation of the 221-F Canyon produces gaseous wastes primarily associated with the dissolution of the irradiated material. These gaseous wastes are released to the atmosphere after treatment by appropriate absorption or filtration.

Actual tritium releases from individual facilities are classified, but a bounding estimate is 5.0×10^4 Ci/yr. Tritium releases from the F-Canyon complex with LWR fuel/target processing would be less than this bounding estimate.

The high-level aqueous waste from 221-F Canyon contains most of the fission products. This waste is concentrated and neutralized before being sent to waste storage tanks; nitric acid from the overheads is recovered for reuse.

B.4.8 Plant Operation

The resources required for normal operation of the light-water reactor and its support facilities at SRS are included in Table B.2. Estimates of the staffing requirements for operation of each of the NPR facilities at SRS are given in Table B.4. The resources for operation of the light-water reactor at SRS are assumed to be the same as that of a light-water reactor at Hanford, except for the cooling water makeup (Section B.4.2). The estimated requirements for energy and for potable and process water for the support facilities are well within current capacity when NPR is operating simultaneously with the existing P, K, and L reactors.

B.4.9 Sitewide Waste Management

The sitewide waste management system at SRS is described in Section A.2.9. Flowcharts for the liquid and solid wastes from the reactor and the support facilities are presented in Appendix M.

The DOE's NPR operations will be conducted consistent with commitments DOE has made and will make in compliance agreements with state and Federal regulatory authorities. If it should become necessary, DOE will work with the regulators to incorporate NPR needs into existing agreements or to develop new agreements to ensure continued compliance. Under no circumstances will DOE's performance pursuant to any existing compliance agreement be compromised or diminished as a result of the NPR project. If there are discrepancies between the waste stream volume and waste treatment capacity figures in the DEIS and in existing compliance agreements, or those currently in negotiation, the figures in the compliance agreements will prevail.

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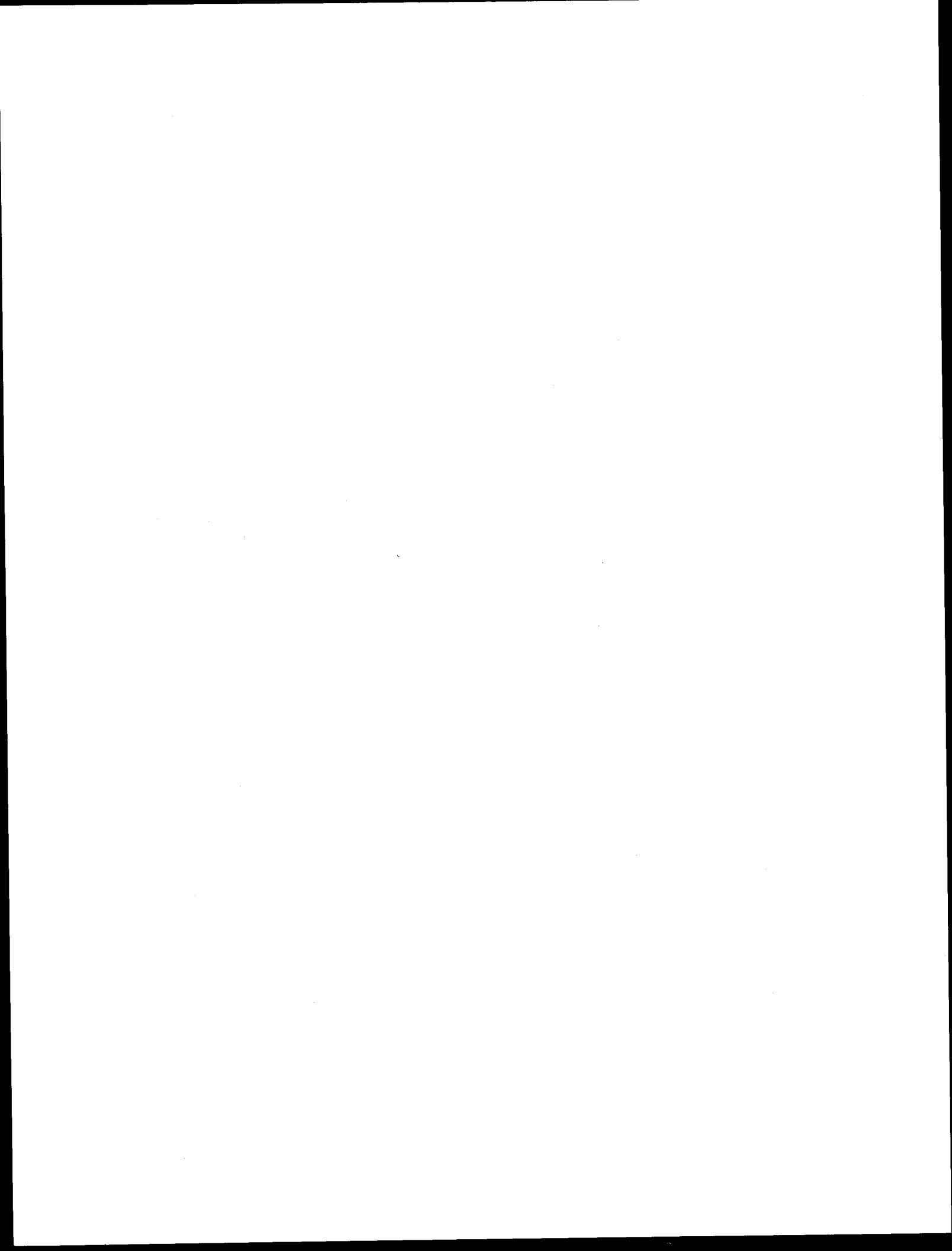
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APPENDIX C:
MODULAR HIGH-TEMPERATURE GAS-COOLED REACTOR TECHNOLOGY



APPENDIX C:

MODULAR HIGH-TEMPERATURE GAS-COOLED REACTOR TECHNOLOGY

C.1 OVERVIEW

C.1.1 Introduction

Appendix C provides a summary description of the New Production Reactor (NPR) modular high-temperature gas-cooled reactor (MHTGR) technology and the location, operation, and waste management of such a facility at each of three alternative DOE sites: the Hanford Site near Richland, Washington (Section C.3); the Idaho National Engineering Laboratory (INEL) Site near Idaho Falls, Idaho (Section C.2); and the Savannah River Site (SRS) near Aiken, South Carolina (Section C.4). The key assumptions given in Appendix A, Section A.1.1, for a heavy-water reactor also apply here.

The production complex at each site, as described in this appendix, would be capable of producing tritium, weapons-grade plutonium, and other isotopes. The complex would include reactor modules, a power conversion system, target and fuel fabrication facilities, irradiated fuel and target processing facilities, and appropriate waste management facilities. Existing support facilities would be used where feasible. Facilities to support tritium production as well as spent fuel processing and plutonium production are included. Section 1 discusses the relationship of these activities to the proposed action and alternatives available for the DOE Reconfiguration PEIS.

C.1.2 Safety and Safety Assurance

Safety and safety assurance will be attained through compliance with applicable DOE orders and national consensus codes and standards. The approach used in the New Production Reactor Program described in Section A.1.2 for heavy-water reactor technology also applies to the MHTGR technology.

The MHTGR would meet the general design requirements given in the *New Production Reactors Requirements Document* (DOE 1989). The existing facilities that would support MHTGR currently meet or will meet all DOE orders, including requirements for nonreactor facilities provided in DOE Order 6430.1A, *General Design Criteria*. The design and construction of the MHTGR and its support facilities would meet the quality requirements for the NPR program under the American Society of Mechanical Engineers NQA-1 standards, *QA Program Requirements for Nuclear Facilities*.

C.1.3 Modular High-Temperature Gas-Cooled Reactor Technology

C.1.3.1 Reactor

The MHTGR would consist of eight reactor modules and turbine generator sets to produce tritium (or plutonium) and also to achieve power production at a nominal plant rating of about 1,100 MWe. Each reactor module would be contained in a vertical, cylindrical, steel/concrete enclosure fully embedded in the earth. Each module would contain separate, vertically positioned reactor and steam generator vessels connected by a horizontal coaxial cross-duct. The reactor vessel would consist of the reactor core components (including fuel and target materials), the reactor structure, and reactivity control components. The reactor core would consist of graphite reflectors and prismatic graphite blocks (fuel elements) containing the fuel and targets. The core would be cooled by helium gas because helium has good heat transfer characteristics and does not appreciably absorb neutrons. Helium coolant would flow through the central channel and around the periphery of each annular target element within the graphite blocks.

Each reactor module in an MHTGR facility would be an independent production unit that would provide a fraction of the overall production goal. Each 350-MWt module could be used to produce tritium, plutonium, or other isotopes, thereby enabling the facility to meet mixed production goals.

The EIS addresses an eight-module facility that would be operated in two power blocks of four modules each. Each power block would consist of a nuclear island (a set of four reactor modules, their support buildings, and operation center), an energy conversion area, and heat dissipation systems. Parallel operations with small production and process units reduce the probability of losing a major fraction of production capability because of system failure, natural disaster, or sabotage.

C.1.3.2 Fuel and Tritium-Target Cycle

Eight reactor modules would constitute a production facility comparable in capacity to the heavy-water reactor and light-water reactor alternatives. The fuel for both tritium and plutonium production would be highly enriched uranium (93.13 wt% uranium-235) in the form of uranium oxycarbide microspheres formed into cylindrical tritium-target elements (compacts). The tritium-target material would be lithium enriched with lithium-6 in the form of lithium aluminate microspheres formed into cylindrical compacts. The reactor core would contain 66 columns of fuel elements with 10 elements per column for a total of 660 fuel elements. The core would also contain 60 target elements in reflector blocks (also prismatic graphite blocks), but these blocks contain no fuel. The highly enriched uranium fuel would sustain a nuclear reaction, and the neutrons produced would be absorbed by the lithium to produce tritium.

The MHTGR has a nominal 3-year fuel residence time in the tritium production mode. Retargeting operations would take place after each 6-month irradiation period. Replaceable reflector elements surrounding the active core would have a maximum lifetime of 9 years. Fuel and reflector elements that have not reached their predicted life, but are removed for target replacement, would be visually inspected, reloaded with new target elements, and inserted in the next reactor module to be refueled.

During refueling in the tritium production mode, all fuel assemblies and target-containing reflectors would be removed and transferred to a storage area. A new core would be assembled using a combination of new and refurbished elements. This loading concept eliminates the time required for exchange of target material in the reusable fuel elements, thereby improving overall plant availability. A 1-month cooling period for tritium targets and a 1-year cooling period for spent fuel is assumed.

Tritium targets removed from the irradiated fuel elements would be transferred to the Tritium-Target Processing Facility, and fuel elements containing spent fuel elements would be transferred to the Spent Fuel Processing Complex. Figure C.1 shows the major facilities, material transfers, and interfaces associated with MHTGR tritium production.

C.1.3.3 Fuel/Plutonium-239 Target Cycle

It is expected that the MHTGR could produce plutonium-239 or other isotopes without significant modifications to the tritium production design. The overall reactor core configuration, reactivity control system, shutdown strategy, and the number and location of target elements would be expected to be the same for all production modes. Thus, plutonium or other isotopes could be produced in one or more reactor modules, while tritium was being produced in the other modules.

The plutonium-target material would be depleted uranium (uranium-238 containing 0.20 wt% uranium-235) in the form of uranium oxycarbide microspheres formed into cylindrical compacts. The reactor core would consist of fuel elements that are large prismatic graphite blocks (as in tritium production) that contain cylindrical fuel compacts formed with highly enriched uranium and target compacts formed with depleted uranium (uranium-238).

At maximum uranium-238 target loading capability, the effective uranium-238 macroscopic capture cross section is appreciably lower than the lithium-6 macroscopic cross section in the tritium production mode. Therefore, the driver-fuel element fissile loading would be reduced by about 35% in the plutonium design option, and 50% of the driver-fuel blocks would be replaced each year. Target elements would be replaced every 3 months. Operation in the plutonium production mode would reduce the capacity factor of the reactor because more frequent core loading would occur.

Conversion of individual reactor modules from tritium production to plutonium production (or vice versa) would require no modifications other than the exchange of one type of fuel/target element for another. Routine core refueling equipment and procedures would be used.

Cooling and shielding would be more demanding for irradiated plutonium targets than for irradiated lithium targets. A 1-year cooling time for plutonium fuel and targets is assumed. Except for some minor revisions to the fuel element design, the Target Storage Area, and transport equipment, no other modifications to the MHTGR would be needed to convert a module from tritium production to plutonium production. Figure C.2 shows the major facilities, material transfers, and interfaces associated with MHTGR plutonium production.



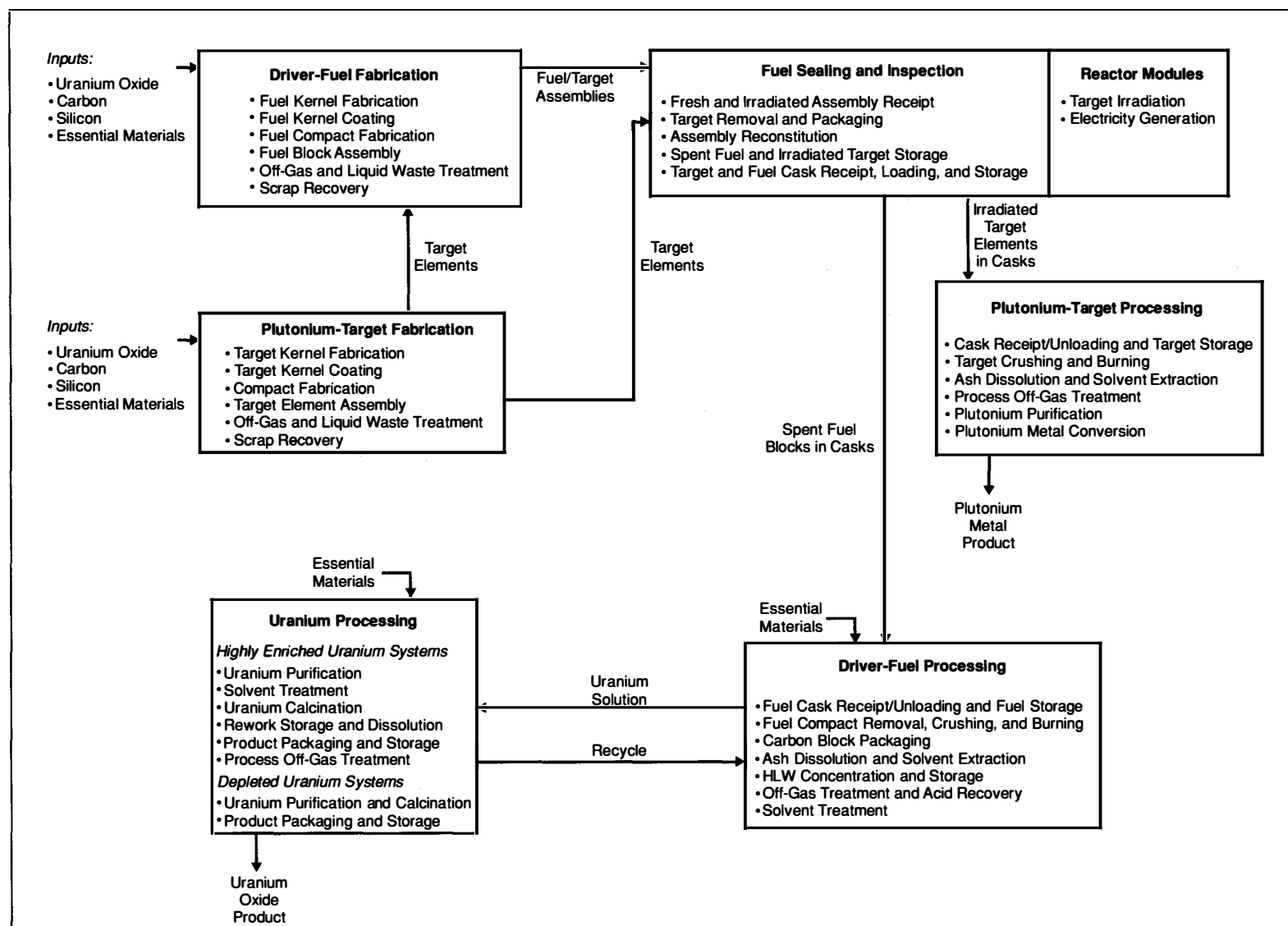


FIGURE C.2 Major Facilities and Interfaces for MHTGR Plutonium Production (Source: WHC 1989b)

C.1.3.4 Waste Management

The DOE conducts its environmental management activities at Hanford, INEL, SRS, and other DOE sites pursuant to compliance agreements with state and Federal regulatory authorities. These agreements guide DOE activities at the sites under applicable environmental laws, regulations, and other standards. Compliance with the terms of these negotiated agreements is one of the highest of DOE's priorities. The DOE's NPR operations will be conducted consistent with commitments DOE has made and will make in these agreements. If it should become necessary, DOE will work with the regulators to incorporate NPR needs into existing agreements or to develop new agreements to ensure continued compliance. Under no circumstances will DOE's performance pursuant to any existing compliance agreement be compromised or diminished as a result of the NPR project. If there are discrepancies between the waste stream volume and waste treatment capacity figures in the DEIS and in existing compliance agreements, or those currently in negotiation, the figures in the compliance agreements will prevail.

Each facility would produce gaseous, liquid, and solid wastes. Gaseous waste would be treated within each facility to reduce the toxic and radioactive contents to within regulatory requirements before discharge to the atmosphere through stacks. Liquid waste would also be treated within each facility either to reduce the toxic and radioactive contents to an acceptable level for discharge to the environment or to an acceptable state for receipt in the liquid waste treatment system existing on each alternative site. In either case, solid waste would be produced. Solid waste would be treated within each facility to a form where it can be further treated, disposed of, or stored within the waste management system existing at each alternative site.

C.2 MODULAR HIGH-TEMPERATURE GAS-COOLED REACTOR TECHNOLOGY AT INEL

C.2.1 Introduction

This section provides information on the generic MHTGR and its proposed support facilities at INEL. The content is largely abstracted from the report *NPR-MHTGR Generic Reactor Plant Description and Source Terms* (EG&G 1989), except where otherwise referenced.

C.2.1.1 New and Existing Facilities Required for the NPR

The modular high-temperature gas-cooled reactor complex would be separate from existing INEL facilities. The complex would include the Reactor Facility, fuel and target fabrication facilities for tritium and plutonium production, a Tritium-Target Processing Facility, and administrative and other support structures (Figure C.3). Spent fuel and plutonium targets would be processed at the Idaho Chemical Processing Plant.

The reactors would normally operate at full power when producing tritium (or plutonium). Thermal energy in the form of steam, which is suitable for producing electricity, would be produced as a by-product of normal operation and could be sold or used to offset

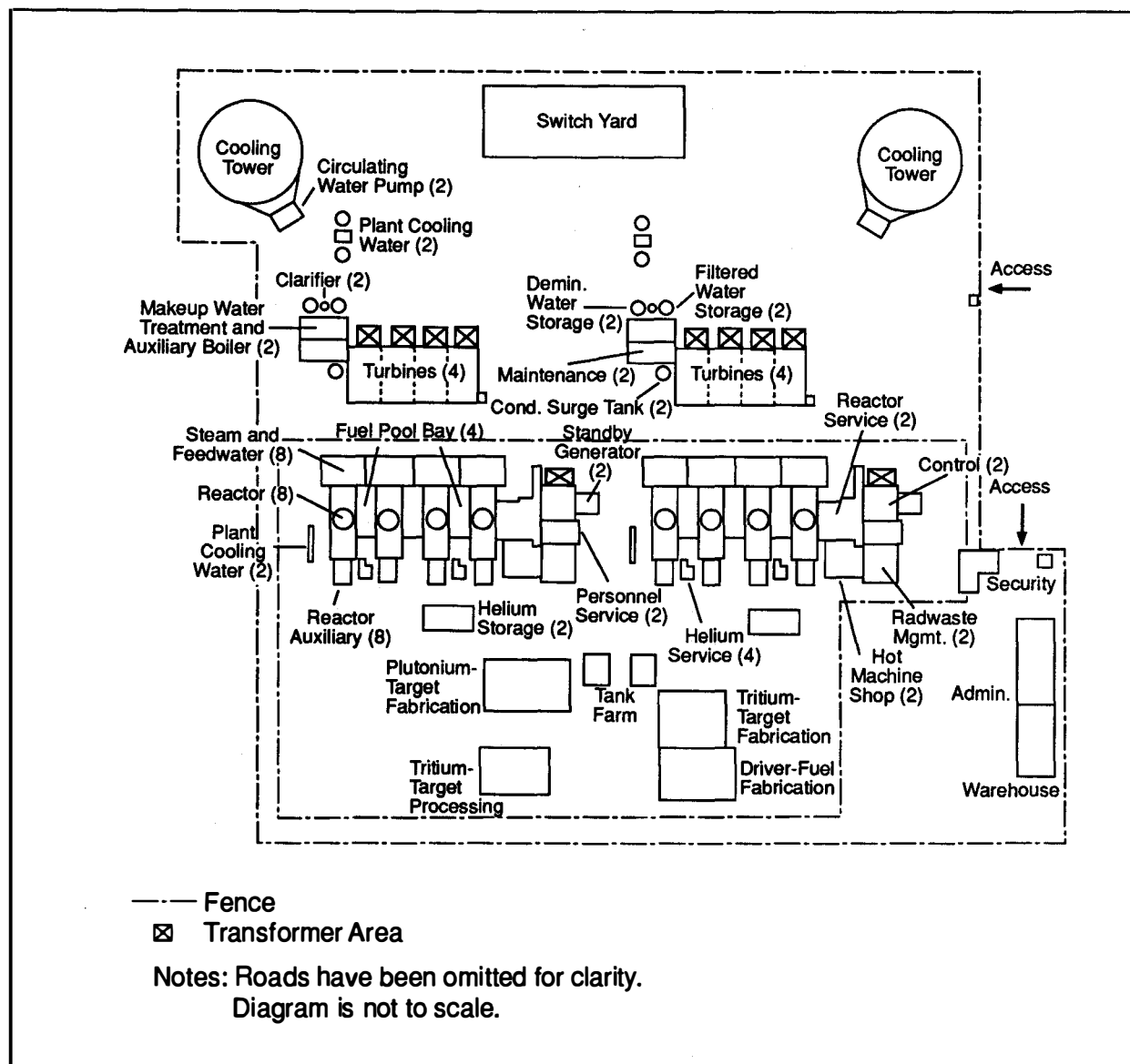


FIGURE C.3 MHTGR Reactor Facility Complex (Source: Modified from WHC 1989b)

production costs. The turbine generators would be located in the Energy Conversion Area adjacent to the MHTGR production plant. A 100% steam bypass capability would be provided for each reactor module, so that the tritium (or plutonium) production operation could continue in each reactor without operation of the electric generating plant.

Gaseous and liquid effluents would be discharged from the MHTGR structures, but discharge points have not been selected. No liquid radioactive waste streams would be discharged to the surface or groundwater. Cooling tower blowdown would be captured in one or more fully lined, leak-monitored, evaporation cooling ponds. Gaseous discharges would be controlled and monitored continuously to meet applicable discharge standards. Sanitary wastes would be discharged on-site in compliance with applicable Federal, state, and local operating permits.

Waste management systems for the MHTGR would be integrated with existing and planned INEL waste management facilities. All proposed facilities would meet applicable Federal, state, and local environmental requirements. Safety reviews would be conducted by DOE internal safety organizations, the Advisory Committee for Defense Nuclear Reactor Safety, and the Defense Nuclear Facility Safety Review Board.

C.2.1.2 Location

The proposed NPR site at INEL is described in Section A.4.1.2.

C.2.1.3 Existing Facilities, Utilities, and On-site Transportation

The existing support facilities -- the Idaho Chemical Processing Plant and the Radioactive Waste Management Complex -- are discussed in Section A.4.1.3. Existing utilities and existing on-site transportation (i.e., roads and railroads) are also described in Section A.4.1.3.

C.2.2 Modular High-Temperature Gas-Cooled Reactor Facility

The MHTGR would serve as an irradiation facility where lithium (or uranium) targets would be exposed to neutron flux for tritium (or plutonium) production. The proposed product from irradiation would be tritium, which would be generated by irradiation of the lithium.

C.2.2.1 Plant Structures

The proposed MHTGR is in the preliminary design phase; therefore, specific design details cannot be presented. However, the MHTGR would incorporate the technology and materials science based on several decades of gas-cooled reactor operation worldwide and on developments for the U.S. nuclear power industry. As a result, the operating features and characteristics of the MHTGR can be defined in sufficient detail to bound both construction and normal operational impacts, as well as to quantify the potential for accidents and their associated consequences.

The primary structures of the reactor complex would consist of the following:

- Two reactor buildings (each housing four reactor modules), a steam bypass facility, fuel and target assembly and storage areas, refueling equipment, fuel cooling and storage areas, and the individual reactor containment envelope (each 350-MWt module would be independently controlled, serviced, and maintained);
- Support buildings containing radioactive waste facilities for handling solid and liquid radioactive waste, helium storage and purification facilities, personnel services, a washdown bay, maintenance services, and auxiliary power systems;

- An operations center, housing the control room near the reactor building, and a Remote Shutdown Facility, where the reactors can be remotely shut down independent of the primary control room;
- Energy conversion areas, which take steam from the steam generator for producing electricity;
- Cooling towers, which receive heated water from the turbine generator condenser circulating water system and the service water system for discharge of waste heat to the environment;
- Site utilities, including communications, electricity, steam, water, and sanitation services; and
- Site services, including perimeter security fences, administration areas, warehouses, a training center, a guardhouse, access gates, rail lines, roads, and parking.

Figure C.4 shows the layout for two reactor modules and their associated buildings (one-half of one nuclear island).

C.2.2.2 Nuclear Reactor Systems

The MHTGR would be based on a moderate-pressure, high-temperature application of nuclear power designed specifically for the production of strategic nuclear materials. The fuel and target materials and operating characteristics were chosen to optimize the production of tritium or plutonium and the containment of tritium or plutonium within the targets until it can be removed from the reactor and processed for recovery. During tritium production, chemical linkage of the tritium with the target material would enhance containment.

The MHTGR would be helium cooled and would operate at a helium exit temperature of 695°C. An electric-driven circulator would pump the helium through the reactor core and a steam generator to produce high-quality steam at 541°C. The steam would drive a turbine generator to produce electricity. Thus, the MHTGR would serve as a production facility and would also produce power. The eight reactor modules would provide about 1,100 MWe to the local power grid with reasonable assurance of a steady supply.

Reactor Module

Each 350-MWt reactor module would consist of the reactor, a steam generator, a circulator, a reactor vessel, a steam generator and circulator vessel, and an interconnecting concentric cross-duct vessel (Figure C.5). (Appendix R briefly describes an alternative MHTGR design with six 450-MWt units.) The reactor vessel would have an inside diameter of about 6.7 m and would be 23 m high. The reactor vessel would contain the reactor core, reflectors, and associated supports. A shutdown cooling heat exchanger and a shutdown cooling circulator would be located at the bottom of the reactor vessel. Top-mounted standpipes would house the control rod drive mechanisms and the reserve shutdown system and would serve as the access ports for the refueling and retargeting operations.

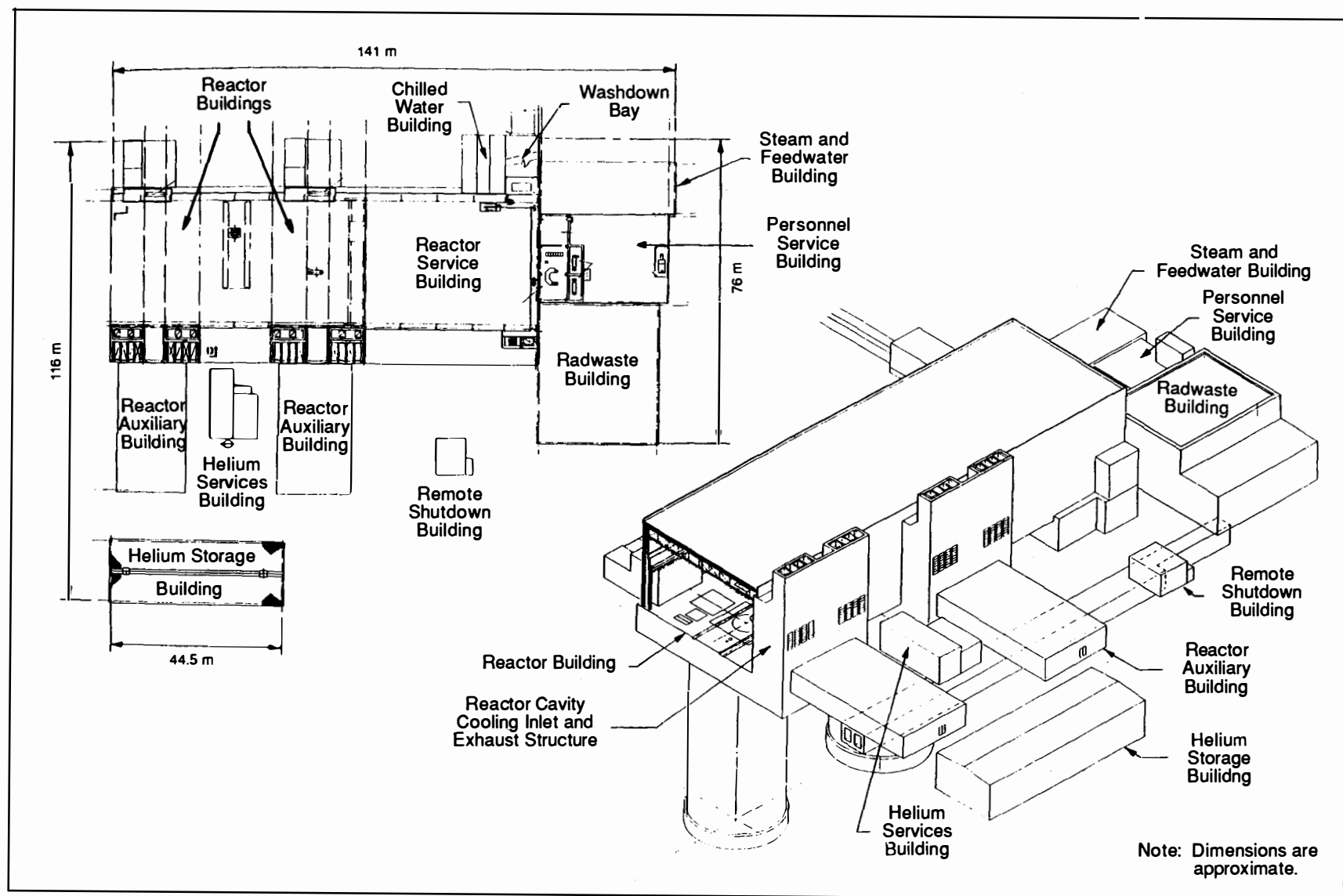


FIGURE C.4 Plan and Isometric Views of the MHTGR Layout, Showing Two Modules and Their Support Buildings (Source: EG&G 1989)

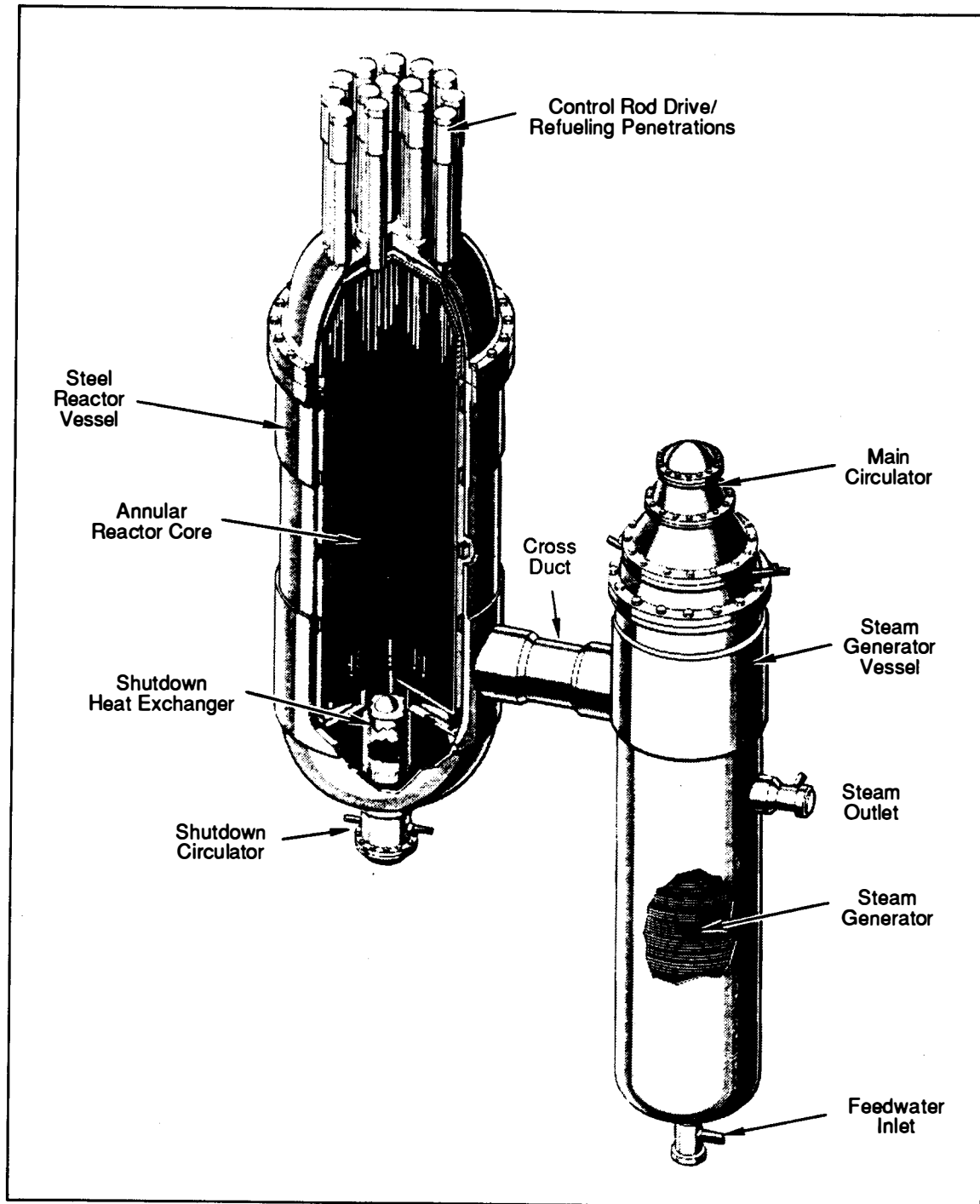


FIGURE C.5 Isometric View of MHTGR Reactor Module (Source: EG&G 1989)

The reactor core would be composed of 660 hexagonal graphite fuel elements. The fuel elements would contain blind holes for fuel rods and full-length vertical coolant holes. Each fuel element would have channels to support the tritium-target assemblies (Figure C.6).

The fuel and target assemblies (Sections C.2.3, C.2.4, and C.2.5) would be stacked in 66 nested columns, ten elements high, forming an annular core. The fueled portion of the annular core would be three fuel blocks thick. Unfueled replaceable graphite blocks would surround the active core, forming replaceable inner and outer radial reflectors and upper and lower axial reflectors. Permanent reflector graphite blocks would be located at the outer periphery of the replaceable reflector blocks.

Core power would be controlled by movable control rods. Reserve shutdown would be available by dropping boron-bearing pellets into the innermost ring of fuel elements. The boron-bearing pellets would be housed in hoppers above the core and would be part of the neutron control subsystem.

Heat generated in the core would be removed by the downward flow of helium. Most of this flow would move through the core in the fuel and target element coolant channels, but some would be directed to the control rod channels and some would pass through the gaps between fuel columns. The coolant flow would pass through the lower reflector and would enter the hot outlet plenum via coolant passages at the corners of the hexagonal blocks.

The heated helium would flow through the inner cross-duct vessel and downward over the steam generator water tube bundle, where steam would be produced. The heated helium would then move up the annular region in the steam generator to the inlet of the single helium circulator, where it would be pumped back to the reactor. On the secondary coolant side, feedwater would enter the steam generator tubing at the bottom of the vessel, flow up through the helical coil tube bundle, and exit as superheated steam at the upper end of the vessel.

A steam bypass system for each reactor module would provide an alternative path to transfer the steam energy from each reactor and steam generator to the environment if the turbine generator were inoperative; i.e., no steam would be used to drive the turbine generator; instead, the steam would be discharged directly to the condenser. This system would dissipate heat generated by the reactor core during operation without the turbine, as well as during start-up and shutdown. The steam bypass system would be equipped with a pressure-reducing and desuperheating station to automatically condition the main steam before it is dumped to the condenser.

Each reactor module steam generator would be connected to an air-blast heat exchanger capable of providing cooling to the module it serves. If the reactor were operating without the turbogenerator or steam condenser, the heat load could be taken by the air-blast heat exchanger with the reactor at full power.

Figure C.7 is a simplified flow diagram for the reactor secondary and power conversion system. When the reactor is shut down for maintenance or refueling, decay heat would be removed from the core by the normal heat transport system or by an independent shutdown cooling system. The shutdown cooling system would consist of a motor-driven circulator coupled with a compact (water-cooled) heat exchanger mounted below the reactor core within the reactor vessel. The system would not be a safety-related system.

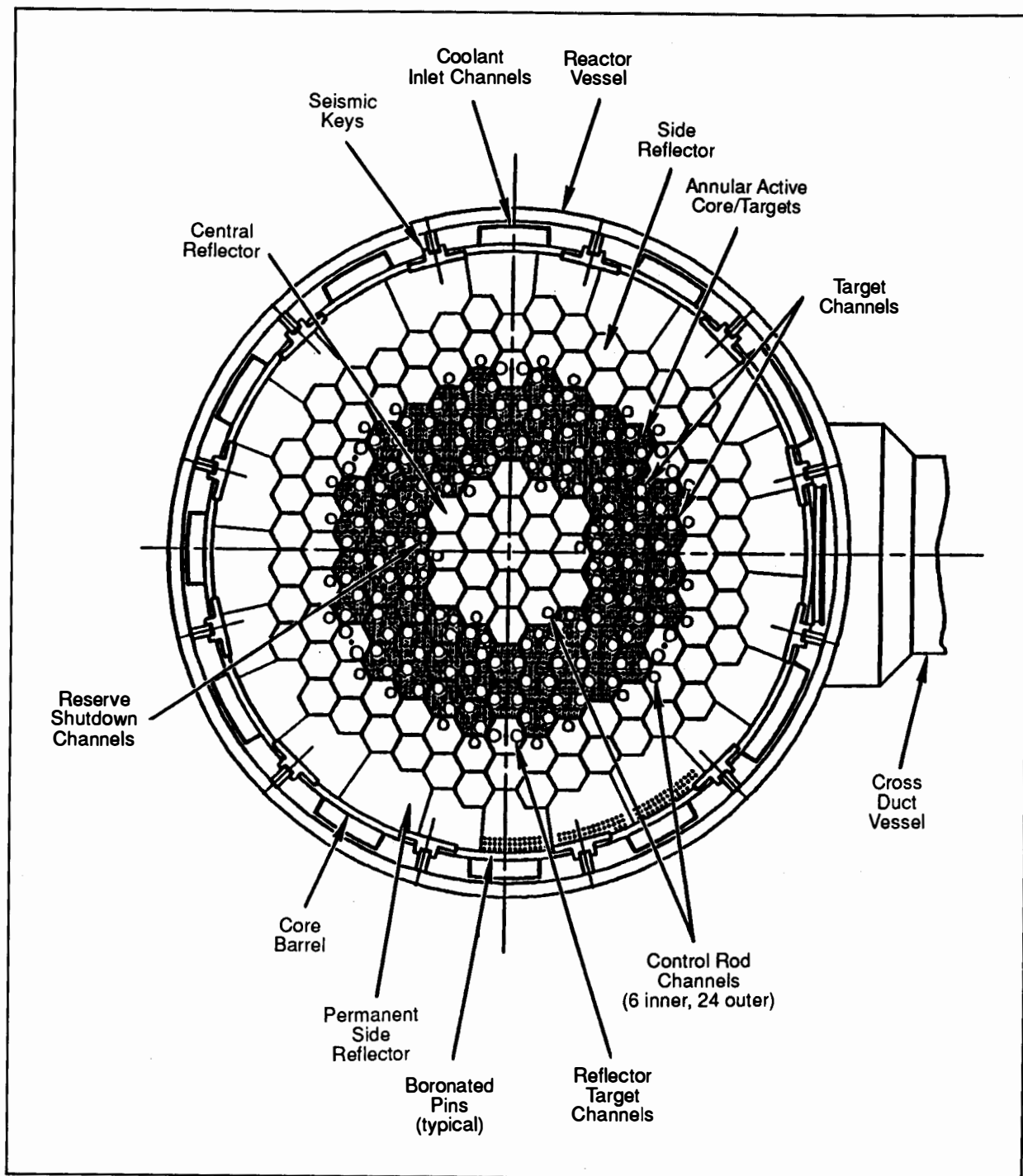


FIGURE C.6 Plan View of MHTGR Core (Source: EG&G 1989)

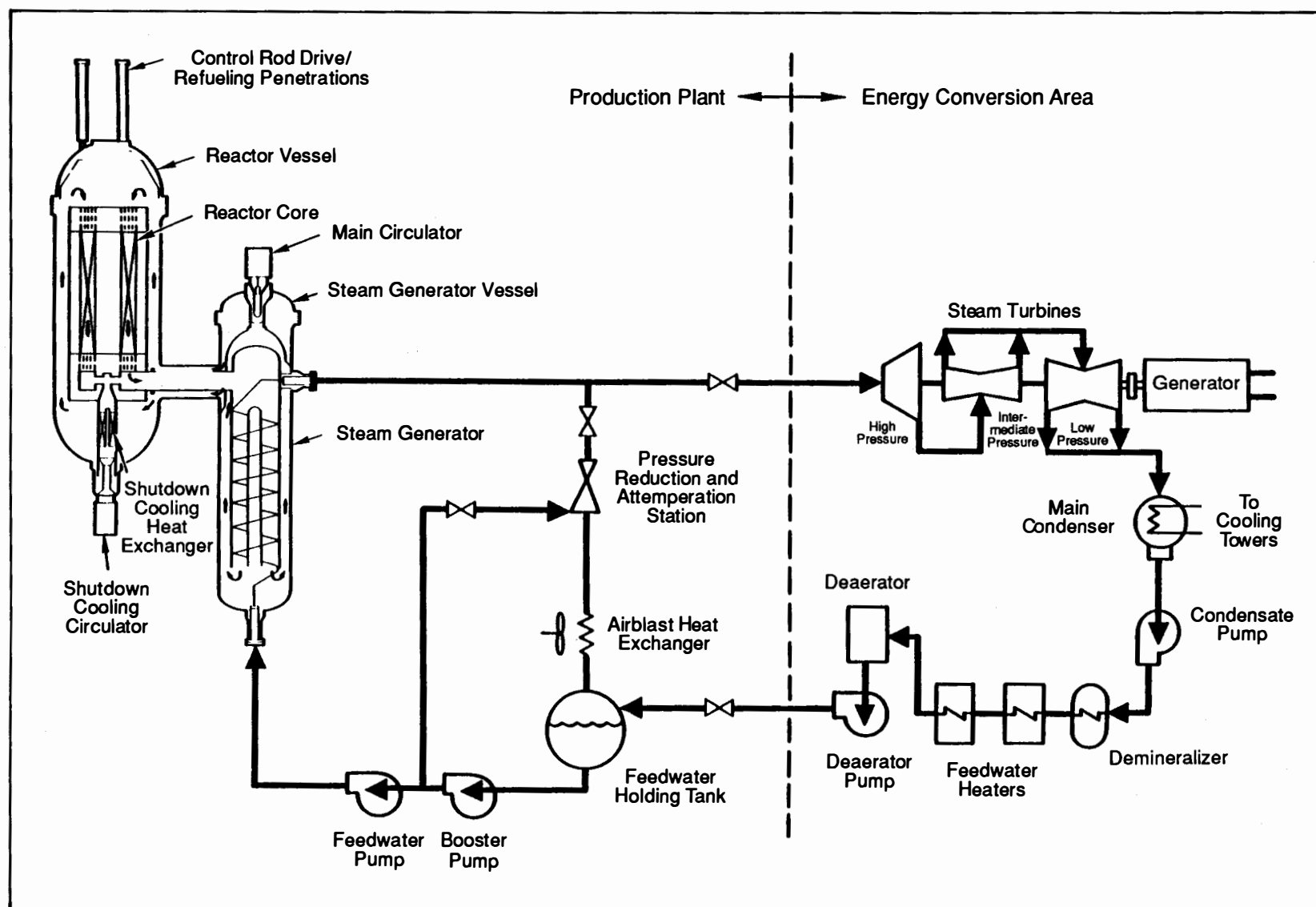


FIGURE C.7 Flow Diagram of the Reactor Secondary and Power Conversion System (Source: EG&G 1989)

Reactor Auxiliary Building

The reactor auxiliary building would be a multilevel, reinforced-concrete structure adjacent to the reactor building. It would contain the helium purification equipment, the uninterruptible power supply, and DC electric supply systems that serve each reactor. Each nuclear island would have four identical reactor auxiliary buildings. The regeneration portion of the helium purification system and a liquid nitrogen system would be located in identical but separate helium service buildings. Two helium service buildings would be provided for each nuclear island.

Reactor Service Building

The reactor service building would be a multilevel, reinforced-concrete, below-grade structure. The building would contain facilities, systems, or components associated with fuel handling and maintenance. Each nuclear island would have one reactor service building, which would be shared by four reactor modules. Reactor support activities occurring within the reactor service building would include new fuel storage facilities, maintenance and inspection facilities, new and spent fuel block and target handling facilities, and maintenance-related activities.

C.2.2.3 Engineered Safety Features

The engineered safety features would include systems designed to prevent, limit, or mitigate the consequences of postulated severe and nonsevere accidents. Table C.1 is a list of representative safety-related systems or structures. These systems are described in an EG&G report (EG&G 1989).

C.2.2.4 Reactor Containment

Four 350-MWt reactor modules would compose one nuclear island. The modules would be arranged in line and would be housed in adjacent, but separate, below-grade, reinforced-concrete silos. The 50-m-deep below-grade location would provide significant design benefits. It would serve as a barrier to external missiles, such as tornado-generated debris, turbine blades, and aircraft. It would reduce seismic-induced stress of the reactor modules, and it would provide significant radiological shielding. This arrangement would facilitate refueling each reactor silo and would allow access by an overhead crane.

Each reactor building and containment structure would include four silos connected by tunnels to form a below-grade pressure containment structure. The cylindrical portion of each silo would be approximately 21-m inside diameter, with 1.1-m-thick reinforced-concrete peripheral walls.

In a design-basis helium system or steam and feedwater system rupture, each reactor silo would communicate with a below-grade pressure containment structure consisting of interconnected tunnels. Both the tunnels and the containment structure would be made of reinforced concrete and would be capable of withstanding internal pressures of about 230 kPa. The pressure-containment tunnel and silos would provide more than 82,000 m³ of free expansion volume. The containment would be designed for a maximum leak rate of 1% per day.

TABLE C.1 Representative Safety-Related Systems or Structures

• Nuclear control system - Control rod drives - Reserve shutdown system - Neutron measurement instruments	• Safety relief valves
• Vessel system - Reactor vessel - Steam generator vessel - Vessel supports - Cross-duct vessel - Pressure relief piping and valves	• Safety protection system - Reactor trip (control rods) - Reactor reserve shutdown control - Main steam isolation and main loop shutdown
• Containment structure - Reactor site - Interconnecting tunnels - Underground pressure-retaining structure	• Monitoring instrumentation system - Interlock on reactor pressure vessel relief valves
• Reactor cavity cooling system - Water panels - Water piping, pumps, and tanks - Relief valves - Heat exchangers - Control system	• Uninterruptible power supply system - Rectifiers - Inverters - Distribution system - Emergency generators
• Steam generator isolation system - Isolation valves - Detection and control systems	• DC power system - Station batteries - Distribution equipment

Source: EG&G 1989.

C.2.2.5 Fuel and Target Handling

The fuel handling and storage systems would consist of the core refueling, fuel and reflector handling, and spent fuel cooling subsystems. The core refueling subsystem would consist of all equipment required to exchange elements between the reactor core and the fuel storage facilities. Before refueling, the reactor would be shut down and depressurized. The reactor vessel control assembly penetrations would provide access to the core sections. All elements in the core would be exchanged in one-sixth of the core area at a time.

A fuel handling machine and fuel transfer cask would remove the core elements from the reactor. After the fuel transfer cask is loaded to capacity (five elements), the cask would be taken to one of two adjacent helium-filled fuel storage wells. Each well would contain a series of vertical storage wells. The wells would be set in a water-cooled storage facility of sufficient size to safely cool spent fuel elements in the pools for up to 1 year, if necessary. In addition, the system would provide a surge capacity of 2 years to accommodate processing operations.

A service water cooling subsystem would remove decay heat generated by the irradiated fuel elements removed from the reactor and stored in the fuel storage wells. The subsystem would provide water cooling to the fuel storage wells to maintain the temperature of the irradiated fuel elements and the surrounding spent fuel storage structure within acceptable limits.

Following a production cycle, the fuel handling machine would empty the reactor vessel of fuel and reflector elements and store them temporarily in fuel storage wells in the reactor building and the reactor service building. Although only one-third of the fuel from each sector would be replaced during each refueling process, all of the fuel would be removed and transferred to fuel storage wells. Each of the six core sectors would then be rebuilt using a combination of new elements and refurbished elements from previous exchanges of target elements.

C.2.2.6 Helium Purification System

The helium purification system would remove fission products, tritium, and chemical impurities from the helium stream. A side stream of helium would be diverted to the purification system and returned to the primary coolant loop for use as a purge gas for selected vessel penetrations and for addition to the main and shutdown helium circulators. The helium purification system would significantly reduce the concentration of a few long-lived radioactive species in the helium system (e.g., tritium, krypton-85, some xenon isotopes, and, at a lower activity, argon-37).

The system would be composed of depressurizers, filters, absorbers, oxidizers, coolers, heaters, compressors and associated piping, valves, and instrumentation and controls necessary to purify the primary coolant and for system depressurization. Regeneration modules would be included to remove and process adsorbed impurities.

C.2.2.7 Power Conversion System

The power conversion system at INEL, which would be in the Energy Conversion Area, would provide all the facilities and equipment for power generation. The facilities would include the turbine building, maintenance building, makeup water treatment and auxiliary boiler building, station cooling towers, station transformers, circulating water pumphouse, electric switchyard, and a fire water pumphouse. The Energy Conversion Area would be divided into two power blocks, one for each nuclear island. Each power block would receive steam from four 350-MWt MHTGR and steam generator modules. The power conversion system equipment might consist of eight 150-MWe turbine generators. Each turbine generator module would be fully independent.

C.2.2.8 Utilities

Electric System

The electricity required by the Reactor Facility (estimated as 80 MW) would be supplied from the MHTGR turbine generators. When the turbine generators are not operating, however, the 80-MW power would be supplied by the INEL system.

Currently, 230-kV electricity is supplied to the INEL system by the Idaho Power Company from the Brady and Goshen substations on the Pacific Northwest Power Grid. Power is fed through the Antelope Substation of the Utah Power and Light Company, where it is transformed to serve the 138-kV INEL transmission loop. The capacity of this system would be inadequate to meet the 80-MW requirement of the MHTGR. Therefore, the system, including the Antelope Substation, would have to be upgraded.

In addition to the main AC power used for helium circulators, boiler feed pumps, circulating water pumps, and heating, the MHTGR facility would also have a DC electric system to supply the eight modules' DC control and instrument channels; a plant DC electric system to supply noncritical DC controls and instruments; a plant uninterruptible, 120-V AC system to supply noncritical instrumentation buses; a 120-V AC electric power system to supply critical plant AC control and instrumentation loads connected to the independent vital buses in each reactor module; and a standby electric power supply using skid-mounted gas turbine or diesel generators.

Heating, Ventilating, and Air Conditioning System

The heating, ventilating, and air conditioning (HVAC) system has environmental implications because building air is exhausted to the atmosphere. Air exhausted from potentially radioactive spaces would be continuously monitored, and, if necessary, filtered through high-efficiency particulate air (HEPA) filters. The HVAC systems would consist of packaged unit coolers strategically located to provide cooling and humidity control for equipment protection. They would maintain the concrete temperature at less than 66°C during normal plant operation. During refueling, and when personnel access is required, air would flow from less contaminated spaces to more contaminated spaces to keep radiation exposure as low as reasonably achievable. Some HVAC systems would maintain the facilities they serve at a vacuum pressure to preclude unmonitored releases. The subsystems would collect radioactive gases and particulates for disposal and would protect personnel from toxic gases, smoke, fumes, and dust.

Water Supply System

At INEL, the water supply would come from multiple deep wells near the Reactor Facility. These deep wells would supply water from the Snake River Plain aquifer, 145 m below grade. The water would be used for potable and plant cooling makeup water as well as for fire water and process water systems.

C.2.2.9 Heat Dissipation Systems

Reactor heat is mainly dissipated by turbine generators, which use energy to produce electricity. Heat is also dissipated by condenser cooling water systems, which send the residual heat to the cooling towers for release to the environment. An air-blast heat exchanger would provide an alternate mode of heat dissipation for each reactor module when the turbine generator is not operating. In addition, other cooling systems also would release heat into the turbine condenser cooling system. The overall plant coolant flow is shown in Figure C.8.

Turbine Condenser Cooling System

The turbine condenser cooling system (circulating water system in INEL nomenclature) would consist of two subsystems. Each subsystem would serve four turbine generator units associated with each nuclear island. Each subsystem would consist of an open-loop system containing turbine generator condensers, a cooling tower, and associated circulating water pumps.

Each nuclear island would have a mechanical draft, wet cooling tower. The cooling tower would cool the turbine condensers and other service water systems. Each tower would be divided into dedicated modules for each turbine generator condenser to allow for isolation and maintenance of one module without affecting the operation of the other modules. Makeup water for cooling tower blowdown, evaporation, and drift would be provided continuously from the deep-well water supply to the cooling tower basin. The water requirements for the cooling tower have been evaluated on the basis of five cycles of concentration for the recirculating water in the cooling tower. The results are presented in Table C.2, along with other water-use parameters for INEL and for the MHTGR adaptation to the other alternative sites.

The blowdown systems would discharge to a lined evaporation pond. The size of the pond is governed by the evaporation rate and the annual precipitation at INEL. The surface area of the evaporation pond for the eight-module MHTGR would be 7.3 km²; if square, each side would be 2.6 km long.

The blowdown pond would be divided into several ponds, each monitored to detect leakage. Sufficient extra capacity would be provided to drain any leaking pond for maintenance or repair (Dinneen 1989).

Water Treatment System

Chlorine and biodegradable chemicals would be added to the turbine condenser system to mitigate biofouling of the main condenser and cooling towers. Chlorine would also be used in the intake pumphouse for this purpose.

A demineralized water makeup system (one system for each nuclear island) would receive and store demineralized water from the raw water treatment system and distribute it to various systems throughout the plant. The system would consist of one demineralized water storage tank, two transfer pumps, valves, and connections.

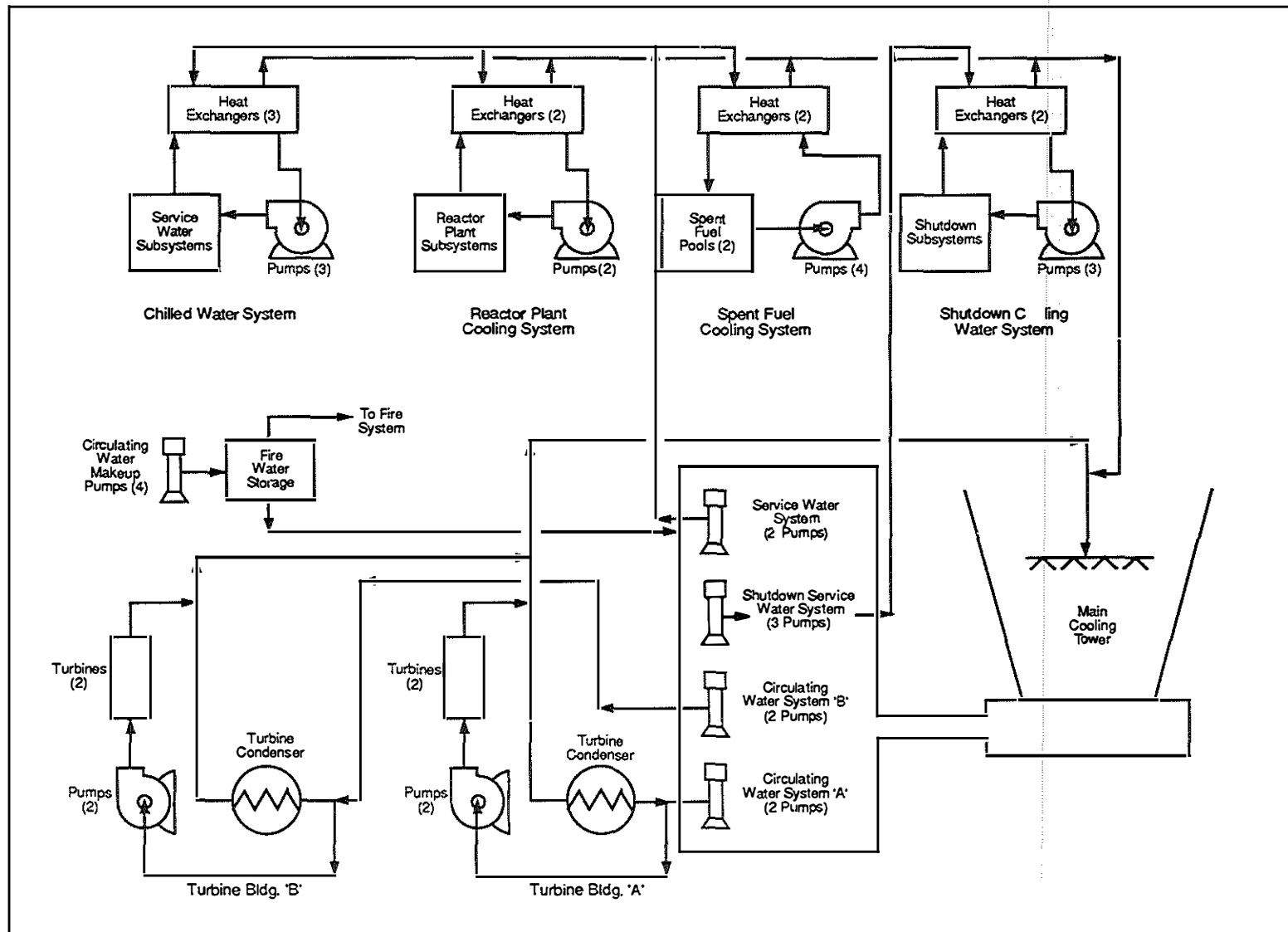


FIGURE C.8 Flow Diagram of the MHTGR Heat Dissipation System (Two Required, One for Each Nuclear Island)
(Source: EG&G 1989)

TABLE C.2 Estimated Water Use for MHTGR Cooling Towers at 2,800-MWt Reactor Power (Bounding Case; Steam Bypass Mode)^a

Type of Water Use	Hanford	INEL	SRS
Evaporation			
Peak (m ³ /s)	0.97	0.95	0.94
Annual (10 ⁶ m ³)	28.2	27.7	27.8
Drift			
Peak (m ³ /s)	0.006	0.006	0.006
Annual (10 ⁶ m ³)	0.193	0.193	0.192
Blowdown			
Peak (m ³ /s)	0.24	0.23	0.61
Annual (10 ⁶ m ³)	6.86	6.70	18.0
Concentration factor	5	5	2.5 ^c
Makeup			
Peak (m ³ /s)	1.21	1.19	1.55
Annual (10 ⁶ m ³)	35.3	34.6	46.0
Temperature control			
Peak (m ³ /s)	NR ^b	NR	0.96
Annual (10 ⁶ m ³)	NR	NR	28.3

^aPeak values are based on the month of greatest water use. Annual values are based on the averages of 12 months.

^bNR = not required.

^cThe concentration factor is limited to 2.5 at SRS to meet discharge requirements for dissolved solids.

Conversion factors: 1 m³ = 264.2 gal;
1 m³/s = 15,850 gal/min.

Source: UE&C 1990.

Raw water from the Snake River Plain aquifer would be demineralized by pumping it through ion-exchange resins until prescribed standards are met. Acid or base chemicals would be added to obtain the desired pH. Periodically, the resins would be backflushed, with output flow directed to a percolation pond.

Other Cooling Water Systems

Other cooling water systems would be open-loop systems to remove waste heat from the station cooling water system, the reactor plant cooling water system, the spent fuel storage

cooling water system, and the shutdown cooling water system. Two flow paths would remove heat during normal and shutdown modes of plant operation. These systems would dissipate heat to the turbine condenser system cooling towers.

C.2.2.10 Waste Management

For the purpose of this EIS, it is assumed that spent fuel would ultimately be disposed of in a Federal repository. Spent fuel processing is analyzed in this EIS as part of the original mission of NPR, which included the production of virgin plutonium-239. However, plutonium production is no longer part of the NPR proposed action. The Waste Management PEIS will assess the impacts of wastes from reprocessing of spent fuel from DOE reactors.

The quantities and types of wastes to be managed depend upon whether spent fuel is reprocessed and whether plutonium is produced. Estimates in this appendix were prepared on the basis that it is reasonably foreseeable that spent fuel could be reprocessed and plutonium produced. If it is decided not to continue those activities, the impacts upon waste management systems from NPR operations would be less than shown here.

The MHTGR waste management systems would handle radioactive and nonradioactive gaseous, liquid, and solid wastes. No high-level or transuranic wastes are expected to be generated at the MHTGR, although the processing of irradiated fuel and targets in the support facilities would generate such wastes in those facilities. The waste management system would be integrated into the existing sitewide waste management system (Section A.4.9). It would process wastes to the extent necessary to provide an acceptable feed to the appropriate sitewide waste management facility. Flowcharts for solid and liquid wastes from the reactor to the sitewide waste management system are given in Appendix M.

All equipment for the MHTGR waste systems, except for some holdup capacity in tanks and sumps, would be in the Radioactive Waste Management Complex and would be shared by all four reactor modules in the nuclear island. The complex would be duplicated for the second power block. Each complex would be equipped with a radioactive solid waste management system that would provide holdup, solidification (if required), packaging, and temporary storage facilities for radioactive materials before transfer from the MHTGR complex. The waste systems would be designed to be functional during all modes of normal plant operation and would process generated wastes in batches.

Gaseous Waste Processing

The radioactive gaseous waste processing system would collect radioactive gaseous waste generated in the Reactor Facility. Normally, nonradioactive nonhazardous gases would be filtered, monitored, and released directly to the Reactor Facility's ventilation system. On receipt of a high radiation signal, these gases would be diverted to the gas waste compressor for processing. Low-level gaseous wastes would be held for temporary storage, allowing for radioactive decay, and released to the atmosphere through the Reactor Facility's ventilation system. All gaseous releases would comply with applicable Federal, state, and local regulations. The gas waste surge tanks would give the system a 1-year storage capacity. The spent filters would be transferred to the solid waste management system for packaging and disposal.

Liquid Waste Processing

The MHTGR liquid waste management system would dispose of treated liquids by recycling them for additional treatment, recycling for reuse to the plant, or discharging to a cooling tower blowdown basin, which would discharge to the one or more lined evaporation ponds (see Turbine Condenser Cooling system discussion in Section C.2.2.9). Treated liquid wastes would be monitored to ensure that levels of radioactivity and chemical concentrations are below acceptable limits before discharge.

The system would clean up activation products in the core auxiliary cooling water, Reactor Facility closed-loop cooling water, or spent fuel cooling system. Main and auxiliary circulator service systems, balance-of-plant equipment, and floor drains generally would contain a low level of radioactivity of variable conductivity and normally would be directed to a receiving tank. High-level radioactivity of variable conductivity (for example, from steam generator drains, helium purification system decontamination waste streams, and radioactive gas waste management system liquid effluents) normally would be directed to a separate receiving tank to facilitate analyses and processing.

Radioactive liquid wastes would be processed on the basis of contamination levels. Low-level wastes meeting predetermined limits would be discharged to the service waste system. Wastes above those limits would be shipped to the Idaho Chemical Processing Plant. Under normal operating conditions, the MHTGR Reactor Facility would generate no high-level liquid wastes.

Detergent waste, originating in the laundry and shower rooms or from radiochemistry laboratory rinse operations, would be directed to a receiving tank. After testing to ensure low activity, the holdup tank would be pumped through a cartridge filter to the cooling tower blowdown basin. The waste unsuitable for discharge would be directed to a third receiver tank in the Radioactive Waste Management Complex. Chemical waste originating from the laboratory drains typically is high in conductivity and has variable radioactivity content. This waste is collected in holdup tanks in the laboratory, and batches are neutralized before solidification.

All nonradioactive nonhazardous liquid wastes eventually would be either sent to the Sanitary Waste Treatment Plant or recycled for plant use. Liquid wastes would be separated as close to the source as possible. Most of the liquid nonradiological waste would be water.

If the water quality meets the requirements for release, the contents of the collection tanks would be discharged directly to the cooling tower blowdown basin. The contents would not be released to the surface or groundwater. Wastewater that does not meet discharge requirements would either be transferred to one of two decay tanks where the radioactivity would be allowed to decay, or treated by ion-exchange and filtration subsystems. Treated wastewater that meets discharge requirements would be discharged to the blowdown basin. Wastewater that does not meet discharge requirements would be mixed with grout and packaged for disposal within the sitewide waste management system.

Solid Waste Processing

The radioactive solid waste system would process radioactive high-conductivity waste solutions. These wastes would result from normal operations and maintenance of the radioactive

liquid waste system and from decontamination processes, radioactive waste system filters, spent resins from radioactive waste process demineralizers, and other miscellaneous low-level radioactive solids (e.g., rags, paper, and other components and equipment that have served their useful life and cannot be decontaminated).

Nonradiological solid waste would be separated into recyclable, combustible, noncombustible, and hazardous waste. Recyclable wastes would be segregated by type and removed by the appropriate service organization for off-site processing. Combustible wastes would be incinerated on-site. Noncombustible wastes would be compacted and strapped before shipment to the INEL landfill for burial. Combustible hazardous waste would be incinerated at the Waste Experimental Reduction Facility before stabilization and burial at the INEL landfill. Hazardous waste containing heavy metals would be packaged and sent to the Hazardous Waste Storage Facility. Very little nonradioactive hazardous solid waste would be generated by the MHTGR.

Hazardous and Mixed Waste Processing

All wastes would be classified according to Title 40, *Code of Federal Regulations*, Part 261 (40 CFR 261), "Identification and Listing of Hazardous Wastes." These wastes would be handled under procedures established in DOE Order 5480.2, *Hazardous and Radioactive Mixed Waste Management*.

At INEL, hazardous wastes would include oils, solvents, acids, and contaminated plastics, gloves, rag stock, and other materials associated with plant operation and maintenance. Collections and interim storage of such wastes would be needed. Wastes would be segregated into radioactive and nonradioactive hazardous materials. Disposal of nonradioactive hazardous wastes at MHTGR would comply with applicable DOE, Federal, state, and local regulations. Nonradioactive hazardous waste would be shipped to the Hazardous Waste Storage Facility for storage until sufficient containers accumulate for shipment to an approved off-site treatment, storage, and disposal facility.

Mixed wastes are considered radioactive hazardous wastes, as defined by the Resource Conservation and Recovery Act. Mixed waste would be transferred to the appropriate facility within the INEL sitewide waste management system. No off-site storage and disposal facilities are licensed to accept radioactive mixed waste, so off-site shipment is not currently a viable option.

Other Waste Processing

"Unregulated waste" would include trash, sludge from the blowdown pond, and treated sanitary wastewater. Such waste streams would be handled in compliance with all applicable DOE, Federal, state, and local requirements. Trash would be compacted at the MHTGR site and disposed of in the INEL sanitary landfill. Sludge from the blowdown pond would either be removed periodically or left until the program ends, when it would be buried at the sanitary landfill. Treated sanitary wastewater would be discharged on-site in compliance with appropriate DOE and Idaho state operating permits.

C.2.3 Fuel and Tritium-Target Fabrication

C.2.3.1 Facility Description

The Fuel Fabrication Facility and the tritium- and plutonium-target fabrication facilities would be located near the reactor within the same security area. The three fabrication facilities would share common resources for storage of the gases and chemicals, which would eliminate extensive piping runs. All facilities would comply with Nonreactor Safety Class 1 criteria (DOE Order 6430.1A, *General Design Criteria for Nuclear Facilities*).

The new Fuel Fabrication Facility, which would include facilities and equipment needed to produce fuel elements, would be 70 m by 46 m with an eave height of 9.1 m. The facility would be divided into general process areas, such as solvent extraction, kernel production, particle coating, rod molding, and scrap recovery; and nonprocess areas, including a lunchroom, office, toilets, and locker rooms.

The Tritium-Target Fabrication Facility would be a new 49-m by 30-m two-story structure with an eave height of 9 m. It would be divided into process and nonprocess areas.

C.2.3.2 Fuel and Target Description

The MHTGR fuel and target design is a hexagonal block containing cylindrical fuel rods and target elements. Fuel rods are fuel particle compacts that contain highly enriched uranium (93.15 wt% uranium-235) in the form of dicarbide as the fissile material. The fuel rods would be incorporated into hexagonal blocks machined from graphite logs (Figure C.9). Each graphite block is a right-regular prism, 0.792 m high with a 0.36-m hexagonal cross section across the flats. A lattice of parallel holes is drilled in the block to allow the coolant to pass. Other blind holes to accommodate fuel rods (approximately 1 cm in diameter by 4.9 cm long) are drilled from the top face of the block. A 5-cm-diameter center hole is used for handling the blocks. Two other holes in the graphite block accommodate targets.

The tritium-target material would be lithium aluminate (enriched by lithium-6) in the form of microsphere kernels, with a TRISO coating (Section C.2.3.3). The target would be sintered into annular, cylindrical compacts. A target element would consist of compacts stacked within an annular graphite sleeve (Figure C.10).

C.2.3.3 Process Description

Fuel Fabrication

Fuel fabrication would consist of five major steps: graphite block fabrication, fuel kernel fabrication, fuel particle coating, fuel particle compact (rod) fabrication, and fuel element assembly; and supporting processes, including scrap recovery, off-gas treatment, and waste treatment. For either tritium or plutonium production, fuel microspheres approximately 0.02 cm in diameter would be produced from highly enriched uranium in the form of uranium oxycarbide.

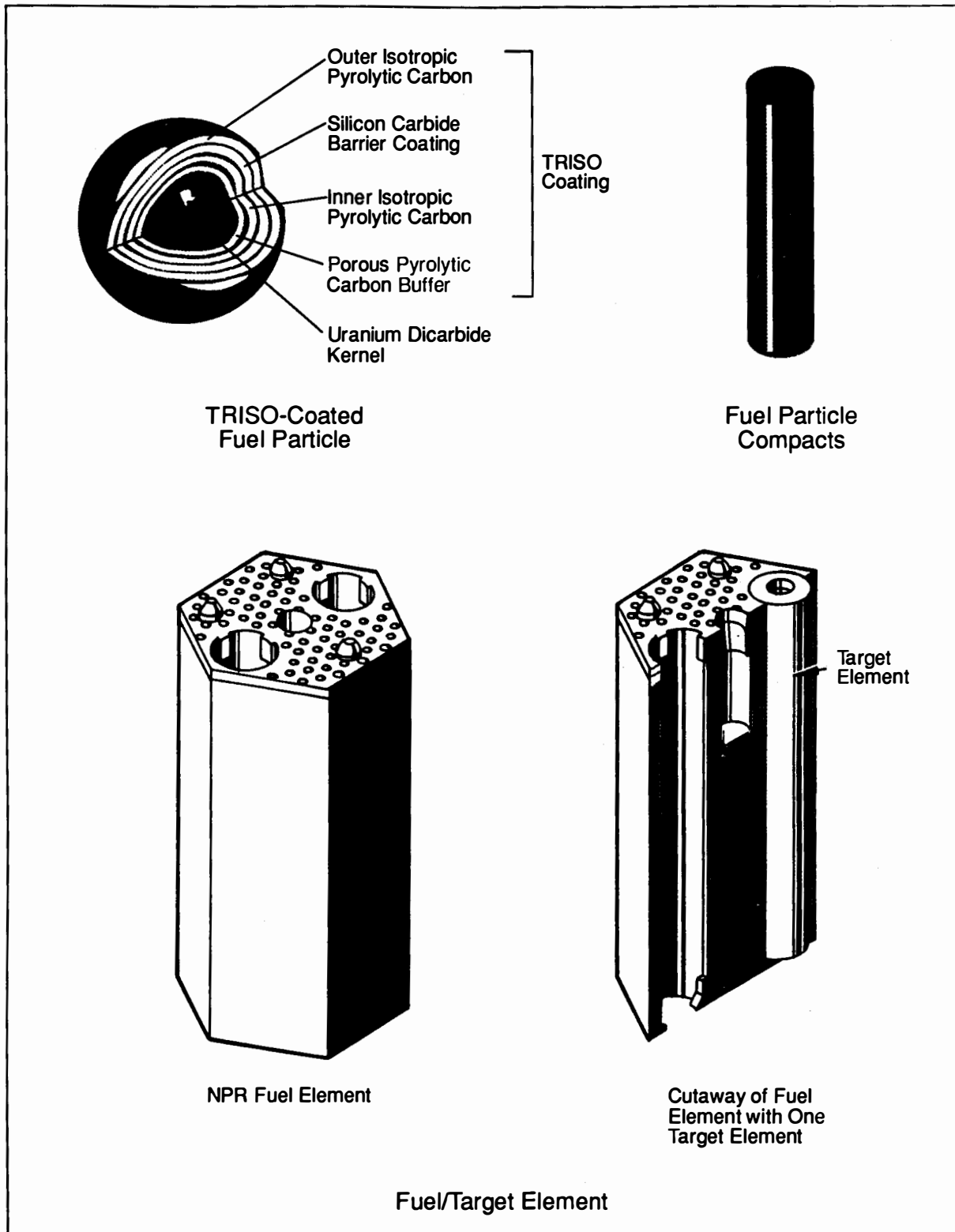


FIGURE C.9 MHTGR Standard Fuel and Tritium-Target Element (Source: Modified from EG&G 1989)

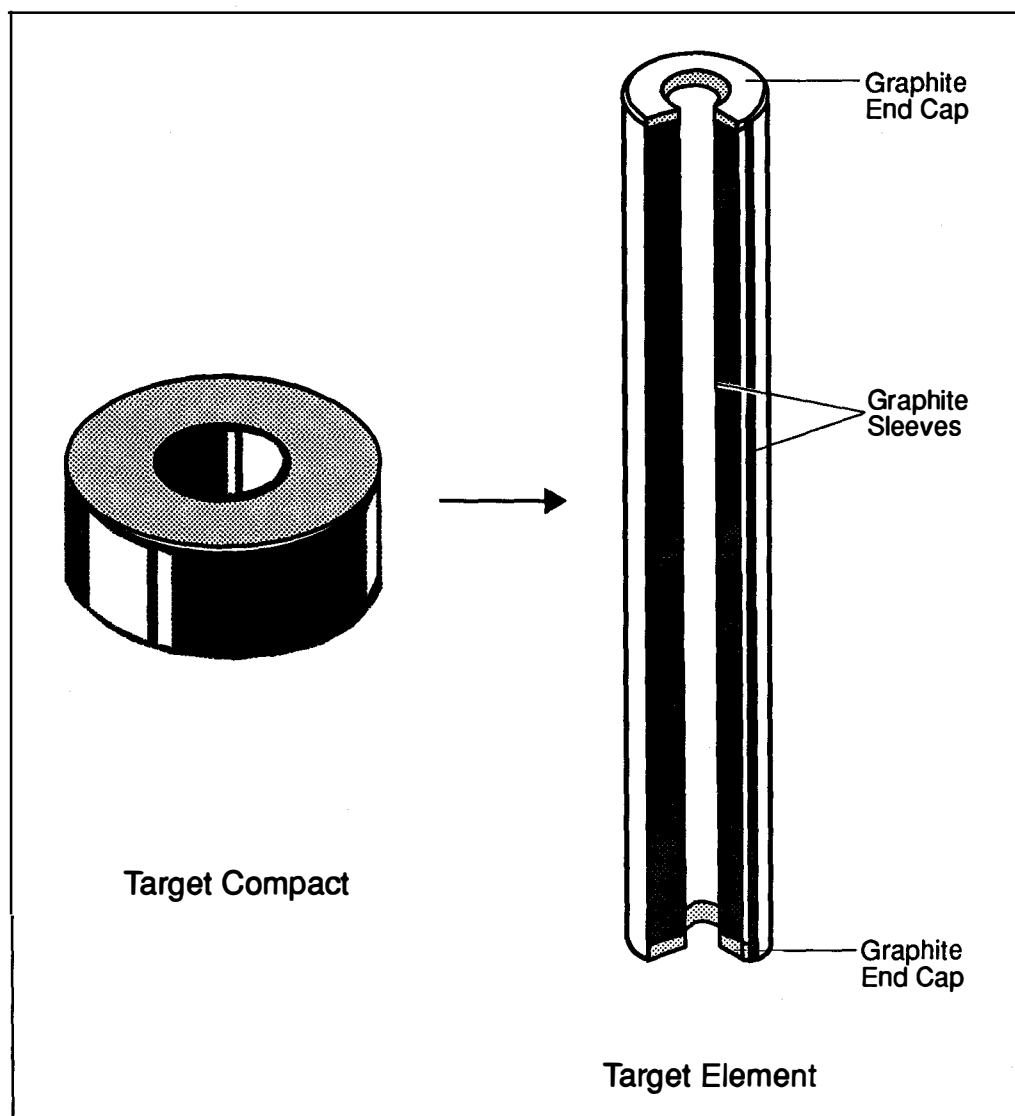


FIGURE C.10 Typical MHTGR Tritium-Target Element (Source: Modified from EG&G 1989)

Four coatings would be applied to the fuel kernels in high-temperature fluidized-bed coating furnaces: a low-density porous pyrolytic carbon (PyC) layer or buffer, an inner isotropic PyC layer, a silicon carbide (SiC) barrier coating, and an outer isotropic PyC coating. This coating configuration, called a TRISO coating, would form the primary barrier to fission product release from the fuel kernels. The coated fuel particle would be about 0.0725 cm in diameter.

A mixture of organic pitch, graphite filler powder, and coated fuel particles would be pressed into rods and sintered to form strong solid fuel compacts. The fuel compacts would have good irradiation stability and would be easy to assemble into the fuel element.

Fuel rods for fuel block loading would be stacked in tubes to the correct stack length, and the stacks would be inserted into graphite fuel element blocks. The power profile in the driver-fuel annulus is flattened by adjusting the position of the fuel rods. This is accomplished

by modest changes in the driver-fuel or the lithium-fuel target loading. After inspection, the fuel holes would be sealed with graphite plugs coated with sealing cement, and the fuel blocks would be cured. After curing, the fuel element would be inspected, packaged, and stored in the Fuel Storage Area for shipment to the reactor.

Vertical dowels would ensure proper alignment of coolant holes between elements in the reactor. The fueled portion of the reactor core would consist of 66 fuel columns, ten fuel elements high, formed into an annular active core configuration surrounded by graphite reflector blocks.

Material rejected from the fuel fabrication process would be recycled through a dry or wet recovery cycle. The dry recovery cycle would process and recycle all material containing uranium that meets metallic impurity limits. The wet recovery cycle would handle all material that needs to be dissolved and purified before recycle to meet metallic impurity level limits.

Tritium-Target Fabrication

The flow sheet for the tritium-target fabrication process is shown in Figure C.11. Feed lithium nitrate and alumina would be fabricated into lithium aluminate kernels about 500 μm in diameter. The lithium aluminate kernels would be contained in an impervious, multilayered TRISO coating that would be applied as described for fuel (see Fuel Fabrication discussion that precedes this section).

The nominal diameter of the TRISO-coated tritium-target particle would be 890 μm . The low-density PyC layer (the buffer coating) would be thicker in the tritium-target particles than in the fuel particles to accommodate the higher gas pressure generated during irradiation. The inner high-density PyC layer would also be thicker in the tritium-target particle designs because lithium aluminate kernels would be less stable than fuel kernels during exposure to high temperatures during SiC deposition. Defective particles generated during target manufacture could be reclaimed and recycled.

The TRISO-coated kernels would be bonded with a carbonaceous matrix and sintered into annular, cylindrical target compacts approximately 8.9 cm in diameter with a 3.6-cm inner diameter. Two target elements, formed by stacking target compacts within an annular graphite sleeve, would be placed in machined holes in each of the 660 prismatic fuel elements (Figure C.9) and in each of 60 reflector elements. Thus, each core would contain 1,440 target elements (11,520 targets in the eight modules). Tritium targets would be replaced every 6 months.

C.2.3.4 Process Effluents and Wastes

Fuel Fabrication

The coating and carbonization operations would produce off-gases that contain argon, hydrogen, organic compounds, and entrained soot particles. The off-gases would pass through an incinerator that burns the hydrogen and soot. Then the incinerator off-gases would be cooled, filtered, and monitored for uranium contamination before being discharged to the atmosphere.

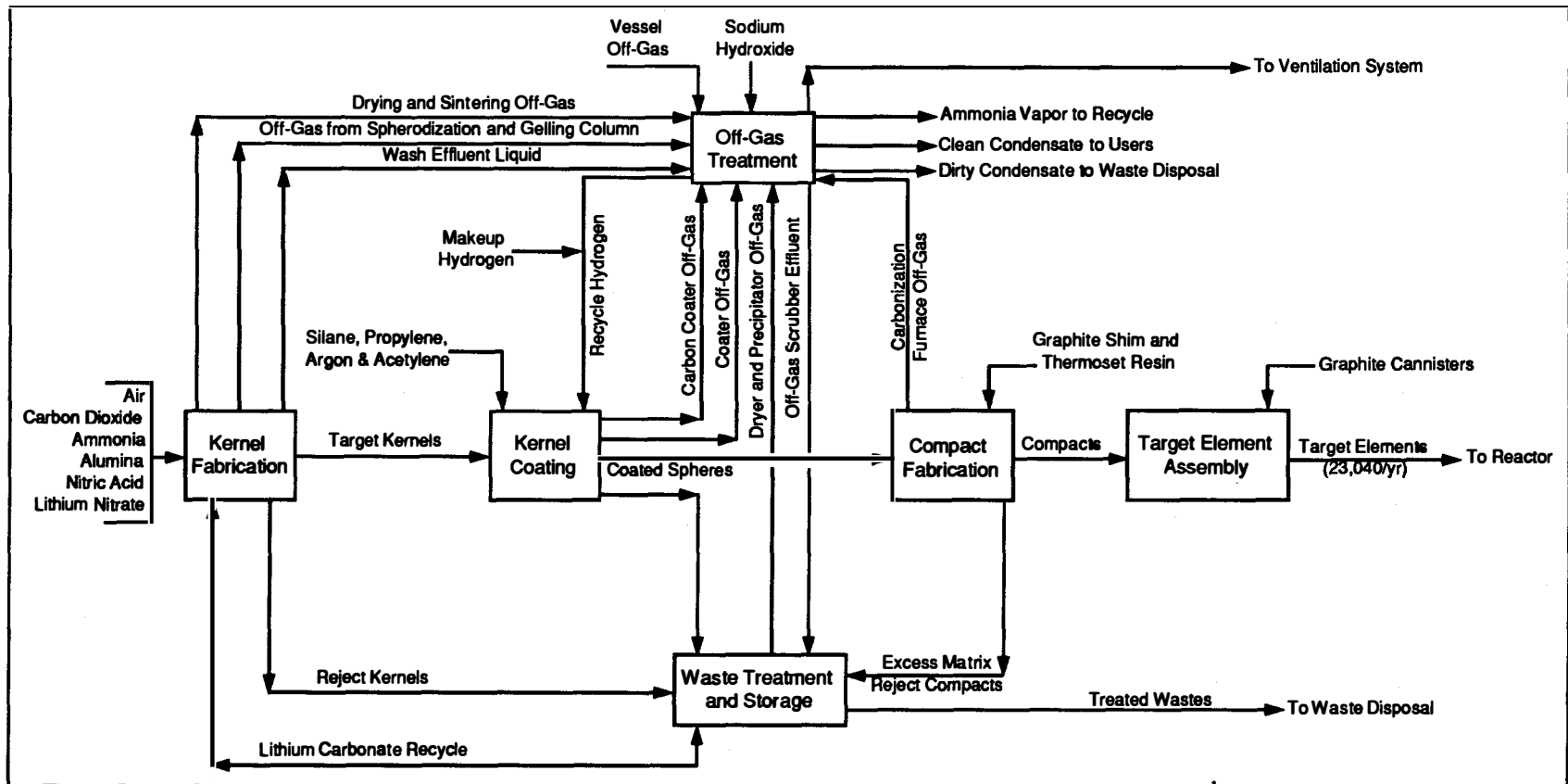


FIGURE C.11 Tritium-Target Fabrication Process at INEL (Source: Modified from EG&G 1989)

Off-gases from the SiC coating would contain hydrogen and hydrogen chloride (HCl). The HCl would be removed with a sodium hydroxide solution in a scrubber, and the hydrogen would be pumped to a surge storage tank for recycling to the coating operation.

Off-gases from dissolution and oxide production in scrap recovery would be scrubbed with water to remove nitrogen oxides (NO_x). The off-gases from both scrub operations would be discharged to the atmosphere. All gaseous releases from the off-gas systems would comply with applicable Federal, state, and local regulations. Acidic and basic solutions from various scrub columns would be sampled, blended in the waste mix tank, and transferred to the existing waste disposal system at the Idaho Chemical Processing Plant.

Low-uranium-content ash from the wet recovery cycle would be collected in an ash hopper and solidified in cement at a drumming station. The drum would be transferred to a cleaning station, where it would be surveyed for exterior contamination, decontaminated as required, and shipped to the Radioactive Waste Management Complex.

Miscellaneous low-level solid wastes, miscellaneous noncombustible solid wastes, and aqueous soot slurry residue from particle washing would be dried, assayed, and packaged for disposal; the drier off-gas would be vented to the atmosphere via the off-gas system; and off-gas filters would be compacted, assayed, and packaged for on-site burial. Miscellaneous noncombustible equipment components, parts, and tools would be decontaminated for reuse or reduced and compacted. The compacted waste would be packaged for disposal. Failed and scrapped equipment would be reduced and packaged for on-site disposal at the Radioactive Waste Management Complex.

Combustible solids (general manufacturing plant waste) would be sorted to remove noncombustibles and then fed to an incinerator. Off-gas from incineration would be quenched, scrubbed, filtered, and vented to the off-gas system. Ash residue would be removed from the incinerator, assayed, and packaged for disposal in the INEL Central Landfill.

Tritium-Target Fabrication

The off-gas stream from kernel fabrication would contain 33% ammonia in air. The ammonia would be recovered as a 12% ammonia solution in water in an ammonia absorber column. The off-gas from the kernel coating would be air with small amounts of carbon dioxide (CO_2) and traces of carbon monoxide (CO). These off-gases would be condensed, filtered, and combined with building exhaust air; refiltered; and monitored before being discharged to the atmosphere. Off-gases from the SiC coating could be treated, reclaimed, and recycled. All gaseous releases from the tritium-target fabrication off-gas systems would comply with applicable Federal, state, and local regulations. Liquid waste streams (condensate from knockout pots and bottoms from scrubber and distillation columns) would be routed to an existing low-level liquid disposal system at the Idaho Chemical Processing Plant.

Solid wastes (scrapped spheres from the sintering furnace, scrapped SiC-coated spheres, and recycle and waste burner residue) would be chemically characterized to determine if they are hazardous or nonhazardous wastes. Nonhazardous wastes would be disposed of at the INEL landfill; hazardous wastes would be stored at the Hazardous Waste Storage Facility before shipment to a licensed hazardous waste disposal site.

About 1 kg/d of sintered LiAl_5O_8 - LiAlO_2 spheres from the sintering operation and about 4 kg/d of SiC-coated spheres would be reject material. This material would be discarded because the recovery and recycle of spheres in this form would be difficult and not cost-effective. Burial in the INEL landfill should be a satisfactory disposal method because the material is inert. However, excess lithium carbonate from the precipitator would be recycled for future runs. The ash from burning rejected green compacts and excess matrix from the rod press machine also would be disposed of as nonhazardous solid waste in the INEL landfill.

C.2.4 Plutonium-239 Target Fabrication

C.2.4.1 Facility Description

The Plutonium-Target Fabrication Facility would be located with the other fabrication buildings within the same security area and would share common resources. The two-story facility would be a 76-m by 46-m reinforced-concrete structure with an eave height of 9 m. The layout would be similar to the Tritium-Target Fabrication Facility.

C.2.4.2 Target Description

The plutonium-239 target would contain depleted uranium (0.20 wt% uranium-235) in the form of uranium dioxide (UO_2) fuel kernels approximately 0.08 cm in diameter. These kernels would have a TRISO coating and would be mixed with graphite and formed into cylindrical compacts approximately 1.5 cm in diameter and 5.1 cm long, i.e., similar in size and shape to fuel rods.

C.2.4.3 Process Description

Plutonium-target compacts would be fabricated using essentially the same process used for fuel rods. Because of the frequency of replacement of the plutonium-target elements in the reactor core, the throughput of materials in the Plutonium-Target Fabrication Facility would be much higher than the throughput in the Fuel Fabrication Facility, assuming that all eight reactors operate in the plutonium production mode. For this reason, fabrication of plutonium-target elements must be highly automated to facilitate faster production.

The present design for plutonium targets requires a somewhat larger channel and the elimination of some fuel channels in each fuel block; otherwise, the fuel blocks would be identical in size and shape to the tritium-target fuel blocks. There would be 1,440 plutonium-target elements in a reactor module; 120 would be in the core outer reflector. The target would be internally cooled, with a space between the target and channel for mechanical clearance. The only additional requirement for plutonium-target operations would be a modest increase in biological shielding and target cooling in the handling of irradiated targets in the target transport casks.

Fuel loading would be different for plutonium production than for tritium production. At maximum uranium-238 target loading capability, the effective uranium-238 macroscopic cross section is much lower than the lithium-6 macroscopic cross section in the tritium production

design. Therefore, the driver-fuel element fissile loading would be reduced in the plutonium design option, and one-half, rather than one-third, of the driver-fuel blocks would be replaced each year. The plutonium-target elements would be replaced every 3 months to limit the buildup of plutonium-240 in the targets. For the plutonium-target fabrication process, reject material would be recycled by either a dry or a wet recovery cycle as in tritium-target fabrication.

C.2.4.4 Process Effluents and Wastes

Process effluents and wastes from plutonium-target fabrication would be similar to the process effluents and wastes from tritium-target fabrication and would be treated in the same way (Section C.2.3.4).

C.2.5 Spent Fuel Processing

For the purpose of this EIS, it is assumed that spent fuel would ultimately be disposed of in a Federal repository. Spent fuel processing is analyzed in this EIS as part of the original mission of NPR, which included the production of virgin plutonium-239. However, plutonium production is no longer part of the NPR proposed action. The Waste Management PEIS will assess the impacts of wastes from reprocessing of spent fuel from DOE reactors.

A new Headend Fuel Processing Facility at the Idaho Chemical Processing Plant would be needed to convert the MHTGR uranium carbide fuel to a uranyl nitrate solution that would be suitable for use as feed to the new Fuel Processing Facility. The Fuel Processing Facility is under construction at the Idaho Chemical Processing Plant and is expected to be completed by the mid-1990s whether or not the proposed reactor is constructed at INEL. The solution from the headend facility would be processed by solvent extraction to separate the enriched uranium from the fission products and then converted to a solid oxide in the new Fuel Processing Facility. Waste treatment systems at the Idaho Chemical Processing Plant would safely process the wastes, as required for interim storage and disposal. A block flow diagram of the facilities and processes is shown in Figure C.12.

C.2.5.1 Facility Description

Headend Fuel Processing

The MHTGR Headend Fuel Processing Facility, which would be designed to Nonreactor Safety Class 1 criteria (DOE Order 6430.1A, *General Design Criteria for Nuclear Facilities*), would be about 26 m by 76 m by 24 m high with 18 m of the structure below grade. The main processing system, which handles the irradiated fuel, would be below grade within shielded cells to provide radiation protection for personnel. The layout for this level is shown in the reference document (EG&G 1989).

The facility would contain equipment for fuel block receiving, handling, storage, and headend processing (fuel rod separation through dissolution and dissolver product clarification

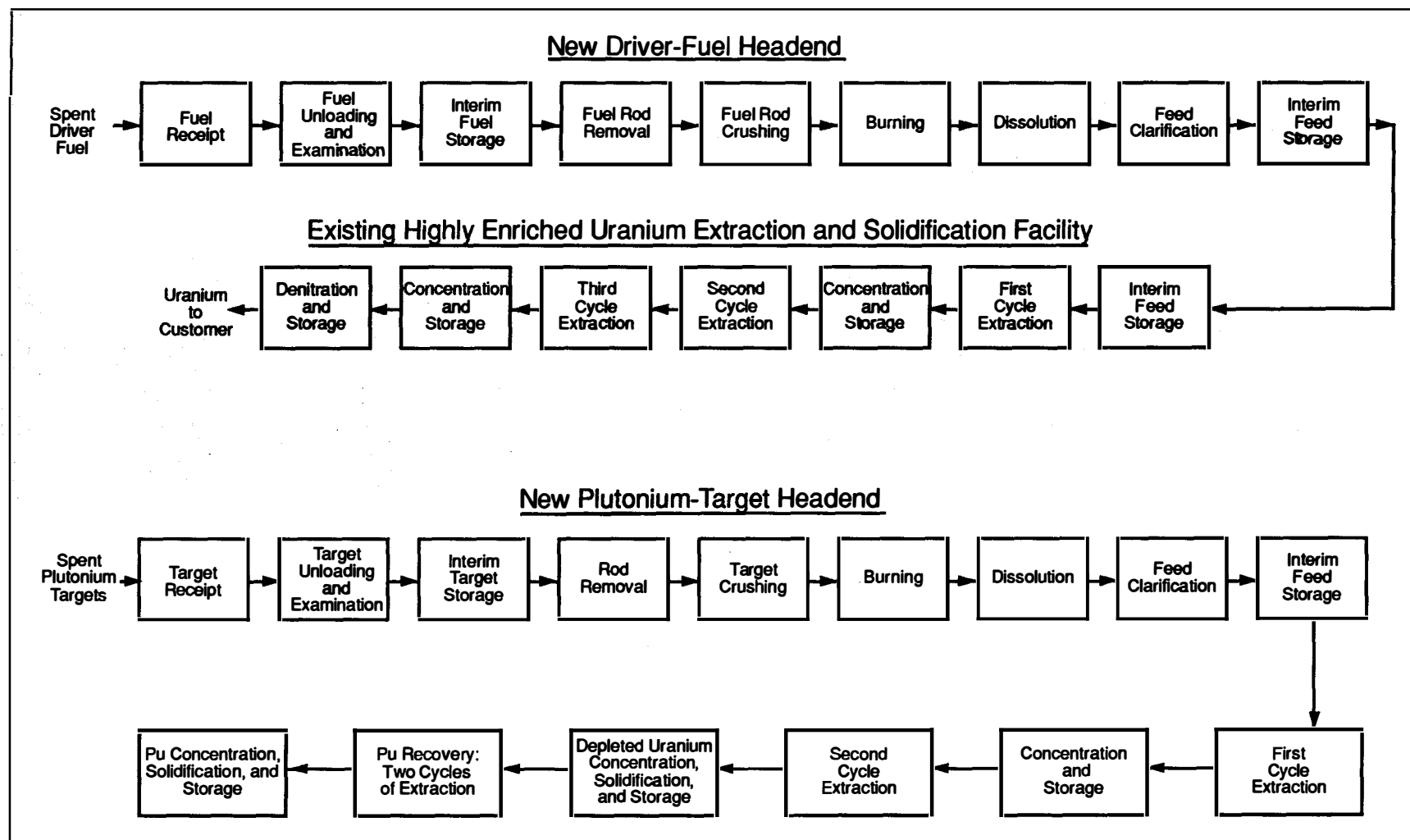


FIGURE C.12 MHTGR Fuel/Plutonium-Target Processing at INEL (Source: Modified from EG&G 1989)

and storage). It would also contain several shielded cells supported by remote-handling and equipment replacement capabilities. Support equipment that does not contain radioactive material would be located in the area contiguous to the shielded hot cells. Nine shielded hot cells would be needed for the headend fuel processing and support functions. Cell designations and major processing or support functions are as follows:

- Cell 1, fuel receipt and transfer;
- Cell 2, fuel storage and disassembly (removal of fuel compacts from the fuel elements);
- Cell 3, crusher and burner;
- Cell 4, dissolver and feed clarification;
- Cell 5, dissolver product storage;
- Cell 6, off-gas treatment;
- Cell 7, decontamination and maintenance for wall-mounted manipulator;
- Cell 8, valve and mechanical equipment corridor; and
- Cell 9, decontamination and maintenance.

The Headend Fuel Processing Facility would be able to process about 10 fuel blocks per day. The facility would be designed to comply with DOE Order 6430.1A, *General Design Criteria for Nuclear Facilities*, and would meet as-low-as reasonably-achievable principles and provide for criticality safety.

Fuel Processing

The Fuel Processing Facility now being constructed would be used for spent fuel processing. The five-level structure will have three levels below grade and two levels above grade and will meet Nonreactor Safety Class 1 criteria (DOE Order 6430.1A, *General Design Criteria for Nuclear Facilities*). The below-grade levels will be cast-in-place, reinforced-concrete structures containing the processing cells; the above-grade levels will be steel superstructure. Other above-grade areas will also be cast-in-place, reinforced-concrete structures to protect personnel and environs from radioactivity, to withstand the natural effects of natural phenomena, and to ensure adequate safeguards. The rectangular facility will be approximately 65.5 m by 75.6 m above grade and 54.90 m by 75.6 m below grade.

The inner core, which will contain all radioactive systems and processes, will be entirely below grade. It will consist of cells containing the processing equipment and piping. The cells will be shielded and accessed only through removable ceiling hatches or through cell access airlocks at the lowest level. The north side of the structure will include a full-length, full-height pump-and-valve corridor, with shielding windows and remote maintenance equipment. The

central control room, processing makeup area, instrumentation corridor, mechanical equipment rooms, electrical equipment rooms, offices, and other support areas will be on the upper levels.

C.2.5.2 Process Description

Headend Fuel Processing

The primary purpose of the Headend Fuel Processing Facility would be to produce a suitable uranyl nitrate solution, which contains the residual uranium, fission products, and transuranics from discharged MHTGR driver fuels, for feed to existing separations processes. The steps used in headend fuel processing are described in the following.

Spent fuel would be loaded into shielded casks and transported by truck from the reactor Fuel Storage Area to the headend facility, where they would be placed in the cask transfer cell. Once in the cask transfer cell, the fuel blocks would be unloaded from the cask and remotely transferred to Cell 2 for inspection and interim storage and, eventually, for rod separation.

Spent fuel blocks would be transferred from the interim storage area to the disassembly table in Cell 2 where the rods would be pushed out of the channels, collected, and placed in interim storage to await transfer to Cell 3. Empty fuel blocks would be transferred to Cell 9 for monitoring, surface decontamination, and packaging for disposal.

Fuel rods would be crushed using a two-stage rod crushing module. The rod crushing module would reduce the fuel rods to material composed mainly of small graphite particles and SiC particle coatings broken to expose the inner carbon coatings and fuel kernel. Products from the crushing system would be pneumatically transferred to the crushed rod surge storage bunkers located by the burner in Cell 3.

A batch-operated fluidized-bed burner would burn off the matrix and coating carbon and convert heavy metals and fission products to their respective oxides. Following burning, the ash would be gravity discharged and packaged in dissolvable canisters for transfer to Cell 4. Off-gas would exit the burner through several sintered metal filters located in a disengaging plenum on top of the burner. Fine material collected on the filters would be returned to the fluidized bed by periodic blowback of the filters with compressed air. Semivolatile fission products in off-gas leaving the burner would be removed, processed through the dissolver and its associated solids removal and drying system, and combined with other fission products and heavy metal in the dissolver supernate sent to separations processing.

Burner ash packaged in thin-walled, dissolvable containers would be charged to a batch-operated dissolver and dissolved in a mixture of fresh and recycled nitric acid. The undissolved solids (mainly SiC hulls, small amounts of unburned carbon, and, possibly, traces of undissolved fission products) would be separated from the dissolver solution by vertical, continuous, solid-bowl centrifuges. Supernate from the primary centrifuge would be transferred to surge storage to await separation processing at the Fuel Processing Facility. Solids containing more than the prescribed level of uranium would be recycled through the dissolver.

All major processing equipment would be designed for remote maintenance and replacement. Major maintenance and repair work would be accomplished following removal of equipment to the decontamination cell. All pneumatic transfers would be accomplished by a vacuum, with the blowers located on the filtered side of the collection vessel. Contaminated slurry would be transferred using simple and reliable steam jets. Clarified solutions would be transferred by remotely replaceable canned pumps.

Fuel Processing

The Fuel Processing Facility would process uranyl nitrate feed solutions from the MHTGR fuel processing headend and from other existing INEL facilities. Feed solution from the fuel processing headend would amount to about 1.4% of the total feed to the Fuel Processing Facility. The process would produce a concentrated uranyl nitrate solution, essentially free of fission products and cladding materials, and then convert this solution to uranium trioxide (UO_3) powder. A simplified functional block flow diagram for the process is included in Figure C.12.

The feed would be received in batches, stored in criticality safe slab tanks, and fed into the first-cycle feed tank. From the tank, the feed would flow in a continuous, controlled manner to the three-cycle solvent extraction system. Each cycle would contain columns for extraction, scrubbing, and stripping (back extraction). The uranium would be extracted into tributyl phosphate, scrubbed, and stripped into an aqueous solution. The first and third cycles would each have a wash column to remove dissolved organics from the product stream. The three extraction cycles, with intercycle evaporators, would increase the uranium concentration by a factor of about 540 and reduce the fission products in the product solution to negligible amounts.

Denitration would convert the aqueous uranium solution from the solvent extraction process to solid UO_3 by spraying the atomized third-cycle product into a heated fluidized bed. The spray droplets would be evaporated, and the residue would be decomposed to solid UO_3 . The UO_3 would be collected, packaged, and stored in a secured vault in the Fuel Processing Facility until it was shipped off-site.

C.2.5.3 Process Effluents and Wastes

Headend Fuel Processing

Gaseous releases would include the process off-gases and potential releases from the heating, ventilating, and air conditioning (HVAC) exhaust air. Volatile releases in the process off-gas would include krypton, iodine, hydrogen-3, ruthenium, and some chemical compounds (e.g., NO_x). Process off-gases would be treated via an extensive cleanup system that removes particulates and volatile contamination to levels that comply with applicable Federal, state, and local regulations. The cleanup system would produce low-level solid wastes that would be mixed with grout, placed in drums, and disposed of on-site. The HVAC supply and exhaust air for the process cells would pass through high-efficiency particulate air (HEPA) filters at the cell inlets and outlets. The HVAC exhaust air would be combined with the cleaned process off-gases and would pass through two more stages of HEPA filtration before being exhausted to the atmosphere via the facility stack. Backup HEPA filtration plenums on the HVAC exhaust system

are maintained in ready standby to ensure safe operating conditions. State-of-the-art sampling and monitoring equipment would also help maintain safe operating conditions.

Contaminated liquid wastes would be generated by decontamination of the process cells, support equipment, SiC hulls, empty fuel blocks, and HEPA filters. These solutions would be transferred to existing waste treatment and disposal systems. Nonradioactive hazardous wastes would include chemical solutions that would be solidified and shipped off-site for final disposal.

Radioactive solid waste from headend operations would include used graphite fuel blocks, failed processing equipment, acid-leached and dried HEPA filters, contaminated packaging and clothing, grout containing SiC hulls and CaCO_3 , and other items. These wastes would be conditioned to reduce their volume, packaged to reduce the risk of contamination, and sent to the INEL Radioactive Waste Management Complex for further treatment, storage, or shipment off-site. Most of the nonradioactive solid waste generated would be office trash and shipping containers. These wastes would be disposed of in the INEL landfill. All packaged material would be monitored before shipment.

Fuel Processing

Radioactive gaseous wastes would mainly result from ventilation flows used for contamination control. Traces of iodine-129, hydrogen-3, and other radionuclides dissolved in the feed solutions would volatilize and be present in the vessel off-gas. Primary contamination control would be provided by the cleanup system. Secondary contamination control would be achieved by housing the equipment in cells and using a series of pressure drops, with the final exhaust air flowing through HEPA filters to remove contamination. After cleanup to remove particulates and condensibles, the exhaust air would be combined with the ventilation air and released to the atmosphere in compliance with all applicable Federal, state, and local requirements. The stack monitoring system would continuously sample ventilation air to monitor particulates and such radionuclides as tritium, antimony-125, carbon-14, and iodine-129.

Liquid wastes would mainly result from the removal of fission products, neutron poisons, and dissolved cladding materials from the feed uranyl nitrate solution. Cleanup and decontamination procedures would also generate radioactive liquid wastes.

Radioactive high-level liquid waste, except the first-cycle aqueous raffinate, would be concentrated before being discharged to the tank farm. The first-cycle aqueous raffinate would be sent directly to the tank farm without concentration.

The various low-level liquid waste streams would be discharged to headers leading to geometrically favorable slab tanks. The liquid waste would be sampled for uranium content. Liquid wastes containing less than disposable limits for uranium would be sent to the process waste header. Liquid wastes containing more than disposable limits for uranium would be sent to the uranium salvage header. Depending on the potential for contamination of the liquid waste stream with uranium, a route would be provided for recycle.

The solvent waste system would handle organic waste from various sources. Organic waste would be collected in slab tanks and sampled for uranium. Decanted waste kerosene would be separated and sampled for uranium. If the uranium concentration is less than disposable limits, organics or kerosene would be transferred to the kerosene waste tank and,

after sampling, would be sent to the existing Organic Disposal Facility, where it would be used as fuel in the New Waste Calcining Facility.

Other nonradioactive liquid waste (e.g., steam condensate, wastes from corridor and floor drains, and waste from the evaporators) would be assayed for radioactivity and hazardous wastes, segregated, and treated to meet DOE limits. Uncontaminated wastes or wastes within established limits would be discharged to the Idaho Chemical Processing Plant service waste system. Hazardous waste would be treated and stored within the INEL sitewide waste management system (Section C.2.9). Service waste would be discharged to one of two existing evaporation ponds. Sanitary wastes, which do not include safety shower effluents from processing areas, would be processed in the Sewage Treatment Facility. Chemical wastes (spilled chemicals and excess makeup chemicals) would be packaged and shipped off-site for disposal until a chemical disposal facility becomes available.

Radioactive solid waste would mainly consist of either contaminated equipment that has served its useful life or failed equipment that cannot be economically repaired for reuse. Other radioactive solid waste would include used HEPA filters (with accumulated particulate radionuclides), disposable clothing, plastic, tape, and materials used in radiation work areas. Items would be sorted and classified as compactible, combustible, or noncompactible. After sorting and packaging, the waste would be transferred to the Radioactive Waste Management Complex for storage and disposal.

Transuranic waste would be classified as contact handled (the dose rate at the container surface is less than 200 mrem/h) or remote handled (the dose rate at the container surface is greater than 200 mrem/h). After classification, it would be sent to the Radioactive Waste Management Complex for further treatment, storage, or shipment to the Waste Isolation Pilot Plant or another appropriate facility.

Combustible waste would be incinerated at the Waste Experimental Reduction Facility. Nonradioactive solid waste (mainly office trash and chemical and material shipping containers) would be compacted and disposed of at the INEL landfill.

C.2.6 Tritium-Target Processing

C.2.6.1 Facility Description

The Tritium-Target Processing Facility would receive irradiated tritium-target elements from the reactor, process the targets to extract the tritium, and package and store the tritium for shipment to SRS facilities. The facility, which would be constructed in the reactor complex to facilitate receipt of the targets, would be designed to Nonreactor Safety Class 1 criteria (DOE Order 6430.1A, *General Design Criteria for Nuclear Facilities*). The two-story building would be 49 m by 24 m by 21 m high with 7 m below grade. Approximately 35% of the building would be devoted to waste treatment. Tritium purification would be conducted in nitrogen-blanketed gloveboxes. Processing support functions would be conducted near the hot cell. General support areas would include an equipment decontamination room, space for electrical and mechanical equipment, and a control room. The facility would operate 5 days a week and three shifts per day.

C.2.6.2 Process Description

The tritium-target process would include target crushing, vacuum treatment, oxidation, diffusion, and distillation. A simplified tritium-target processing flow sheet is shown in Figure C.13. The target crushing and tritium extraction system would crush the target elements and rupture the target particles, exposing the tritium-bearing kernels. While some tritium would be released by the crushing operation, the balance would be released by heating the crushed material in a vacuum furnace. The released tritium and associated gases would be sent to the tritium recovery system for separation of the tritium (Section A.2.6). After tritium extraction, the crushed residue would be pneumatically removed from the extraction furnace using nitrogen. When the system is verified as leaktight and evacuated, the tritium storage beds would be heated, and the purified tritium would be collected on the cooled hydride bed of one of the two product containers. The container would then be sealed and prepared for shipment to SRS.

C.2.6.3 Process Effluents and Wastes

No particulate radioactive releases are expected from the Tritium-Target Processing Facility. The materials handled in the process plus the thorough treatment of off-gas streams would ensure that if radioactive particulates were released, they would not be significant.

Gaseous effluents from tritium processing would include a purge air from the hot-cell detritiation system, regeneration N_2 and treated off-gases from the tritium recovery system, and ventilation air. All streams would be continuously monitored and filtered through HEPA filters to ensure that radioactivity releases are as low as reasonably achievable. The cell detritiation system would clean any tritium released to a cell. The only gaseous radioactive releases from the Tritium-Target Processing Facility would be tritium, either as elemental tritium or tritiated water. The total estimated release of tritium is discussed in Appendix H.

Nonradioactive gaseous waste would be monitored and exhausted through one-stage HEPA filters. All gaseous releases from tritium-target processing would comply with applicable Federal, state, and local regulations.

Liquid low-level wastes would include mop water, water from equipment decontamination, and glassware cleaning solutions. The liquid wastes would be mixed with kieselguhr and cement in steel drums, which would be sent to the Radioactive Waste Management Complex.

Liquid high-level wastes would include pump oil, water from gas stream driers, and waste liquids generated from any other "hot" process. The liquid wastes would be either transferred for packaging and disposal by double-wall transfer lines or delivered in individual containers. The liquid would be mixed, sampled, and assayed for tritium content, using an in-line calorimeter. Water containing sufficient concentrations of tritium for recovery would be decanted and filtered, and after removal of the organics, it would be calorimetered, packaged, and shipped to the Tritium Purification Facility. Batches of high-level wastewater with lower levels of tritium would be solidified by mixing with cement in drums, and the drums would be sent to the Radioactive Waste Management Complex.

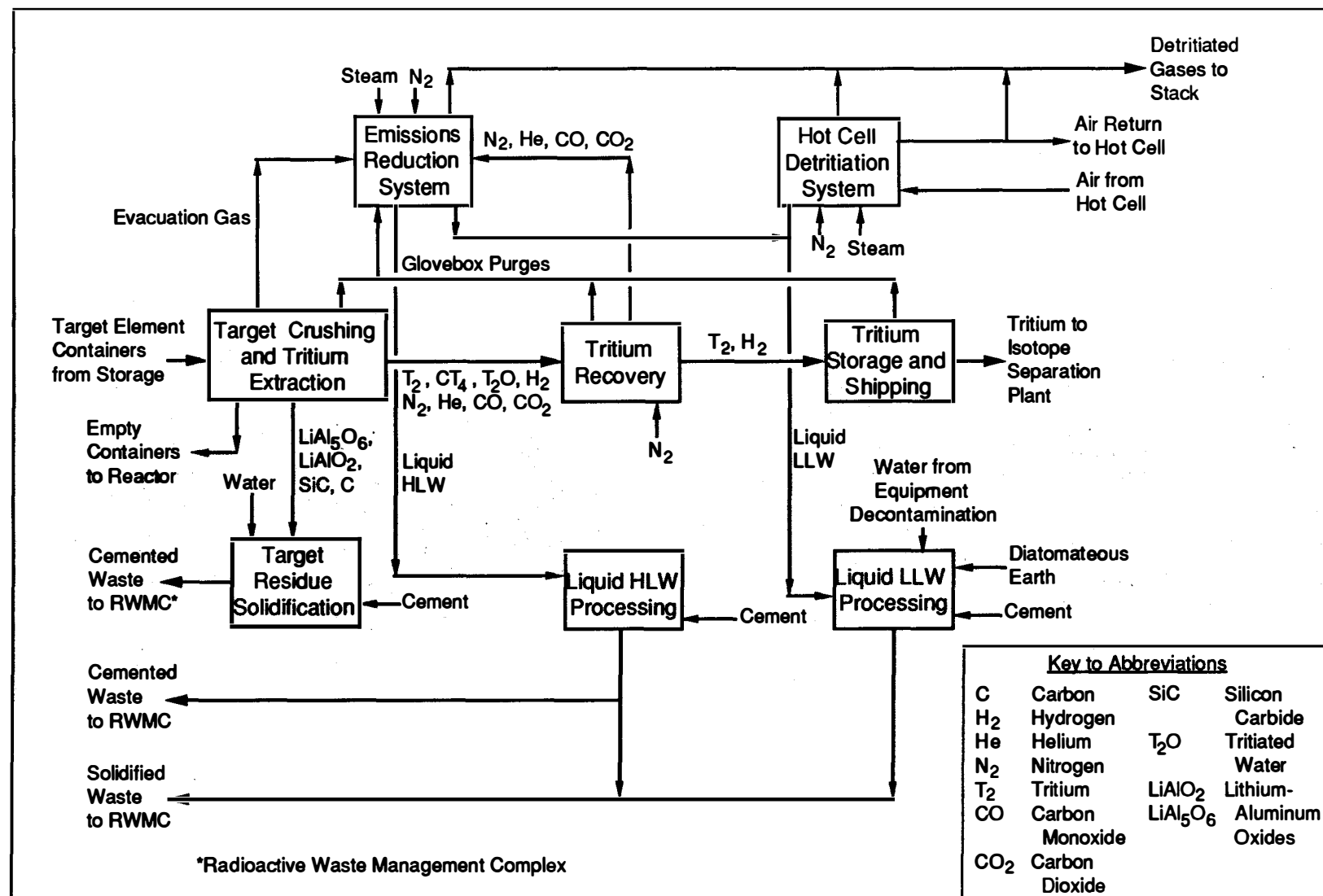


FIGURE C.13 Tritium-Target Processing at INEL (Source: Modified from EG&G 1989)

Batches of oil would be solidified by using attapulgite clay as an absorbant in a 0.10-m³ drum liner. The drum liner would be placed in a 0.11-m³ open-head drum, the space between the liner and the drum would be filled with nonhardening asphalt, and the drum lid would be bolted in place. The package would then be placed in a 0.21-m³ steel drum, the void volume would be filled with asphalt, and the lid would be bolted in place. The drums would be sent to the Mixed Waste Storage Facility to await disposal at a RCRA-approved facility.

Solid residue from the extraction furnaces would consist of carbon, lithium aluminate, and SiC hulls. The residue would be assayed, solidified, and packaged for transfer and disposal at the Radioactive Waste Management Complex. Other radioactive solid wastes would consist of such items as failed plant equipment, gloves, shoe covers, bubble suits, boots, tape, polyvinyl chloride materials, mops, glassware, and spent HEPA filters. These items would be sorted as compactible, combustible, or noncompactible. Compactible waste would be compressed into disposal drums using a hydraulically driven trash compactor. After packaging, the waste would be transferred to the Radioactive Waste Management Complex for storage and ultimate disposal. Combustible waste would be incinerated at the Waste Experimental Reduction Facility.

Nonradioactive solid waste (e.g., office trash and empty chemical shipping containers) would be disposed of at the INEL landfill. Nonradioactive liquid wastes would be monitored and then discharged to the sanitary sewage system. Shower and lavatory wastewater would also be sent to the sanitary sewage system.

C.2.7 Fuel/Plutonium-Target Processing

At INEL, MHTGR plutonium-target elements would be processed in a new facility at the Idaho Chemical Processing Plant. The facility would process about 180 target elements per day, 300 days per year.

C.2.7.1 Facility Description

Equipment for plutonium-target processing would be housed in a structure designed to Nonreactor Safety Class 1 criteria (DOE Order 6430.1A, *General Design Criteria for Nuclear Facilities*). The facility would contain several shielded cells supported by remote-handling and replacement capabilities. With few exceptions, the shielded process cells would be located below grade. Irradiated targets would be handled in shielded cells to provide radiation protection for personnel. Support equipment that does not contain radioactive material would be in areas contiguous to the hot cells. The facility layout would be similar, but not identical, to the proposed headend facility. Additional space would be needed to accommodate the increased processing throughput and for plutonium recovery equipment and operations.

The facility would have six major areas for processing: target receiving and storage, target crushing and burning, uranium recovery, plutonium recovery, plutonium-oxide-to-metal conversion, and low-level waste collection and conversion. The areas would be supported by typical balance-of-plant features such as uranium and plutonium salvage, solvent cleanup, utilities, waste disposal, chemical makeup, nitric acid regeneration and recycle, remote maintenance, analytical support, and remote decontamination facilities.

C.2.7.2 Process Description

Plutonium-target elements removed from the fuel blocks at the reactor complex would be canned and shipped to the Plutonium-Target Processing Facility. Sufficient storage for 30 days of plutonium production at eight MHTGR modules would be provided.

A flow diagram of plutonium-target processing is included in Figure C.12. Plutonium and uranium would be recovered as follows. The target element and the target particles would be crushed. As the SiC particles are fractured, the internal matrix of carbon, uranium oxide (UO_2), and plutonium oxide (PuO_2) would be exposed to high-temperature fluidizing gases. The carbon would burn to CO_2 , and the UO_2 would convert to U_3O_8 . The bed temperature would convert most of the PuO_2 to a high-fired form. The fluidizing gases would carry the uranium and plutonium particulates out of the bed; the more massive and fractured SiC hulls would remain in the bed. At the end of the burning cycle, the elutriated uranium, plutonium, fission product oxides, and some residual carbon would be transferred to a uranium dissolver.

The depleted uranium would be separated from the plutonium during a nitric acid dissolution of the burner ash; the high-fired PuO_2 is relatively insoluble in nitric acid. The uranium would be purified through two tributyl phosphate extraction cycles and would be converted to UO_3 in a fluidized-bed denitrator (or calciner). The plutonium-bearing sludge from the ash dissolver would be transferred for the silver-catalyzed dissolution of high-fired PuO_2 . The resulting solution would pass through two Plutonium-Uranium Extraction (PUREX) process cycles for plutonium purification. The plutonium product would be concentrated, converted to PuO_2 in a second denitrator, and subsequently converted to metal. The UO_3 granular product would be stored until shipment to the Plutonium-Target Fabrication Facility. The plutonium metal would be shipped to the Rocky Flats Plant in Golden, Colorado.

C.2.7.3 Process Effluents and Wastes

The principal radioactive gaseous fission product releases would be krypton-85. Other fission product releases would be limited to traces not captured by upstream removal processes and submicron particulate filters.

The off-gas and ventilation air would be discharged through double HEPA filters, continuously monitored for radioactivity, and discharged to the atmosphere through the stack in compliance with applicable Federal, state, and local regulations. Releases of NO_x from uranium denitration would be minimized by treatment, monitored, and discharged to the atmosphere through the stack. All gaseous releases from plutonium-target processing would comply with applicable Federal, state, and local regulations.

Most radioactive liquid wastes would be high-level waste from the first-cycle extraction system. These wastes would be transferred to the Idaho Chemical Processing Plant tank farm to await further treatment.

Low-level aqueous wastes would appear in the downstream recovery cycle, with smaller amounts from decontamination activities. These wastes would be accumulated, sampled, and concentrated in a thermosystem evaporator. Concentrated aqueous wastes would be sent to the Idaho Chemical Processing Plant tank farm to await calcination in the New Waste Calcining Facility.

Process-related nonradioactive aqueous wastes would be disposed of in a future lined evaporation pond. Traces of radioactivity and hazardous components contained in evaporator condensate would be discharged routinely to the service waste stream.

The burner bed (mostly silicon carbide) would be transferred to a grouting system for disposal as solid waste. The semivolatile fission products would be trapped (adsorbed) by a relatively cooler fluidized bed. Noble gases would be released to the atmosphere in compliance with applicable Federal, state, and local regulations. Carbon-14 released during burning would be removed from the burner off-gas by calcium hydroxide; the resulting calcium carbonate slurry would be transferred to a grouting system for disposal. Iodine would not need to be removed because the plutonium targets would be processed after the short-lived iodine isotopes have decayed.

Radioactive undissolved solids would accumulate from several sources, including calcium carbonate from the carbon-14 scrubber, particulates (hulls) from the secondary burner, sludge from dissolvers, and miscellaneous contaminated paper goods and equipment. Solid waste would mainly be grout from calcium carbonate, produced during the removal of carbon-14. Radioactive solid waste would be sent to the Radioactive Waste Management Complex.

Nonradioactive solid releases would mainly be compactible solids such as paper, boxes, service waste, and gases. In general, the solids would be compacted and sent to the waste burial ground. Small amounts of chemical solid wastes would be disposed of, using existing cold chemical waste disposal procedures.

C.2.8 Plant Operation

The resource requirements for normal operation of the MHTGR and its support facilities are summarized in Table C.3. Additional details are given in the following sections.

C.2.8.1 Energy Requirements

All electricity required by the facility would be supplied from the MHTGR turbine generators, except when the generators are bypassed or when the reactor is shut down. When the turbine generators are shut down and all eight reactor modules are operating, the requirement for electricity would be 80 MW. The 80-MW load would be supplied from the INEL grid, which would need to be upgraded to supply the MHTGR. The major users of electricity would be the helium circulators, the boiler feed pump, circulating water pumps, and heating. Electricity would also be used for space heating and auxiliary heating.

Fossil energy would be needed for four or more emergency standby diesel generators (or gas turbines), with a total capacity of approximately 10 MWe. These generators would require approximately 130 m³/yr of No. 2 diesel oil, assuming each generator would operate 2 h/month to verify system operability. The annual estimated requirements for utilities (air, water, diesel fuel, steam, and electricity) for normal operation of MHTGR fuel cycle facilities, which are much less than for the reactor, can be found in Chapter 5 of an EG&G report (EG&G 1989).

TABLE C.3 Estimated Annual Commodity Requirements for Operation of the MHTGR Complex

Commodity	Unit	Hanford		INEL		SRS	
		Tritium Mode	Plutonium Mode	Tritium Mode	Plutonium Mode	Tritium Mode	Plutonium Mode
Energy							
Electric	MWh	600,000	600,000	600,000	600,000	600,000	600,000
Fuel (diesel, gasoline, kerosene)	L	231,000	394,000	200,000	200,000	291,000	382,000
Steam	kg	1.17×10^7	1.23×10^8	5.00×10^6	3.49×10^8	5.00×10^6	3.50×10^8
Steam, coal	t	530	3,530	Electric	Electric	14,400	48,500
Materials							
Metals							
HEU ^a as U ₃ O ₈ (93.1% U-235)	t	2.17	2.27	2.17	2.27	2.17	2.27
DU ^b as U ₃ O ₈ (0.2% U-235)	t	0	720	0	720	0	720
Lithium nitrate (Li-6 enriched)	t	3.40	0	3.40	0	3.40	0
Aluminum oxide	t	5	0	5	0	5	0
Carbon power	t	0.40	104	0.40	104	0.40	104
Graphite blocks	t	176	264	176	264	176	264
Graphite canisters	t	116	0	116	0	116	0
Graphite granules	t	32.50	3.50	32.50	3.50	32.50	3.50
Chemicals/cleaners/dissolvers							
Attapulgate clay	t	10	0	10	0	10	0
Asphalt	t	10	0	10	0	10	0
Betz 2020	L	375,000	375,000	375,000	375,000	375,000	375,000
Betz 2040	t	680	680	680	680	680	680
Betz 3612	L	17,000	17,000	17,000	17,000	17,000	17,000
Betz C-77-P	t	3.86	3.86	3.86	3.86	3.86	3.86
Calcium hydroxide	t	320	2,470	320	2,470	320	2,470
Calcium oxide	t	104	212	106	212	113	212
Decontamination solutions	L	74,500	174,000	78,100	178,000	73,700	174,000

TABLE C.3 (Cont'd)

Commodity	Unit	Hanford		INEL		SRS	
		Tritium Mode	Plutonium Mode	Tritium Mode	Plutonium Mode	Tritium Mode	Plutonium Mode
Chemicals/cleaners/ dissolvers (cont'd)							
Methyl chloroform (CH ₃ CCL ₃)	t	0.70	191	0.70	186	0.70	186
Methyltrichlorosilane	t	1.80	472	1.80	472	1.80	472
Sodium carbonate	t	1.10	19.3	15	11.5	2	17
Nitric acid, fresh	L	83,100	1.75 × 10 ⁶	85,000	1.31 × 10 ⁶	83,095	1.75 × 10 ⁶
Sodium hydroxide	L	1.10 × 10 ⁷	1.10 × 10 ⁷	1.10 × 10 ⁷	1.10 × 10 ⁷	1.10 × 10 ⁷	1.10 × 10 ⁷
Sulfuric acid (for pH control)	L	1.29 × 10 ⁷	1.29 × 10 ⁷	1.29 × 10 ⁷	1.29 × 10 ⁷	1.29 × 10 ⁷	1.29 × 10 ⁷
Gases							
Acetylene	m ³	65,600	2.31 × 10 ⁶	79,800	2.31 × 10 ⁶	66,000	2.31 × 10 ⁶
Ammonia	m ³	445	5,620	445	5,620	420	5,620
Water							
Cooling system	L	4.3 × 10 ⁷	4.3 × 10 ⁷	4.26 × 10 ⁷	4.26 × 10 ⁷	5.53 × 10 ⁷	5.53 × 10 ⁷
Process and other	L	1.29 × 10 ⁶	1.54 × 10 ⁶	1.83 × 10 ⁶	1.98 × 10 ⁶	4.02 × 10 ⁶	3.32 × 10 ⁶
Work force ^c	Workers	1,389	1,675	1,210	2,084	1,071	1,201

^aHEU = highly enriched uranium.

^bDU = depleted uranium.

^cOperation of an MHTGR at SRS assumes concurrent operation of existing K, L, and P reactors. Waste management workers are included.

Source: Roman 1991.

C.2.8.2 Staffing Requirements

Estimates of the staffing requirements for normal operation of an eight-module MHTGR complex are provided in Table C.4. Staffing for operation of the electric generating plant is not included because it is not part of the proposed action.

C.2.9 Sitewide Waste Management

The MHTGR sitewide waste management systems would handle radioactive and nonradioactive solid, liquid, and gaseous wastes. The waste systems at each facility would be integrated into the sitewide waste management system. Each facility would process waste to provide an acceptable feed to the sitewide waste management facilities.

The DOE's NPR operations will be conducted consistent with commitments DOE has made and will make in compliance agreements with state and Federal regulatory authorities. If it should become necessary, DOE will work with the regulators to incorporate NPR needs into existing agreements or to develop new agreements to ensure continued compliance. Under no circumstances will DOE's performance pursuant to any existing compliance agreement be compromised or diminished as a result of the NPR project. If there are discrepancies between the waste stream volume and waste treatment capacity figures in the DEIS and in existing compliance agreements, or those currently in negotiation, the figures in the compliance agreements will prevail.

**TABLE C.4 MHTGR Operations Staffing Requirements
(Number of Employees)**

Facility	Hanford	INEL	SRS ^a
Reactor Facility and subfacilities ^b	458	458	458
Tritium-Target Fabrication	70	120	80
Plutonium-Target Fabrication	247	486	181
Fuel Fabrication	80	93	62
Tritium-Target Processing	136	130	38
Spent Fuel Processing	625	331	224
Plutonium-Target Processing ^c	870	969	291
Waste Management	20	78	209
Total			
Tritium mode	1,389	1,210	1,071
Plutonium mode	1,675	2,084	1,201

^aAssumes operation of existing K, L, and P reactors.

^bIncludes 22 persons for operation of the Energy Conversion Area.

^cIncludes spent fuel processing workers.

Sources: Bean 1990; Bowman 1990; Evans 1990.

Waste processing at each MHTGR facility was described earlier in this section. The sitewide waste management facilities at INEL are described in Section A.3.9.1. Flowcharts for radioactive and nonradioactive liquid wastes and solid radioactive wastes are given in Appendix M.

C.3 MODULAR HIGH-TEMPERATURE GAS-COOLED REACTOR TECHNOLOGY AT HANFORD

C.3.1 Introduction

This section provides information on the siting, design, and operation of a modular high-temperature gas-cooled reactor and its proposed support facilities at Hanford. The information presented in this section is largely abstracted from Westinghouse Hanford reports for the reactor (WHC 1989a) and its support facilities (WHC 1989b), except where otherwise referenced. The Hanford reports reference an EG&G report that describes the generic modular high-temperature gas-cooled reactor at INEL (EG&G 1989), which is abstracted in Section C.2. Only specific, unique data applicable to the Hanford MHTGR are presented. Section C.2 is referenced where no distinction exists between INEL and Hanford modular high-temperature gas-cooled reactors.

C.3.1.1 New and Existing Facilities Required for the NPR

The Hanford site-specific implementation of MHTGR support facilities would use the existing Fuels and Materials Examination Facility for installation of tritium-target processing equipment. New facilities would be constructed to support fuel and target fabrication, spent fuel processing, and irradiated plutonium-target processing. The waste management activities would be integrated into the system planned for handling current waste inventories. Figure C.1 shows the MHTGR support facilities, the interfaces among them, and the material flows.

C.3.1.2 Location

The proposed NPR facility would be located in the southeast area of DOE's Hanford Site in Benton County, Washington. The Hanford Site, described in Section A.3.1.2 for the heavy-water reactor, is also applicable for the MHTGR. The fuel and target fabrication facilities would be constructed at the reactor site. Targets would be processed in the existing Fuels and Materials Examination Facility. Spent fuel would be processed in a new structure in the 200-East Area. Existing and planned waste management facilities would be used where possible to support operation of the reactor fuel cycle. Figure A.12 shows the locations of the proposed reactor and its support facilities at the Hanford Site.

C.3.1.3 Existing Facilities, Utilities, and On-site Transportation

Existing facilities, utilities, and on-site transportation are discussed in Section A.3.1.3.

C.3.2 Modular High-Temperature Gas-Cooled Reactor Facility

The description of the Reactor Facility for the modular high-temperature gas-cooled reactor at INEL (Section C.2.2) is also adequate for the MHTGR at Hanford, except as discussed in the following sections.

C.3.2.1 Plant Structures

The site plan for the Reactor Facility is identical to the site plan given for INEL (Figure C.3), except the plant orientation would take advantage of the natural slope at Hanford and allow gravity flow for the circulating water system. The Reactor Facility would occupy a 1.3-km² area; however, during construction, approximately 5 km² would be disturbed. All systems and equipment necessary for each nuclear island would be located within a common boundary.

The reactor would normally be operated at design power and would produce tritium or plutonium. Thermal energy (e.g., steam), which would be suitable for producing electricity, would be produced as a by-product of normal reactor operation and could be sold to offset production costs. Each reactor module would be capable of 100% steam bypass, so each reactor module could operate independent of electric generation.

C.3.2.2 Electric System

The Hanford off-site power supply to the reactor site described in Section A.3.2.3 for the heavy-water reactor is also applicable for the MHTGR.

C.3.2.3 Heat Dissipation Systems

In general, the overall plant coolant flow (Figure C.8) would be similar to the coolant flow at INEL, except the raw water would be taken from the Columbia River instead of deep wells and would be discharged to the river rather than to evaporation ponds. Discharge to the river would comply with Federal, state, and local regulations.

Two mechanical draft wet cooling towers would provide the cooling requirements under Hanford conditions. The estimated annual and peak cooling water use is given in Table C.2.

The raw water intake pumphouse and system for a heavy-water reactor at Hanford (Section A.3.3.2.2) is also adequate for the MHTGR at Hanford. The maximum projected demand for raw water is 1.21 m³/s. Similarly, the discharge system for the heavy-water reactor at Hanford (Section A.3.2.2) is also adequate for the MHTGR at Hanford. The average MHTGR discharge flow rate would be 0.14 m³/s at five cycles of concentration. However, the discharge

line would accommodate a maximum discharge rate of $0.38 \text{ m}^3/\text{s}$, providing the capability, if necessary, to blow down at lower cycles of concentration.

To minimize the deposit of alkaline scale materials, sulfuric acid would be continuously fed to the system to control the pH and alkalinity of the circulating water. Biological fouling in the circulating water system would be controlled by intermittent chlorination. Chlorination would occur a maximum of three times per day during the summer months when biological activity is at its peak. To ensure that no chlorine is discharged to the environment, blowdown would be terminated during chlorination and would not be resumed until the total residual chlorine in the circulating water has dropped to less than $0.0001 \text{ mg}/\text{m}^3$. The chemistry of the circulating water system is given in Appendix P.

C.3.2.4 Waste Management

Waste management at the Reactor Facility for the MHTGR at Hanford would be similar to the waste management system at INEL (Section C.2.2.10), except disposal of the wastes after treatment at the facility would be to the appropriate parts of the Hanford sitewide management system (Section A.3.9).

C.3.3 Fuel and Tritium-Target Fabrication

C.3.3.1 Facility Description

The fuel and tritium-target fabrication facilities for Hanford would be similar to the MHTGR fuel and tritium-target fabrication facilities planned for INEL and would meet the same design criteria (Section C.2.3.1). The fabrication buildings would be adjacent to the reactor (Figure C.3).

C.3.3.2 Process Description

The fuel fabrication process would produce about 2,000 hexagonal graphite fuel assemblies per year. The tritium-target fabrication process would produce about 25,000 target elements per year. Section C.2.3.3 describes the fabrication processes; no significant deviations would occur if the plants were built at Hanford.

C.3.3.3 Process Effluents and Wastes

Section C.2.3.4 describes the off-gas treatment systems of the proposed fabrication facilities for INEL; no significant deviations are anticipated for the Hanford facilities. Exact stack locations and heights would not be defined until the conceptual design is initiated and preliminary dispersion calculations are completed. For EIS calculations, plant stack locations are assumed to be directly downwind of the respective facility. The Fuel Fabrication Facility stack would be 13 m high, based on a nominal 3-m above-roof level. The Tritium-Target Fabrication Facility stack would be 12 m high, based on keeping the stack exhaust above the head of any person on the roof.

No radioactive effluents would be generated in the Tritium-Target Fabrication Facility. No gaseous radioactive effluents are expected from the Fuel Fabrication Facility, except for traces of radon-219 and radon-222, which are present in the uranium-235 and uranium-238 decay chains. While quantities of these isotopes would depend on the age of the uranium feed since it was processed, they are expected to be less than 0.001% of the uranium release values.

At Hanford, the nonradioactive gaseous effluent streams and the liquid waste streams from the fuel and tritium-target fabrication facilities would be similar to the effluents for the INEL fabrication facilities (Section C.2.3.4). Estimates of fuel combustion emissions are based on providing 200 kW of emergency power to each fabrication facility, plus an allocation for delivery vehicles. Approximately 20% of all combustion emissions would be from stationary equipment.

Radioactive liquid wastes from the Fuel Fabrication Facility would be transferred by truck to the 200-East Area for concentration and grout incorporation. Nonradioactive liquid wastes from fuel and tritium-target fabrication would be disposed of according to regulations existing at the time the facility is designed. The options could include packaging as hazardous waste for off-site disposal, on-site disposal as grout, disposal to the ground, evaporation, or recycle. Sanitary wastes would be discharged to a tile field or to a sanitary treatment facility, if one were built for the MHTGR complex. Sanitary wastes would be similar to sanitary wastes at the INEL fabrication facilities.

Liquid waste streams from the fabrication facilities would have a pH greater than 12.5, making these wastes RCRA-regulated wastes. The NaOH streams would be segregated or neutralized to minimize or eliminate the hazardous materials.

Radioactive solid wastes would be transported to the 200 areas and disposed of in low-level waste burial grounds. Nonradioactive nonhazardous wastes would be disposed of in the Hanford Central Landfill. Hazardous solid wastes would be packaged and disposed of in compliance with Federal, state, and local regulations in effect when the facility is operated.

No mixed wastes would be generated in the Tritium-Target Fabrication Facility. Some mixed wastes would be generated in the Fuel Fabrication Facility from uranium recovery, decontamination, and laboratory activities.

C.3.4 Plutonium-Target Fabrication

Fuel for plutonium production would be fabricated in the same way as fuel for tritium production; however, plutonium-target fabrication would be carried out as described below.

C.3.4.1 Facility Description

The Plutonium-Target Fabrication Facility for Hanford would be similar to the Plutonium-Target Fabrication Facility for INEL (Section C.2.4.1).

C.3.4.2 Process Description

The Plutonium-Target Fabrication Facility would produce about 50,000 target elements per year of depleted uranium (0.2 wt% uranium-235). The process for fabricating plutonium-target elements at INEL is described in Section C.2.4.3; no significant changes would need to be made for a facility built at the Hanford Site.

C.3.4.3 Process Effluents and Wastes

Section C.2.3.4 describes the off-gas treatment system of the proposed INEL Plutonium-Target Fabrication Facility. The Hanford facility would be similar. The exact location and height of the stack would not be defined until the conceptual design is initiated and preliminary dispersion calculations are completed. For EIS calculations, the plant stack is assumed to be located directly downwind from the facility. The Plutonium-Target Fabrication Facility stack would be 13 m high, based on a nominal 3-m above-roof level.

The estimated gaseous releases for the Plutonium-Target Fabrication Facility would be similar to the gaseous releases for the INEL fabrication facility (Section C.3.3.3). Estimates of fuel combustion emissions are based on providing 200 kW of emergency power to the facility.

Radioactive liquid wastes from the Plutonium-Target Fabrication Facility would be transferred by truck to the 200-East Area for concentration and grout incorporation. Nonradioactive liquid wastes would be disposed of according to regulations existing at the time the facility is designed. Options could include packaging as hazardous waste for off-site disposal, on-site disposal as grout, disposal to the ground, evaporation and recycle, or resale. Sanitary wastes would be discharged to the Fast Flux Test Facility sanitary waste treatment system.

Some mixed wastes would be generated in the Plutonium-Target Fabrication Facility from uranium recovery, decontamination, and laboratory activities. The liquid waste streams would have a pH greater than 2.5, making these waste streams RCRA-regulated wastes. The NaOH stream would likely be segregated or neutralized to minimize or eliminate hazardous materials.

C.3.5 Spent Fuel Processing

At Hanford, the spent fuel would be processed in new facilities that would accommodate both spent fuel processing and plutonium-target processing systems. Installation of a plutonium-target processing system would be deferred until production requirements indicated a demand for plutonium.

The spent fuel processing facilities would be located in the 200-East Area. The purpose of the facilities would be to recover uranium (and plutonium during plutonium production) from irradiated fuel. Uranium would be recovered by chemically separating the uranium from undesired actinides and fission products. After chemical separation, the uranium product would be converted to an oxide.

Figure C.14 provides a general description of the functions incorporated in spent fuel processing. Additional information on plutonium-target processing is presented in Section C.3.7.

C.3.5.1 Facility Description

The Spent Fuel Processing Complex would consist of two main buildings, the fuel processing building and the uranium recovery building. These buildings are the same as the buildings described in Section A.3.5 for the heavy-water reactor at Hanford. The functions included in both buildings are shown in Figure C.14. Supporting facilities and services would be as described for a heavy-water reactor at Hanford (Section A.3.5.1).

The fuel processing building would contain equipment for spent fuel receipt, examination, and storage; fuel block disassembly; fuel rod removal, crushing, burning, and dissolution; headend operations; solvent extraction process operations; and ancillary operations such as process off-gas treatment and waste treatment. The building would be a T-shaped concrete structure, 116 m by 139 m by 37 m high, with a maximum above-grade height of 23 m. For plutonium production, the building would also include target element receipt, examination, and storage; target element crushing and burning; ash dissolution; and plutonium recovery, purification, and metal conversion. The headend fuel operations that would be carried out in the fuel processing building (spent fuel receipt, examination, and storage; fuel block disassembly; fuel rod removal, crushing, burning, and dissolution) are described for INEL in Section C.2.5.2.

The uranium recovery building would contain equipment for concentration of uranyl nitrate solution produced at the fuel processing building, for conversion of the solution to uranium oxide, and for ancillary operations. The building would be a rectangular concrete structure, 30 m by 27 m by 14 m high, with a maximum above-grade height of 7.6 m. Figure C.15 shows a plan view of the two buildings; the locations of specific areas are outlined.

C.3.5.2 Process Description

The processes carried out in the fuel processing building, e.g., solvent extraction operations, would be conducted as described for the light-water reactor at Hanford (Section B.2.5.2), but without recovery of plutonium. Plutonium would not be recovered because only low levels of plutonium are present in MHTGR spent fuel, and thus in the feed stream. Plutonium would be discharged to the high-level waste stream via the first-cycle solvent extraction process. The second and third plutonium cycles in LWR spent fuel processing would not be present. This results in a separation system similar to the system described in the Fuel Processing discussion in Section C.2.5.2.

The processes carried out in the uranium recovery building would be similar to the processes described in Section C.2.5.2. The Hanford site-specific processing would use rotary calciners instead of fluidized beds, but this modification would not significantly affect environmental releases.

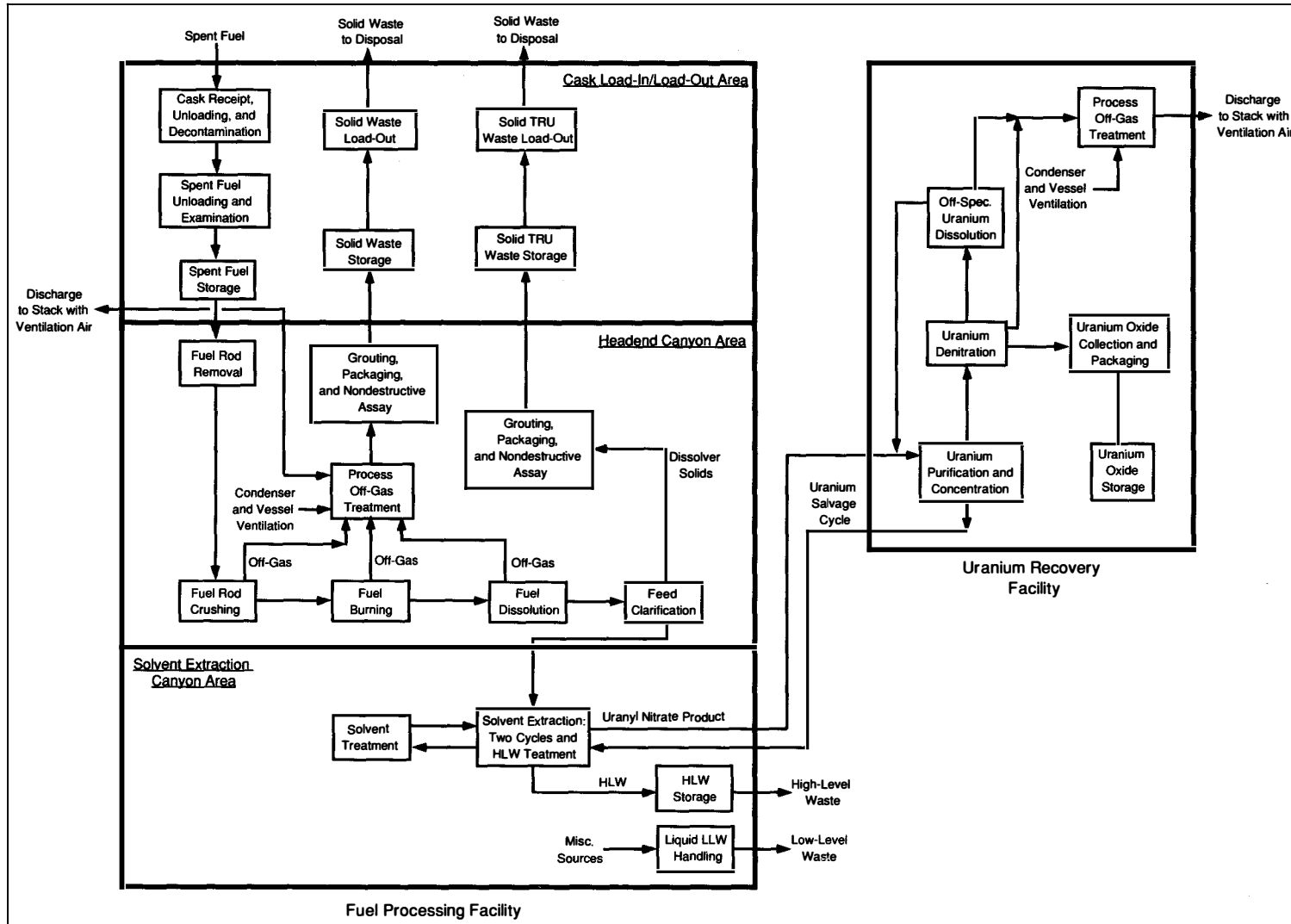


FIGURE C.14 Spent Fuel Processing Complex at Hanford (Source: WHC 1989b)

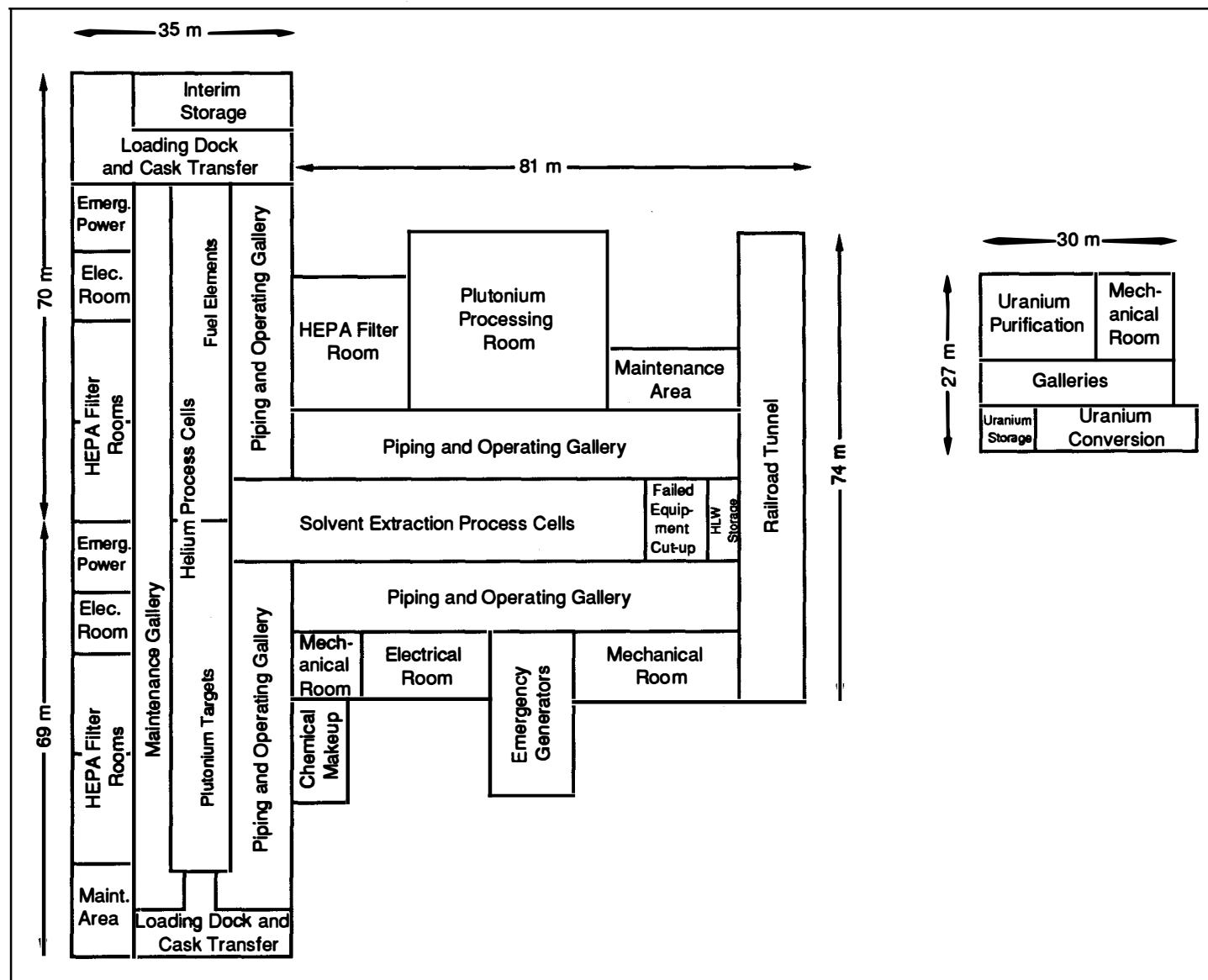


FIGURE C.15 Building Layout of Spent Fuel Processing Complex at Hanford (Source: WHC 1989b)

C.3.5.3 Process Effluents and Wastes

Each facility would have independent off-gas treatment systems, including separate stacks. Off-gas from the equipment would be treated near the source to minimize the size of the treatment system needed to reduce these concentrations. The major elements of the planned Fuel Processing Facility heating, ventilation, and air conditioning (HVAC) system are given in Figure C.16. The HVAC system for the uranium recovery building would be planned with the same design philosophy.

The differences in plant layout between INEL and Hanford site-specific fuel processing facilities would result in differences in the process off-gas systems. Hanford's headend and solvent extraction operations would be combined in the Fuel Processing Facility. Off-gas from the solvent extraction vessels would be combined with the headend off-gas streams after the headend streams have been treated. Figure C.17 shows the major elements of the off-gas treatment process.

At Hanford, uranium oxide production from uranyl nitrate solution would occur in the uranium recovery building (instead of in the same facility as solvent extraction operations at INEL). Denitration off-gas from uranium oxide production, which contains nitric acid, would be condensed to recover the nitric acid. Off-gas from other process vessels would be cooled, passed through HEPA filters, and discharged to the vessel off-gas system, where it would be combined with the building's ventilation air and directed to the stack.

During normal operation, the volume of ventilation air released to the environment through the Fuel Processing Facility stack would be approximately $120 \text{ m}^3/\text{s}$. This discharge would be primarily ventilation air, but it also would contain CO_2 and NO_x as nonradioactive effluents.

During normal operation of the uranium recovery building, approximately $23.8 \text{ m}^3/\text{s}$ of ventilation air would be released to the main stack. The ventilation air would contain NO_x , mainly from the denitration process in which uranyl nitrate is converted to uranium oxide. All gaseous releases from spent fuel processing would meet Federal, state, and local regulations.

Water vapor would be released from the cooling towers during normal process operations, and additional releases would come from fuel combustion sources. Approximately 25% of fuel combustion emissions would be associated with stationary equipment; the remainder would be generated by delivery vehicles.

No planned releases of liquid radioactive effluents to the environment are expected from the fuel processing and uranium recovery buildings. Liquid wastes would be segregated as high-level, low-level, mixed, hazardous, or nonhazardous nonradioactive wastes. Solutions generated within process cells containing radionuclides would be converted to solids or transferred to the waste management system for disposal. High-level waste, primarily the aqueous waste stream from the first solvent extraction column, would contain 0.07 M of nitric acid, 0.04 M of sodium nitrate, uranium, and ferric nitrate.

Low-level wastes would result from solvent treatment, decontamination activities, sumps, and excess process condensate and would be almost entirely water. The waste might contain small amounts of nitric acid, sodium carbonate, potassium permanganate, and uranium, with traces of fission products and actinides.

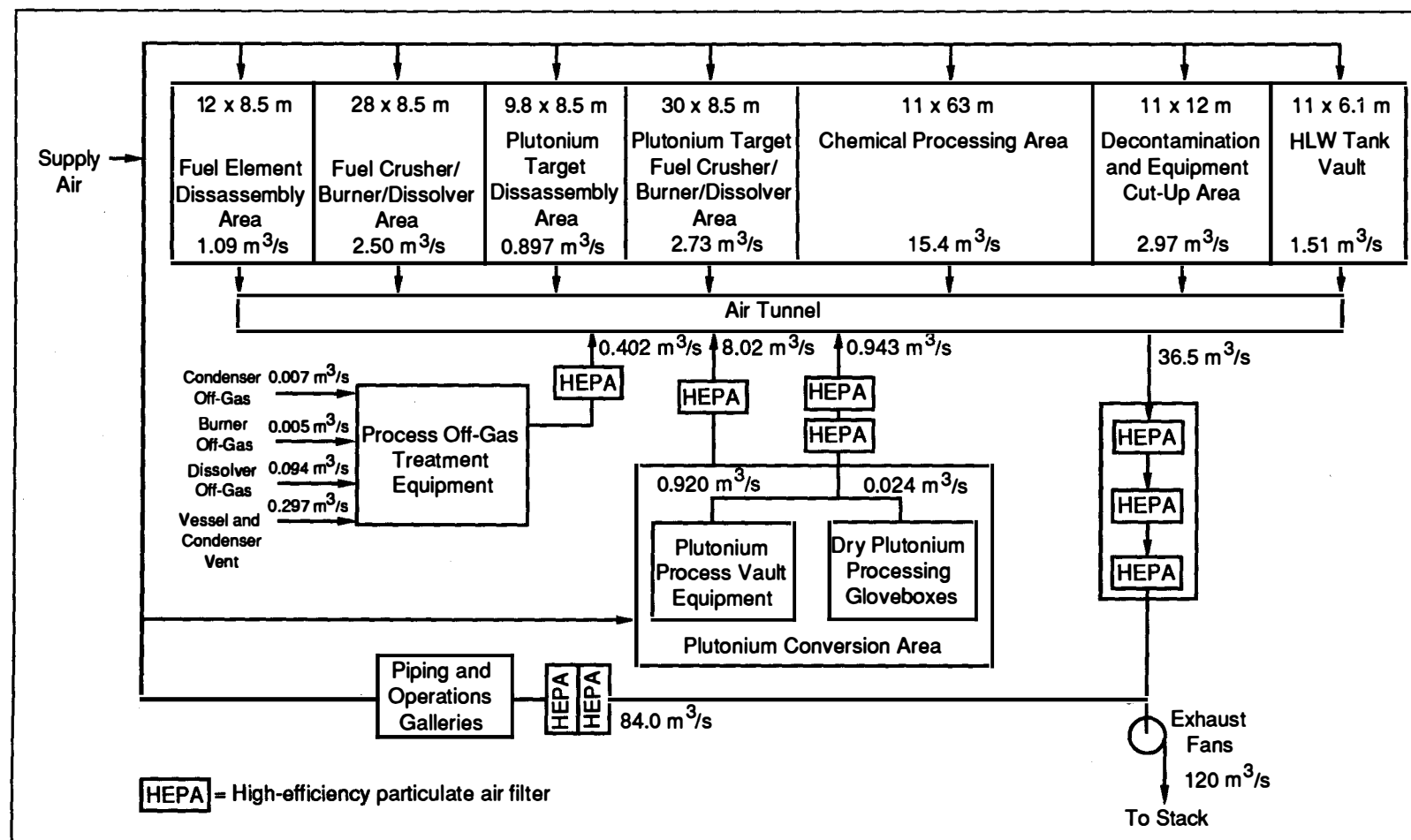


FIGURE C.16 Heating, Ventilating, and Air Conditioning System for MHTGR Fuel Processing Facilities at Hanford
(Source: WHC 1989b)

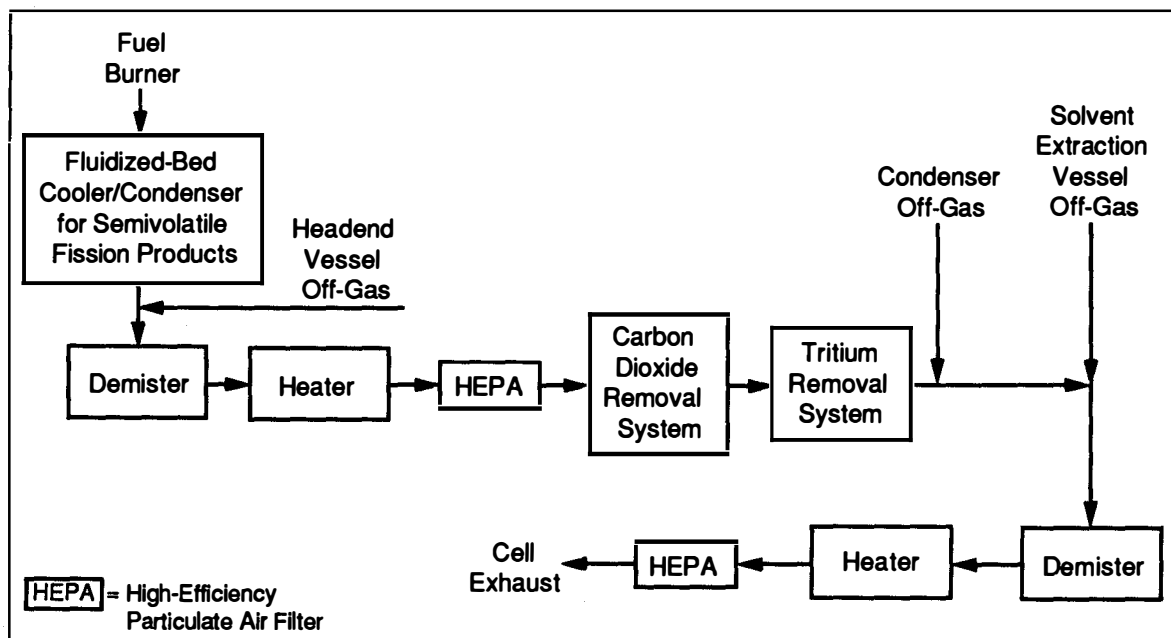


FIGURE C.17 Major Elements of the Off-Gas Treatment Process for MHTGR Fuel Processing Facilities at Hanford (Source: WHC 1989b)

Nonradioactive liquid waste from normal operations would be divided into service and sanitary wastes. Service waste would include steam condensate, waste from corridor and floor drains, and condensate from nonprocess equipment. Sanitary waste would include water from all sanitary services for the facilities.

The RCRA waste generated from fuel processing operations would include unusable chemical solutions and spent solvents, greases, and lubricants. Organic mixed waste would be generated from the solvent waste system.

Radioactive solid wastes generated during normal operations would include fuel block matrices (remains of the fuel block after the fuel rods are separated from the block), dissolver solids, CO₂ removal system solids (calcium carbonate), spent HEPA filters, spent iodine adsorber beds, and miscellaneous solid wastes. Calcium carbonate slurry from the CO₂ and tritium removal system liquid would be mixed with Portland cement grout to produce a nontransuranic solid waste. Fuel element dissolver solids would be mixed with Portland cement grout to produce a transuranic solid waste.

Radioactive solid wastes would be transported to the 200 areas and disposed of in low-level waste burial grounds. Nonradioactive nonhazardous solid waste would consist mainly of office trash and material shipping containers and would be disposed of in the Hanford Central Landfill. Hazardous solid wastes would be packaged and disposed of according to regulations in effect when the facility is operated. The wastes at Hanford would be similar to the wastes at INEL.

C.3.6 Tritium-Target Processing

C.3.6.1 Facility Description

Tritium-target processing systems would be installed within the Fuels and Materials Examination Facility. The description of the light-water reactor Tritium-Target Processing Facility (Section B.2.6.1) is also applicable for the MHTGR processing facility.

Target processing would use the main hot cell in the central portion of the process building and in adjacent rooms on multiple floors. The conceptual layout of the main process cell systems is similar to the layout for LWR processing (Section B.2.6.1).

C.3.6.2 Process Description

Tritium targets would be received and unloaded at the Fuels and Materials Examination Facility. The targets would be crushed before being heated in the extraction furnace to drive off the tritium. The tritium gas would be collected and fed through a heated decomposer bed to remove reactive impurities, and the remaining gas would pass through another bed to separate the inert materials from the hydrogen isotopes. The tritium would be separated from the other hydrogen isotopes in the thermal cycling absorption process unit. Tritium would be recovered from process off-gas streams and the blanket gas from the gloveboxes before release via the stack.

The flow diagram and a complete description of the process steps required for tritium extraction for the MHTGR at Hanford are identical to the tritium extraction process described in Section C.2.6.2 for the modular high-temperature gas-cooled reactor at INEL. Tritium processing, collection, and loadout would be identical to the processes described in Section A.3.6.2 for tritium-target processing at Hanford.

C.3.6.3 Process Effluents and Wastes

The existing 35.7-m-high exhaust stack at the Fuels and Materials Examination Facility is on the north side of the facility. Estimated off-gas flow at this facility is 40 m³/s. The ventilation system would need to be modified to accommodate target processing.

A schematic of the projected process ventilation and off-gas systems is shown in Figure B.15. The gases involved in these systems would include mixtures of argon and nitrogen with hydrogen isotopes, including pure tritium. These gases would be sent to one of two collection tanks, depending on the composition of the gas.

Elemental tritium would be sent directly to a uranium hydride bed. Gases containing hydrogen oxides would be sent through a uranium decomposer; all gases containing argon or nitrogen would be sent to a four-stage diffuser unit; and hydrogen would be sent to the gas collection system.

Other gases would be collected in two tanks; the contents of these tanks would be sampled and analyzed for tritium contamination. If within acceptable limits for discharge, the

gases would be sent to the purge cleanup system, where they would pass through two stages of HEPA filtration before discharge to the stack. If tritium concentration is high, the gas would be recycled through the diffuser. No particulate radioactive releases are expected.

The principal gaseous radioactive release from the Tritium-Target Processing Facility would be tritium in its elemental form (T_2 or HT) or as tritiated water (T_2O or HTO). Tritium releases are discussed in Appendix H. Air or gases from tritium-target processing (i.e., argon, helium, and nitrogen) would be released via the stack. The process gases would represent less than 1% of the total stack flow.

No radioactive liquid wastes would be released from the Tritium-Target Processing Facility. All radioactive liquids generated by the process would be solidified in the facility and handled as solid waste. Nonradioactive liquid wastes would consist of nonprocess water, nonprocess steam condensate, and sanitary wastes. The volume of nonprocess water is estimated to be 10,000 m³/yr.

All radioactive solid waste would contain some tritium. Nonradioactive solid waste would consist of miscellaneous trash and scrap materials. No RCRA waste or mixed waste has been identified. All solid waste would be handled in the sitewide waste management system (Section A.3.9).

C.3.7 Fuel/Plutonium-Target Processing

Plutonium spent fuel and plutonium targets would be processed in the buildings constructed to process spent fuel from the tritium production fuel cycle. Additional equipment would be used to achieve processing capacities associated with the plutonium production fuel cycle. In addition to the processing needs described in Section C.3.5.1, plutonium-target solvent extraction operations and recovery of depleted uranium and plutonium targets would need to be included. Figure C.18 is a general process diagram of spent fuel processing and plutonium-target processing at Hanford.

C.3.7.1 Facility Description

The fuel processing and uranium recovery buildings (Section C.3.5.1) would contain sufficient space to accommodate the additional equipment needed to support the plutonium fuel cycle. The new equipment would be installed on the basis of the same design considerations used during the original plant construction.

C.3.7.2 Process Description

The processing of spent fuel elements supporting plutonium production is generally identical to the processing of spent fuel elements for tritium production (Section C.3.5.2). Initial steps in plutonium-target processing would occur in the fuel processing building. Separate dedicated equipment would be used for target processing. The headend operations to support MHTGR plutonium-target processing operations at Hanford are described in Section C.2.7.2. Off-gases from the fuel and target burners would be combined. Liquid and solid wastes from

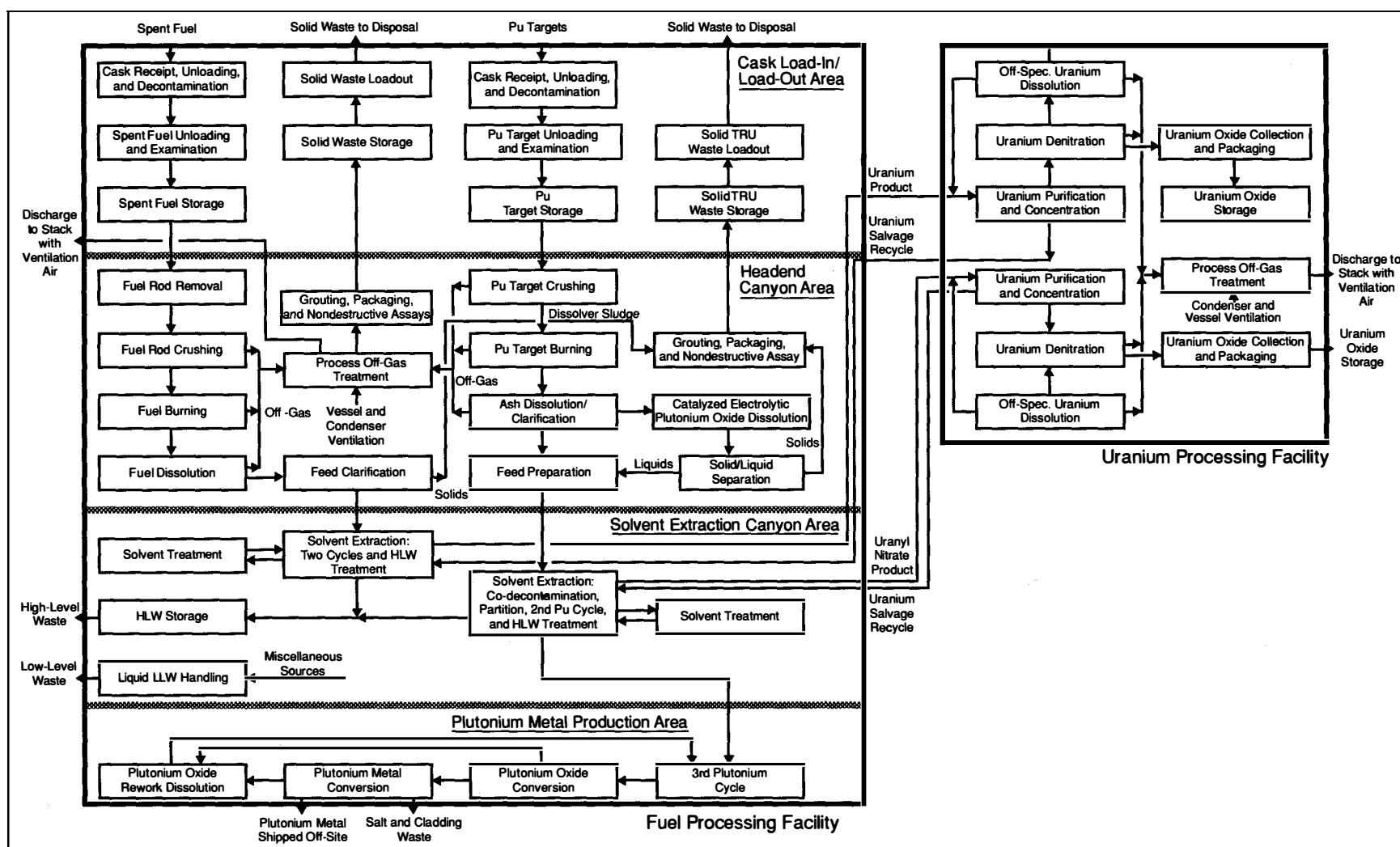


FIGURE C.18 MHTGR Fuel/Plutonium-Target Processing at Hanford (Source: WHC 1989b)

fuel processing and target processing also would be combined operations as appropriate. Solutions from the target ash dissolvers and the plutonium sludge dissolvers would be combined for subsequent solvent extraction operations.

Solvent extraction operations in support of plutonium-target processing would be similar to solvent extraction operations (Section B.2.5.2) for light-water reactor fuel processing operations. As in the LWR plutonium production case, a 30 vol% tributyl phosphate flow sheet would be used to accommodate the large uranium throughput.

The uranium recovery building would require additional dedicated equipment for the concentration and calcination of the depleted uranium from target processing. Uranium oxide calcination operations are described in Section C.2.5.2. Stirred-bed calciners would be used instead of fluidized beds for the Hanford site-specific processing case. Plutonium conversion to metal in support of plutonium-target operations would be similar to plutonium processing operations for LWR plutonium production operations (Section B.2.5.2).

C.3.7.3 Process Effluents and Wastes

Plutonium production would need to have systems to treat off-gases from the process equipment and ventilation zones. These systems would be in addition to the systems used to process tritium spent fuel in the same buildings. The design of the dedicated plutonium systems, however, would be similar to the tritium production design (Section C.3.5.3), but sized for the larger throughputs.

The wastes from spent fuel processing and plutonium-target processing have the characteristics described in Section C.3.5.3; however, quantities would differ because of the larger throughput, as shown in the flowcharts in Appendix M.

C.3.8 Plant Operation

The resources for operation of the MHTGR and the fabrication facilities to be constructed in the reactor area are summarized in Table C.3.

C.3.8.1 Utility Requirements

The utility requirements for the MHTGR fuel cycle facilities would be supplied from existing facilities. Figure C.19 presents the projected water distribution pattern for primary utilities and emissions associated with utilities supporting the Hanford fuel processing facilities. Assuming existing PUREX plant operations are discontinued at the time of NPR operation, utility capacity would be available for MHTGR support. Steam and water requirements for the MHTGR facilities are factors of 40 and 250, respectively, lower than existing PUREX plant demands.

The electricity requirement for an MHTGR at Hanford is identical to the electricity requirement for INEL (Section C.2.8.1). The water needed for turbine condenser cooling at Hanford is described in Section 3.2.3 and shown in Table C.2.

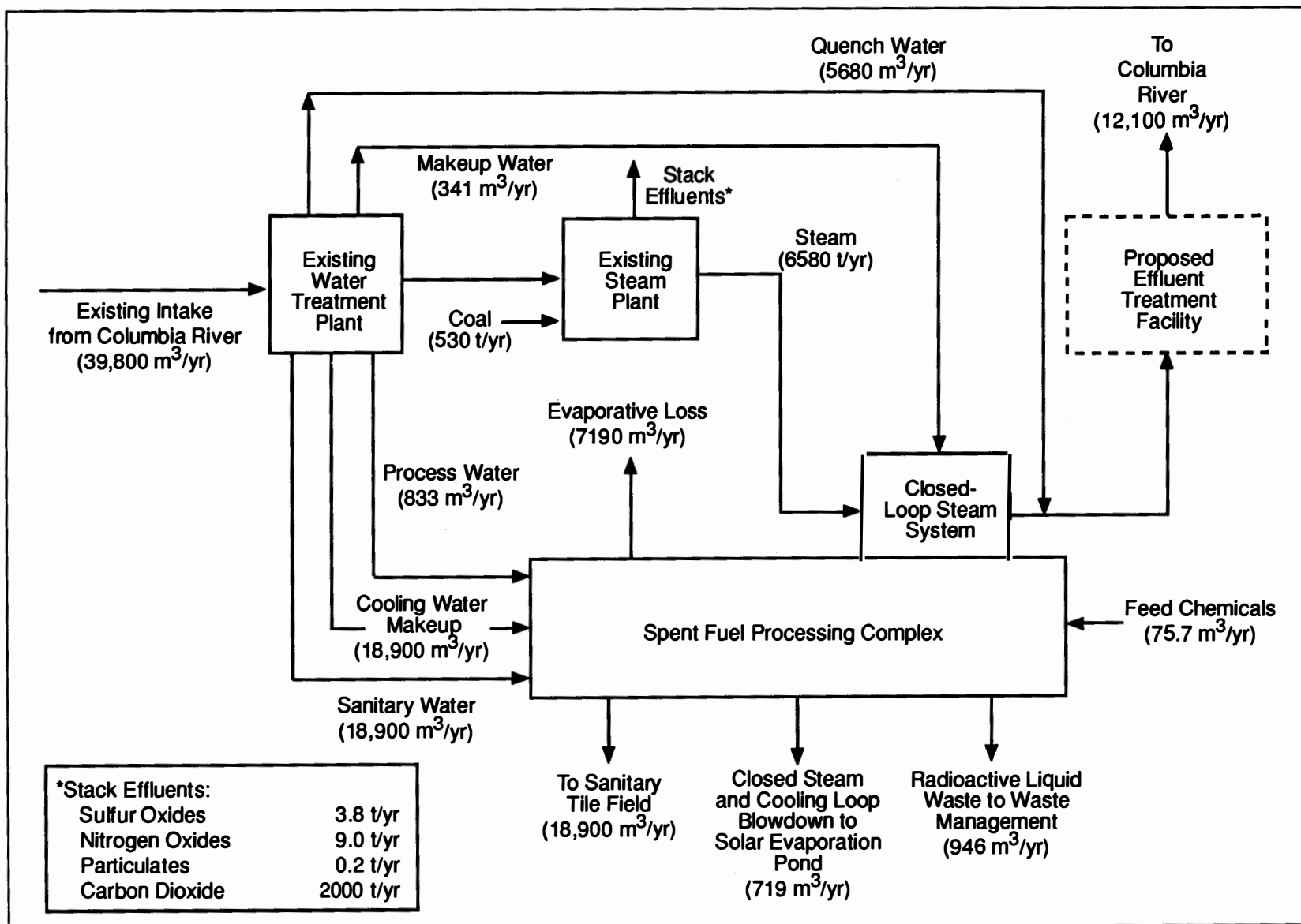


FIGURE C.19 MHTGR Water Distribution and Utility Effluents for Fuel Processing Facilities at Hanford (Source: WHC 1989b)

C.3.8.2 Staffing Requirements

The staffing requirements for normal operation of the MHTGR and its support facilities are given in Table C.4. Operation of the electric generating plant is not included because it is not part of the proposed action.

C.3.9 Sitewide Waste Management

Waste generated by operation of the MHTGR and its support facilities would be processed and prepared for disposal or transfer to the sitewide waste management system in the generating facility. Waste management for each of the MHTGR facilities is described in Section C.3. Flowcharts for radioactive and nonradioactive liquid wastes are given in Appendix M.

The existing and planned facilities identified by the Hanford Sitewide Waste Management Plan would manage the waste generated by the MHTGR and its support facilities. These facilities and their capabilities are described in Section A.3.9.1. Additional capabilities, supplementing the support facilities, to allow disposal of carbon blocks from spent fuel processing and solidified wastes regulated by the Washington Department of Environment from fabrication facilities have not been identified.

The DOE's NPR operations will be conducted consistent with commitments DOE has made and will make in compliance agreements with state and Federal regulatory authorities. If it should become necessary, DOE will work with the regulators to incorporate NPR needs into existing agreements or to develop new agreements to ensure continued compliance. Under no circumstances will DOE's performance pursuant to any existing compliance agreement be compromised or diminished as a result of the NPR project. If there are discrepancies between the waste stream volume and waste treatment capacity figures in the DEIS and in existing compliance agreements, or those currently in negotiation, the figures in the compliance agreements will prevail.

C.4 MODULAR HIGH-TEMPERATURE GAS-COOLED REACTOR TECHNOLOGY AT SRS

C.4.1 Introduction

The purpose of this section is to define modifications to the modular high-temperature gas-cooled reactor and its proposed support facilities at the Savannah River Site (SRS). The material in this section is largely abstracted from Savannah River reports for the reactor (WSRC 1991a) and for its support facilities (WSRC 1991b), except where otherwise referenced. The Savannah River reports reference an EG&G report that summarizes the MHTGR at the Idaho National Engineering Laboratory (EG&G 1989); the EG&G report is abstracted in Section C.2.

C.4.1.1 New and Existing Facilities Required for the NPR

The SRS is an integrated site for producing tritium and plutonium using heavy-water reactor technology. Facilities for the fabrication and postirradiation processing of HWR fuel and targets currently exist at SRS. The site also has waste management facilities to handle wastes produced by the fabrication and processing facilities. Under current plans, the facilities would support operation of three existing HWRs through at least the late 1990s.

Some of the existing facilities at SRS can be used directly to support the operation of the MHTGR, others would have to be modified, and some new facilities would have to be built. New fuel and target fabrication facilities would be built adjacent to the reactor to support the MHTGR in the tritium and plutonium production modes. A new headend facility for H-Canyon to process irradiated enriched uranium fuel associated with tritium and plutonium production also would be needed. A new tritium extraction cell would need to be added to the planned Replacement Extraction and Purification Facility. This cell would be used to process irradiated lithium targets to recover tritium and store it before further treatment and loadout in the planned Replacement Extraction and Purification Facility. A new headend facility for F-Canyon would be needed to process irradiated plutonium targets.

The facility design described in Section C.2.2 would require minor performance modifications to the cooling tower design for operation in SRS meteorological conditions and also for the raw water intake and blowdown systems. Most of the other plant characteristics, performance data, and emissions would be unaffected. The design of the underground structures might need to be modified because of the subsurface geological and hydrological conditions at SRS.

C.4.1.2 Location

The reference site for the Reactor Facility at SRS would be the site described in Section A.2.1.3 for a heavy-water reactor at SRS. The SRS heavy-water reactor site also is adequate for adaptation to the modular high-temperature gas-cooled reactor at SRS, including location and the 131-ha area.

New fuel and target fabrication facilities would be constructed at the reactor site. The other support facilities would be additions to existing facilities whose locations are described in Section A.2.1.3.

C.4.1.3 Existing Facilities, Utilities, and On-site Transportation

The existing facilities, utilities, and on-site transportation are described in Section A.2.1.3. The incoming electric service to the reactor site would not need modifications. The MHTGR would include the option of electric power generation. An additional corridor would be needed for the outgoing transmission lines. The corridor for incoming utilities to the site would be 30 m wide. An additional 49-m corridor would be needed for an outgoing 500-kV power line.

C.4.2 Modular High-Temperature Gas-Cooled Reactor Facility

The plant description provided in Section C.2.2 is adequate for the modular high-temperature gas-cooled reactor SRS adaptation, except as noted in the following sections.

C.4.2.1 Plant Structures

The arrangement of the Reactor Facility (Figure C.3) for the modular high-temperature gas-cooled reactor at INEL would apply to SRS, except for the Tritium-Target Processing Facility. The SRS would not have such a facility located with the reactor because tritium-target processing would be carried out at the Replacement Tritium Facility, which would be modified for the MHTGR fuel cycle.

The arrangement and layout of the nuclear island would be as shown in Figure C.4, except 50-m-deep subsurface structures for INEL might need modification to account for the high subsurface water table at SRS. The major impacts would be in site excavation and preparation and in the use of construction materials to withstand additional geohydrological conditions.

C.4.2.2 Electric System

The Reactor Facility electric system would be modified as needed to interface with the 230-kV SRS electric grid. Transformer power conditioning equipment located with the reactor within the facility fence would be modified.

C.4.2.3 Heat Dissipation Systems

Turbine Condenser Cooling System

Either mechanical or natural draft cooling towers could be used at SRS. Cooling tower blowdown would be discharged to the Savannah River (Section A.2.2) rather than to the evaporation ponds described for the MHTGR at INEL (see the Turbine Condenser Cooling System discussion in Section C.2.2.9). At SRS, total makeup requirements for evaporative losses, drift, and blowdown would be bounded by the data given in Table C.2.

The raw water intake structure for the heavy-water reactor (Section A.2.2.9) would be sufficient for raw water intake for the MHTGR. As with the new heavy-water reactor at SRS, thermal discharge standards would limit blowdown temperatures to 32°C. In addition, the site would limit the differential temperature between the blowdown discharge and open river water to 2.8°C. As a result, the blowdown would likely need to be mixed with additional raw river water to meet the differential temperature standard. A temperature differential between the tower outlet and the ambient river water temperature has been estimated for a recirculating cooling tower. The maximum differential occurs in February, when the average Savannah River temperature is 8°C and the tower output would be 14°C. The additional raw river water flow needed to reduce this temperature differential is estimated in Table C.2.

Water Treatment System

The water treatment system for SRS would be similar to the water treatment system for Hanford (Section C.3.2.3). However, because suspended solids and biological activity are higher in the Savannah River than in the Columbia River, additional flocculants and chlorine might be required. The resulting secondary coolant chemical concentrations for 2.5 cycles of concentration are given in Table 3.2 of WSRC 1989a.

The effluent water discharge point described in Section A.2.2.9 for the new heavy-water reactor would be sufficient to define the discharge point for the cooling tower blowdown water, sanitary water, and treated liquid radioactive waste effluents for the MHTGR.

C.4.2.4 Waste Management

The effluents and wastes generated at the Reactor Facility (Section C.2.2.10) would be constant regardless of the site location. The processing of the SRS effluents and wastes would be similar to the processing described in Section C.2.2.10, except disposal would be to the SRS sitewide waste management system. No modifications are planned to the SRS waste disposal infrastructure for handling reactor-generated solid radioactive waste and solidified liquid wastes.

C.4.3 Fuel and Tritium-Target Fabrication

New facilities would be used to fabricate the MHTGR fuel and tritium targets. The fuel and target fabrication facilities at SRS would be similar to the facilities at INEL (Section C.2.3.1). The fuel and targets for SRS would be identical to the fuel and targets for INEL (Section C.2.3.2). The tritium-target fabrication process at SRS would be identical to the tritium-target fabrication process at INEL (Section C.2.3.3).

The effluents and wastes generated from MHTGR fuel and target fabrication at SRS would be the same as at INEL (Section C.2.3.4), except disposal would be to SRS waste management systems. The aqueous discharges at SRS would be processed through the M-Area Liquid Effluent Treatment and Disposal Facility. This facility would process the liquid waste to remove most of the chemical contamination and radioactivity so that treated water could be released to on-site streams. Solid wastes would be sent to the SRS sitewide waste management systems.

C.4.4 Fuel/Plutonium-Target Fabrication

New facilities would be used to fabricate the MHTGR plutonium targets. The Plutonium-Target Fabrication Facility at SRS would be similar to the INEL facility (Section C.2.4.1). The plutonium target at SRS would be identical to the plutonium target at INEL (Section C.2.4.2). The SRS fabrication process would be identical to the INEL fabrication process (Section C.2.4.3).

The effluents and wastes generated from MHTGR plutonium-target fabrication at SRS would be the same as the effluents and wastes generated at INEL (Section C.2.4.4), except

disposal would be to SRS waste management systems. Treatment of aqueous discharges and solid wastes for plutonium-target fabrication at SRS would be the same as for fuel fabrication (Section C.4.3).

C.4.5 Spent Fuel Processing

A new headend facility would produce a clarified product solution of uranium dissolved in nitric acid. The clarified nitric acid solution would be suitable for feed to the solvent extraction portion of the H-Canyon.

C.4.5.1 Facility Description

A new headend facility would be constructed adjacent to the existing Building 221-H (H-Canyon). It would be similar to the headend facility at INEL (Section C.2.5.1). The H-Canyon facility, which would be used to separate uranium and plutonium from mixed fission products, is described in Section A.2.5.1.

C.4.5.2 Process Description

The spent fuel from the MHTGR would be processed through the new headend facility and then through the Building 221-H solvent extraction system. Spent fuel from the tritium and plutonium production modes would be handled in this way.

Three major operations are associated with spent fuel processing: fuel crushing, burning, and dissolution, followed by clarification of the resulting nitrate solution treated to remove suspended particulates; solvent extraction, where the nitrate solution is processed to recover and then purify uranium; and product conversion, where the purified uranium nitrate stream is converted from a liquid to a solid. The first operation would be carried out in the new MHTGR headend facility, using the process described in Section C.2.5.2. The last two operations would be performed in the H-Canyon, using the processes described in Section A.2.5.2. Plutonium would be disposed of as high-level liquid waste because it would be present only in small quantities.

C.4.5.3 Process Effluents and Wastes

The operation of the new Headend Fuel Dissolution Facility and Building 221-H would produce gaseous wastes, primarily wastes associated with dissolution of the spent fuels. These gaseous wastes would be released to the atmosphere after treatment for iodine absorption and filtering through HEPA filters. Actual tritium releases from individual facilities are classified. For the EIS, a bounding estimate for the canyons is used. The estimate is greater than the expected release of tritium, even if NPR spent fuel were processed in addition to spent fuel from the existing reactors. Tritium releases are discussed in Appendix H.

The high-level liquid waste from Building 221-H and associated process operations would contain most of the fission products. The waste would be concentrated and neutralized before transfer to waste storage tanks; the nitric acid from the overheads would be recovered for reuse.

Low-level liquid wastes would result from evaporator overheads and steam condensates. These effluents would be processed through the existing F- and H- areas Effluent Treatment Facility. The liquid waste would be processed to remove most of the chemicals and radioactivity so that the treated water could be released to on-site streams.

Radioactive solid waste would be produced as part of the irradiated fuel processing operations. The principal waste volume would be the used graphite block reflector and fuel elements, but there would also be failed process equipment, spent HEPA filters, spent ion-exchange resins, contaminated packaging and clothing, grout containing silicon carbide hulls, and other items. Wastes would be separated into low-level, transuranic, and mixed fractions; conditioned to reduce volume; and packaged for transfer to the appropriate SRS sitewide waste management facilities (Section A.2.9.1) for further treatment, storage, or disposal. Hazardous and other solid wastes produced during fuel processing would be disposed of within the sitewide waste management system.

C.4.6 Tritium-Target Processing

C.4.6.1 Facility Description

A new Replacement Extraction and Purification Facility is currently being planned to support existing heavy-water reactors, and it would be functional when the MHTGR starts operations. A detailed facility description is given in Section A.2.6.1; however, tritium-target processing at MHTGR would require specific tritium crushing and extraction areas (Section C.2.6.1).

C.4.6.2 Process Description

For MHTGR tritium extraction, irradiated tritium-target elements are crushed to fracture the coatings and release tritium. The crushed material is heated in a vacuum furnace to drive off the tritium. The tritium is first sent to a tritium storage system and then to the tritium purification system. After tritium extraction, the crushed residue is pneumatically transferred from the extraction furnace to a disposal facility, using nitrogen from a closed-cycle system. A more detailed description of this part of the process can be found in Section C.2.6.2. Tritium purification for MHTGR targets would take place in the planned Replacement Extraction and Purification Facility (Section A.2.6.2).

C.4.6.3 Process Effluents and Wastes

Tritium is the only radionuclide expected to be released to the atmosphere from MHTGR tritium-target processing. Tritium releases are discussed in Appendix H. The off-gas processing would be similar to the off-gas processing described in Section A.2.6.3.

Liquid waste would be produced by the tritium-target processing operation and would be treated as described in Section A.2.6.3. Radioactive solid waste (Section C.2.6.3) and nonradioactive nonhazardous waste would also be produced by the tritium-target processing operation. These wastes would be treated, disposed of, or stored within the SRS sitewide waste management system. Mixed waste and hazardous wastes are not expected to be produced by tritium-target processing.

C.4.7 Plutonium-Target Processing

The metal targets from the existing P, K, and L heavy-water reactors are processed through Building 221-F and its associated facilities to recover plutonium from the plutonium targets. With a new headend, Building 221-F would be used to recover plutonium from MHTGR.

C.4.7.1 Facility Description

Building 221-F (F-Canyon) is a double-canyon, reinforced-concrete structure designed to withstand high external blast pressures. It is similar in design to Building 221-H (H-Canyon) (Section A.2.5.1). For the MHTGR, a headend facility would be added next to F-Canyon. The new headend facility would be approximately 27 m by 73 m by 24 m, with 18 m of the structure below grade. It would be similar to the MHTGR spent fuel headend facility at INEL (Section C.2.5.1).

C.4.7.2 Process Description

The F-Canyon facility currently uses the PUREX process to separate uranium, neptunium, plutonium, and fission products contained in the irradiated metal targets. Three major operations would be associated with the processing of MHTGR targets at the F-Canyon complex with the new MHTGR headend facility: target crushing, burning, dissolution, and clarification, where the carbide fuel is dissolved and the resulting nitrate solution is treated to remove suspended particulates; solvent extraction, where the nitrate solution is processed to recover and purify the uranium and plutonium; and product conversion, where the purified nitrate streams are converted from a liquid to a solid. The first operation is described in Section C.2.7.2. The last two operations are described in Section A.2.7.2.

C.4.7.3 Process Effluents and Wastes

The principal gaseous wastes from plutonium-target processing would be associated with the dissolution of the irradiated targets. These gaseous wastes would be released to the atmosphere after treatment by absorption or filtration.

The high-level aqueous waste from Building 221-F processes would contain most of the fission products to be concentrated and neutralized before being sent to waste storage tanks. Nitric acid from the overheads would be recovered for reuse.

Low-level liquid wastes would result from evaporator overheads and steam condensates. The radioisotopes released with the low-level liquid waste during the processing of irradiated fuel would be processed through the F- and H-areas Effluent Treatment Facility. The liquid waste would be processed to remove most of the chemicals and radioactivity so that the treated water could be released to on-site streams.

Radioactive solid wastes, transuranic wastes, mixed wastes, hazardous wastes, and nonradioactive nonhazardous wastes would be produced by irradiated depleted uranium-target processing operations. These wastes would be similar to wastes produced in spent fuel processing and would be treated as described in Section C.2.5.3.

C.4.8 Plant Operation

Resource requirements for normal operation of the MHTGR and its support facilities at SRS are summarized in Table C.3. Staffing requirements are given in Table C.4. Operational requirements described in Section C.2.8 are adequate for adaptation of the modular high-temperature gas-cooled reactor at SRS, except for the cooling tower requirements, which are described in Section C.4.2.2 and tabulated in Table C.2.

C.4.9 Sitewide Waste Management

The gaseous effluents would be treated at each generating facility as described earlier in this section. The effluents and waste generated at the reactor are described in Section C.4.2.3. The effluents and wastes generated at each support facility are described in Sections C.4.3 to C.4.7. Flowcharts for solid wastes and radioactive and nonradioactive liquid wastes are presented in Appendix M. The sitewide waste management operations impacted by the proposed NPR, and the expected condition of the SRS waste management operations in the year 2000 (the time frame for MHTGR start-up), are described in Section A.2.9.

The DOE's NPR operations will be conducted consistent with commitments DOE has made and will make in compliance agreements with state and Federal regulatory authorities. If it should become necessary, DOE will work with the regulators to incorporate NPR needs into existing agreements or to develop new agreements to ensure continued compliance. Under no circumstances will DOE's performance pursuant to any existing compliance agreement be compromised or diminished as a result of the NPR project. If there are discrepancies between the waste stream volume and waste treatment capacity figures in the DEIS and in existing compliance agreements, or those currently in negotiation, the figures in the compliance agreements will prevail.

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*Copies of correspondence and other unpublished material cited in this list are available in U.S. Department of Energy Reading Rooms.

