

# **Draft Versatile Test Reactor Environmental Impact Statement**

## **Volume 2** *Appendices A-H*





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# COVER SHEET

**Lead Agency:** U.S. Department of Energy (DOE)

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**Abstract:** This *Versatile Test Reactor Environmental Impact Statement* (VTR EIS) evaluates the potential environmental impacts of proposed alternatives for the construction and operation of a new test reactor, as well as associated facilities that are needed for performing post-irradiation evaluation of test articles and managing spent nuclear fuel (SNF). In accordance with the Nuclear Energy Innovation Capabilities Act of 2017 (NEICA) (Pub. L. 115–248), DOE assessed the mission need for a versatile reactor-based fast-neutron source (or Versatile Test Reactor) to serve as a national user facility. DOE determined that there is a need for a fast-neutron spectrum VTR to enable testing and evaluating nuclear fuels, materials, sensors, and instrumentation for use in advanced reactors and other purposes. In accordance with NEICA, DOE is pursuing construction and operation of the 300 megawatt (thermal) VTR. The reactor would be a pool-type, sodium-cooled reactor that uses a uranium-plutonium-zirconium metal fuel. The analysis also includes the potential impacts from post-irradiation examination of test articles, management of spent fuel, and activities necessary for VTR driver fuel production.

The Idaho National Laboratory (INL) VTR Alternative would include the construction of the VTR adjacent to the Materials and Fuels Complex (MFC) at the INL Site. Existing MFC facilities, some requiring new equipment, would be used for post-irradiation examination and conditioning SNF. The Oak Ridge National Laboratory (ORNL) VTR Alternative would include the construction of a VTR and a hot cell building at ORNL. The hot cell building would provide post-irradiation examination and SNF conditioning capabilities. Both alternatives would require construction of a concrete pad for dry storage of SNF pending shipment

to an offsite storage or disposal facility. DOE does not intend to separate, purify, or recover fissile material from VTR driver fuel.

DOE also evaluates options for preparing the uranium/plutonium/zirconium feedstock for use in the reactor driver fuel (fuel needed to run the reactor) and for fabricating the driver fuel. Feedstock preparation would be performed using new capabilities installed in an existing building at the INL Site or the Savannah River Site (SRS). Fuel fabrication would be performed using existing or newly installed equipment in existing buildings at the INL Site or SRS.

**Preferred Alternative:** DOE's Preferred Alternative is the INL VTR Alternative. DOE would construct and operate the VTR at the INL Site adjacent to the MFC. Existing facilities within the MFC would be modified and used for post-irradiation examination of test assemblies. SNF would be treated to remove the sodium and converted into a form that would meet the acceptance criteria for a future permanent repository. The treated SNF would be temporarily stored at a new storage pad near the VTR.

DOE has no preferred option at this time for where it would perform reactor fuel production (feedstock preparation or driver fuel fabrication) for the VTR. This EIS evaluates options for both processes at the INL Site and at SRS. DOE will state its preferred options for feedstock preparation and driver fuel fabrication in the Final VTR EIS, if preferred options are identified before issuance.

**Public Involvement:** DOE issued a Notice of Intent to Prepare an environmental impact statement for a Versatile Test Reactor in the *Federal Register* (84 FR 38021) on August 5, 2019, to solicit public input on the scope and environmental issues to be addressed in this VTR EIS. Comments received during the August 5 through September 4, 2019, scoping period were considered in the preparation of this Draft EIS. Comments on this Draft EIS will be accepted following publication of the U.S. Environmental Protection Agency Notice of Availability. Comments can be submitted to the address provided above or emailed to [VTR.EIS@nuclear.energy.gov](mailto:VTR.EIS@nuclear.energy.gov). Opportunities to provide oral comments will be announced in news media near the DOE sites at a later date. Comments received during the comment period will be considered during the preparation of the Final EIS. Comments received after the close of the comment period will be considered to the extent practicable.

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# **ACRONYMS, ABBREVIATIONS, AND CONVERSION CHARTS**

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## ACRONYMS, ABBREVIATIONS, AND CONVERSION CHARTS

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°C	degrees Celsius
°F	degrees Fahrenheit
AEG	Acute Exposure Guideline Level
ALARA	as low as reasonably achievable
ANS	Advanced Neutron Source
AoA	Analysis of Alternatives
APC	Air Pollution Control
AQD	Air Quality Division
APE	area of potential effects
ARF	airborne release fraction
ATR	Advanced Test Reactor
B <sub>4</sub> C	boron carbide
BCCs	Birds of Conservation Concern
BCR	Bird Conservation Region
BEIR	Biological Effects of Ionizing Radiation
BGEPA	Bald and Golden Eagle Protection Act
BJWSA	Beaufort-Jasper Water and Sewer Authority
BLM	Bureau of Land Management
CAA	Clean Air Act
CAIRS	Computerized Accident Incident Reporting System
CBCG	Columbia Basin Consulting Group
CCOs	criticality control overpacks
CD	Critical Decision
CEM	continuous emission monitoring
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFA	Central Facilities Area
CFR	<i>Code of Federal Regulations</i>
CO	carbon monoxide
CO <sub>2</sub>	carbon dioxide
CO <sub>2</sub> e	carbon dioxide equivalent
CRBR	Clinch River Breeder Reactor
CSWTF	Central Sanitary Wastewater Treatment Facility
CWA	Clean Water Act
D&D	decontamination and decommissioning
D&R	dismantlement and removal
DART	Days Away, Restricted or on-the-job Transfer
dB	decibels
dBA	A-Weighted Decibel Scale
DHS	U.S. Department of Homeland Security
DNFSB	Defense Nuclear Facilities Safety Board
DOD	U.S. Department of Defense

DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DR	damage ratio
DSAs	documented safety analyses
EA	environmental assessment
EBR	Experimental Breeder Reactor
EDGs	emergency diesel generators
EFF	Experimental Fuels Facility
EIS	environmental impact statement
EM	electromagnetic
EPA	U.S. Environmental Protection Agency
EPHA	Emergency Planning Hazard Assessment
ERDA	U.S. Energy Research and Development Administration
ERO	Emergency Response Organization
ERPG	Emergency Response Planning Guideline
ESA	Endangered Species Act
ESER	Environmental Surveillance, Education, and Research
ESRP	Eastern Snake River Plain
ETTP	East Tennessee Technology Park
FC	frequency-consequence
FCF	Fuel Conditioning Facility
FFCA	Federal Facilities Compliance Act
FFTF	Fast Flux Test Facility
FMF	Fuel Manufacturing Facility
FONSI	Finding of No Significant Impact
FOTAs	Fuels Open Test Assemblies
FR	<i>Federal Register</i>
FRR	Foreign Research Reactor
FTC	fuel transfer cask
FTE	full-time equivalent (person)
GEH	GE Hitachi Nuclear Energy
GHG	greenhouse gas
gpm	gallons per minute
GWP	global warming potential
HACs	hazardous air contaminants
HALEU	high assay, low-enriched uranium
HAPs	hazardous air pollutants
HAZMAT	hazardous materials
HEPA	high-efficiency particulate air
HEU	highly enriched uranium
HFEF	Hot Fuel Examination Facility
HFIR	High Flux Isotope Reactor
HLW	high-level radioactive waste
HRS	heat removal system
HT-9	a stainless-steel alloy of iron, chromium, molybdenum, tungsten, nickel, and carbon
HVAC	heating, ventilation, and air conditioning

IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
IDA	International Dark-Sky Association
IDAPA	Idaho Administrative Procedures Act
IDEQ	Idaho Department of Environmental Quality
IDFG	Idaho Fish and Game
IHXs	internal heat exchangers
IMCL	Irradiated Materials Characterization Laboratory
INF	irradiated nuclear fuel
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
IPaC	Information for Planning and Consultation
IPDES	Idaho Pollutant Discharge Elimination System
ISA	Idaho Settlement Agreement
ISCORS	Interagency Steering Committee on Radiation Standards
ISO	International Organization for Standardization
IVTM	In-Vessel Transfer Machine
JFD	joint frequency distribution
KIS	K-Area Interim Surveillance
kV	kilovolt
L <sub>dn</sub>	Day-Night Average Sound Level
L <sub>eq</sub>	Equivalent Sound Level
LAMDA	Low Activation Materials Design and Analysis Laboratory
LANL	Los Alamos National Laboratory
LCF	latent cancer fatality
LEU	low-enriched uranium
LFR	lead-cooled fast reactor
LFTR	lead/lead-bismuth-cooled fast test reactor
LOOP	loss of offsite power
LOS	level of service
LLW	low-level radioactive waste
LPF	leak path factor
MACCS	MELCOR Accident Consequence Code System
Magnox	magnesium alloy
MAP	mitigation action plan
MAR	material at risk
MBTA	Migratory Bird Treaty Act
MCEP	Motor Carrier Evaluation Program
MCL	Maximum Contaminant Level
MDOR	Multicycle Direct Oxide Reduction
MEI	maximally exposed individual
MeV	million electron volts
MFC	Materials and Fuels Complex
MFFF	MOX Fuel Fabrication Facility
MHR	Multipurpose Haul Road
MLLW	mixed low-level radioactive waste

MOTAs	Materials Open Test Assemblies
MOX	mixed oxide
MSA	Material Storage Area
MSE	Molten Salt Extraction
MSFTR	molten-salt-cooled fast test reactor
MSR	molten salt reactors
MVa	megavolt-amperes
MW	megawatt
MWh	megawatt-hour
MWth	megawatts thermal
NAAQS	National Ambient Air Quality Standards
NASA	National Aeronautics and Space Administration
NCRP	National Council on Radiation Protection and Measurements
NDC	Natural Phenomena Hazards Design Category
NEAC	Nuclear Energy Advisory Committee
NEPA	National Environmental Policy Act
NEICA	Nuclear Energy Innovation Capabilities Act of 2017
NERP	National Environmental Research Park
NESHAP	National Emission Standards for Hazardous Air Pollutants
NFS	Nuclear Fuel Services, Inc.
NHPA	National Historic Preservation Act
NIW	noninvolved worker
NNSA	National Nuclear Security Administration
NNSS	Nevada National Security Site
NO <sub>2</sub>	nitrogen dioxide
NOA	Notice of Availability
NOI	Notice of Intent
NOx	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NPH	natural phenomena hazard
NPS	National Park Service
NRAD	neutron radiography
NRC	U.S. Nuclear Regulatory Commission
NRHP	National Register of Historic Places
NSUF	Nuclear Science User Facilities
O <sub>3</sub>	ozone
ORR	Oak Ridge Reservation
ORNL	Oak Ridge National Laboratory
OSHA	Occupational Safety and Health Administration
PAC	protective action criteria
PC	Performance Category
PCBs	polychlorinated biphenyls
pCi/L	picocuries per liter
PCS	plant control systems
PDCF	Pit Disassembly and Conversion Facility
PEIS	Programmatic Environmental Impact Statement

PF-4	Plutonium Facility
PGA	peak ground acceleration
PHTS	Primary Heat Transport System
PIDAS	Perimeter Intrusion Detection and Assessment System
PLOHS	protected loss of heat sink
PM <sub>2.5</sub>	particulate matter less than or equal to 2.5 microns in diameter
PM <sub>10</sub>	particulate matter less than or equal to 10 microns in diameter
PMDA	Plutonium Management and Disposition Agreement
PNNL	Pacific Northwest National Laboratory
POCs	pipe overpack containers
ppm	parts per million
PRA	probabilistic risk assessment
PRISM	Power Reactor Innovative Small Module
PSBO	protected station blackout
PSD	Prevention of Significant Deterioration
psig	pounds per square in gauge
PTC	permit to construct
PTOP	protected transient overpower
R&D	research and development
RADTRAN	Radioactive Material Transportation Risk Assessment
RCRA	Resource Conservation and Recovery Act
REDC	Radiochemical Engineering Development Center
rem	roentgen equivalent man
RESL	Radiological and Environmental Sciences Laboratory
RF	respirable fraction
RH-TRU	remote-handled transuranic waste
RISKIND	Risks and Consequences of Radioactive Material Transport
ROD	Record of Decision
ROI	region of influence
RPS	Reactor Protection System
RVACS	Reactor Vessel Auxiliary Cooling System
RWMC	Radioactive Waste Management Complex
SA	Supplemental Analysis
SAHX	sodium-to-air heat exchanger
SBO	station blackout
SCDHEC	South Carolina Department of Health and Environmental Control
SCDNR	South Carolina Department of Natural Resources
SDA	Subsurface Disposal Area
SDC	seismic design category
SDWA	Safe Drinking Water Act
SGCN	Species of Greatest Conservation Need
SHPO	State Historic Preservation Officer
SIP	State Implementation Plan
SNF	spent nuclear fuel
SO <sub>2</sub>	sulfur dioxide
SPD	Surplus Plutonium Disposition

SR	State Route
SRNL	Savannah River National Laboratory
SRNS	Savannah River Nuclear Solutions
SRPA	Snake River Plain Aquifer
SRR	Savannah River Remediation
SRS	Savannah River Site
SRTE	Savannah River Tritium Enterprise
STA	Secure Transportation Asset
SWAP	State Wildlife Action Plan
SWPPP	stormwater pollution prevention plan
SWPT	sanitary wastewater treatment plant
T&E	threatened and endangered
TAPs	toxic air pollutants
TDEC	Tennessee Department of Environment and Conservation
TEEL	Temporary Emergency Exposure Limit
TRC	Total Reportable Cases
TREAT	Transient Reactor Test
TRU	transuranic
TRUPACT-II	Transuranic Package Transporter Model 2
TSCA	Toxic Substance Control Act
TSP	total suspended particulates
TTHM	total trihalomethanes
TVA	Tennessee Valley Authority
TWPC	Transuranic Waste Processing Center
TWRA	Tennessee Wildlife Resources Agency
µg/L	micrograms per liter
U/Pu/Zr	uranium/plutonium/zirconium alloy
UK	United Kingdom
ULOF	unprotected (without scram) loss-of flow
ULOHS	unprotected loss-of-heat-sink
U.S.C.	<i>United States Code</i>
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGCRP	U.S. Global Change Research Program
USGS	U.S. Geological Survey
UTOP	unprotected transient overpower
VOC	volatile organic compound
VRM	Visual Resource Management
VTR	Versatile Test Reactor
WAG	Waste Area Group
WCS	Waste Control Specialists
WebTRAGIS	Web Transportation Routing Analysis Geographic Information System
WIPP	Waste Isolation Pilot Plant
Y-12	Y-12 National Security Complex
ZPPR	Zero Power Physics Reactor

**CONVERSIONS**

METRIC TO ENGLISH			ENGLISH TO METRIC		
Multiply	by	To get	Multiply	by	To get
<b>Area</b>					
Square meters	10.764	Square feet	Square feet	0.092903	Square meters
Square kilometers	247.1	Acres	Acres	0.0040469	Square kilometers
Square kilometers	0.3861	Square miles	Square miles	2.59	Square kilometers
Hectares	2.471	Acres	Acres	0.40469	Hectares
<b>Concentration</b>					
Kilograms/square meter	4.46	Tons/acre	Tons/acre	0.224	Kilograms/square meter
Milligrams/liter	1 <sup>a</sup>	Parts/million	Parts/million	1 <sup>a</sup>	Milligrams/liter
Micrograms/liter	1 <sup>a</sup>	Parts/billion	Parts/billion	1 <sup>a</sup>	Micrograms/liter
Micrograms/cubic meter	1 <sup>a</sup>	Parts/trillion	Parts/trillion	1 <sup>a</sup>	Micrograms/cubic meter
<b>Density</b>					
Grams/cubic centimeter	62.428	Pounds/cubic foot	Pounds/cubic foot	0.016018	Grams/cubic centimeter
Grams/cubic meter	0.0000624	Pounds/cubic foot	Pounds/cubic foot	16,018.5	Grams/cubic meter
<b>Length</b>					
Centimeters	0.3937	Inches	Inches	2.54	Centimeters
Meters	3.2808	Feet	Feet	0.3048	Meters
Kilometers	0.62137	Miles	Miles	1.6093	Kilometers
<b>Radiation</b>					
Sieverts	100	Rem	Rem	0.01	Sieverts
<b>Temperature</b>					
<i>Absolute</i>					
Degrees C + 17.78	1.8	Degrees F	Degrees F - 32	0.55556	Degrees C
<i>Relative</i>					
Degrees C	1.8	Degrees F	Degrees F	0.55556	Degrees C
<b>Velocity/Rate</b>					
Cubic meters/second	2118.9	Cubic feet/minute	Cubic feet/minute	0.00047195	Cubic meters/second
Grams/second	7.9366	Pounds/hour	Pounds/hour	0.126	Grams/second
Meters/second	2.237	Miles/hour	Miles/hour	0.44704	Meters/second
<b>Volume</b>					
Liters	0.26418	Gallons	Gallons	3.7854	Liters
Liters	0.035316	Cubic feet	Cubic feet	28.316	Liters
Liters	0.001308	Cubic yards	Cubic yards	764.54	Liters
Cubic meters	264.17	Gallons	Gallons	0.0037854	Cubic meters
Cubic meters	35.314	Cubic feet	Cubic feet	0.028317	Cubic meters
Cubic meters	1.3079	Cubic yards	Cubic yards	0.76456	Cubic meters
Cubic meters	0.0008107	Acre-feet	Acre-feet	1233.49	Cubic meters
<b>Weight/Mass</b>					
Grams	0.035274	Ounces	Ounces	28.35	Grams
Kilograms	2.2046	Pounds	Pounds	0.45359	Kilograms
Kilograms	0.0011023	Tons (short)	Tons (short)	907.18	Kilograms
Metric tons	1.1023	Tons (short)	Tons (short)	0.90718	Metric tons
<b>ENGLISH TO ENGLISH</b>					
Acre-feet	325,850.7	Gallons	Gallons	0.000003069	Acre-feet
Acres	43,560	Square feet	Square feet	0.000022957	Acres
Square miles	640	Acres	Acres	0.0015625	Square miles

a. This conversion is only valid for concentrations of contaminants (or other materials) in water.

**METRIC PREFIXES**

Prefix	Symbol	Multiplication factor
exa-	E	1,000,000,000,000,000,000 = 10 <sup>18</sup>
peta-	P	1,000,000,000,000,000 = 10 <sup>15</sup>
tera-	T	1,000,000,000,000 = 10 <sup>12</sup>
giga-	G	1,000,000,000 = 10 <sup>9</sup>
mega-	M	1,000,000 = 10 <sup>6</sup>
kilo-	k	1,000 = 10 <sup>3</sup>
deca-	D	10 = 10 <sup>1</sup>
deci-	d	0.1 = 10 <sup>-1</sup>
centi-	c	0.01 = 10 <sup>-2</sup>
milli-	m	0.001 = 10 <sup>-3</sup>
micro-	μ	0.000 001 = 10 <sup>-6</sup>
nano-	n	0.000 000 001 = 10 <sup>-9</sup>
pico-	p	0.000 000 000 001 = 10 <sup>-12</sup>