RSI-KES-DLV-TO3-002

Engineering Evaluation/ Cost Analysis (EE/CA) for the F-Complex at the Knolls Atomic Power Laboratory

December 2022

Prepared for:

U.S. Department of Energy
Environment Management Consolidated Business Center –
New York Project Office

Prepared by:

Contract Number: 89303321DEM000057

Task Order Number: 89303321FEM400235

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LIST OF ACRONYMS

°	degrees
ACM	asbestos-containing material
ALARA	as low as reasonably achievable
ARAR	Applicable or Relevant and Appropriate Requirement
ATR	Advanced Test Reactor
CAA	Clean Air Act of 1970
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations
Ci	Curie
cm^2	square centimeter
cy	cubic yard(s)
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EE/CA	Engineering Evaluation/Cost Analysis
EM	DOE Office of Environmental Management
EPA	U.S. Environmental Protection Agency
ES	Executive Summary
F	Fahrenheit
FCPE	Full Core Physics Experiment
FPR	Flexible Plastic Reactor
ft	foot (feet)
HAZ	Hazardous
HDPE	High-density polyethylene
hr	hour
HSA	Historical Site Assessment
in	inch(es)
kW	kilowatt
LFM	Legacy Facility Management
LLC	limited liability company
LLW	low level waste
ls	lump sum
M	million
mRem	millirem
NCP	National Contingency Plan
NEPA	National Environmental Policy Act of 1970
NHPA	National Historic Preservation Act of 1966
NPDES	National Pollutant Discharge Elimination System
NR	Naval Reactors
NRLFO	Naval Reactors Laboratory Field Office
NTCRA	Non Time Critical Removal Action
NY	New York

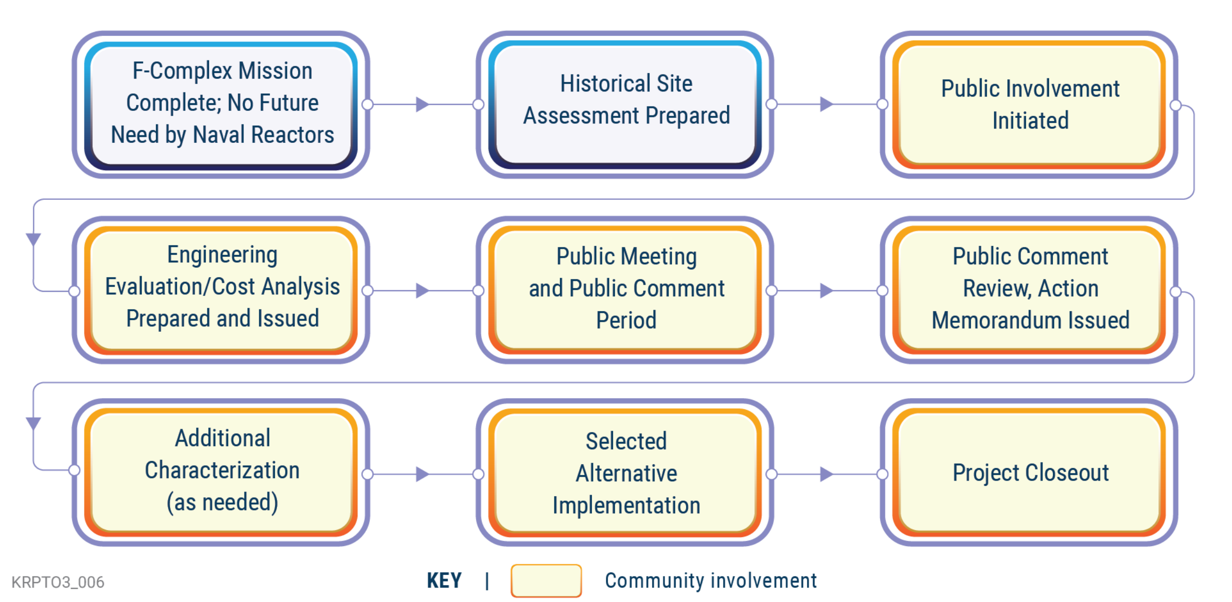
NYCRR	New York Codes, Rules and Regulations
NYSDEC	New York State Department of Environmental Conservation
NYSHPO	New York State Historic Preservation Office
O&M	operation and maintenance
PCB	polychlorinated biphenyl
pCi	picocurie(s)
psi	pounds per square inch
RADIAC	radiation detection, indication, and computation
RCF	RADIAC Calibration Facility
RCRA	Resource Conservation and Recovery Act of 1976
Rem	Roentgen equivalent man
RmAO	removal action objective
sf	square foot (feet)
SNM	special nuclear material
SPRU	Separations Process Research Unit
SWMU	solid waste management unit
T&E	threatened or endangered
TBC	to be considered
TTR	Thermal Test Reactor
W	watt
yr	year

EXECUTIVE SUMMARY

This Engineering Evaluation/Cost Analysis (EE/CA) has been prepared for the U.S. Department of Energy (DOE) and Office of Naval Reactors (NR) at the Knolls Atomic Power Laboratory (Knolls Laboratory) in Niskayuna, NY, to identify alternatives for disposition of the F-Complex. As the F-Complex has reached the end of its mission and cannot be reused by the Knolls Laboratory in its present state, DOE no longer has a need for the buildings and is seeking a disposition alternative that is protective of human health and the environment while balancing its effectiveness, implementability, and cost.

Disposition of the F-Complex is being planned as a Non-Time Critical Removal Action (NTCRA) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980. In addition, National Environmental Policy Act (NEPA) values are incorporated into the CERCLA process, in accordance with DOE NEPA policy (DOE 2002). Figure ES-1 delineates the phases of the CERCLA NTCRA process for the F-Complex and the position and timing of the EE/CA in the overall process.

Figure ES-1. Phases of the CERCLA NTCRA Process for the F-Complex



The F-Complex, located in the northwest portion of the upper level of the Knolls Laboratory site, consists of five integrally connected buildings referred to as F1, F2, F3, F4, and F6 (F5 was demolished in 1978). The buildings were constructed between 1951 and 1970 and supported the Knolls Laboratory mission over their lifetime. From the early 1950s to the 1980s, the buildings housed a variety of test research reactors. At the end of the research phase for each reactor, the nuclear fuel was removed leaving all or portions of the "reactor assembly" in place. The F-Complex has three inactive, defueled, research reactor assemblies, referred to in this document as "defueled assemblies."

The three defueled assemblies in F-Complex are the Full Core Physics Experiment (FCPE) and the Thermal Test Reactor (TTR), both located in Building F2, and the Flexible Plastic Reactor (FPR), located in F6. The defueled assemblies are described in Section 1.1.2 (Description of the F-Complex) as a part of the building descriptions.

F-Complex is a contributing element of the Knolls Site Historic District. In accordance with the National Historic Preservation Act (NHPA), the DOE has finalized a Programmatic Agreement, in cooperation with the New York State Historic Preservation Office, which defines actions that DOE will take to mitigate loss of contributing elements. Those actions include documenting the history of F-Complex in accordance with the existing Programmatic Agreement.

A Historical Site Assessment (HSA) has been prepared (DOE 2022a) to document the presence of residual contamination within the F-Complex. Low levels of radioactive contamination are present on inaccessible building surfaces. In addition, regulated and hazardous materials are present in areas throughout the buildings such as friable and non-friable asbestos. Chemical contamination includes beryllium in overhead areas (primarily in inaccessible locations); lead in paint and shielding around reactor components; and polychlorinated biphenyls (PCBs) in paints and light ballasts.

Over time, as the facilities age, costs to maintain conditions protective of human health and the environment increase and the potential for a release to the environment increases. Therefore, DOE is evaluating alternatives for addressing the residual contamination and hazardous materials in the F-Complex: Alternative 1, continued Legacy Facilities Management (LFM), the "no action" alternative; Alternative 2, Cleanout of the Defueled Assemblies; and Alternative 3, Demolition of F-Complex. A qualitative risk evaluation is completed to identify potential risks to human health or the environment and justify the need for a removal action. The goal of the F-Complex removal action is to restore the F-Complex and surrounding area to a state that is consistent with DOE's continuing research mission at the Knolls Laboratory site. Three removal action alternatives were considered for F-Complex disposition, as described in Table ES-1.

Table ES-1. Removal Action Alternatives

Alternative	Description
Alternative 1 – Continued Legacy Facility Management (LFM) ("No Action" alternative)	Under this alternative, the buildings and defueled assemblies would remain in their current state while LFM activities would continue.
Alternative 2 – Cleanout of Defueled Assemblies	This alternative would involve removal of tanks, equipment, and piping associated with the defueled assemblies and decontamination and removal of the defueled assemblies. LFM activities would continue.
Alternative 3 – Demolition of F-Complex	This alternative would involve removal of tanks, equipment, and piping associated with the defueled assemblies, decontamination and removal of the defueled assemblies, and demolition of all five buildings within the F-Complex.

In this EE/CA, the three removal action alternatives are evaluated in terms of effectiveness, implementability, and cost. The advantages and disadvantages of each alternative are analyzed relative to one another so that key tradeoffs that would affect the remedy selection can be identified.

DOE recommends that Alternative 3, Demolition of F-Complex, be selected as the preferred removal action. Demolition would be a permanent and effective remedy that is readily implemented with demonstrated technologies and would make the building footprint available for use by DOE in continuing its research mission at the Knolls Laboratory.

1.0 INTRODUCTION

The DOE no longer has a need for the F-Complex, which was formerly used by NR to conduct research and testing of nuclear reactors used in aircraft carriers and submarines. Due to residual contamination in the buildings, the F-Complex cannot be reused by the Knolls Laboratory in its present state. While the F-Complex continues to be maintained in a safe condition, the potential for a release to the environment increases as the facilities age and deteriorate. Therefore, DOE is evaluating alternatives for the disposition of the F-Complex to address the residual contamination.

Disposition of the F-Complex is being planned as a NTCRA under CERCLA and in a manner consistent with the National Oil and Hazardous Substances Pollution Contingency Plan (National Contingency Plan [NCP]). In addition, NEPA values are incorporated into the CERCLA process in accordance with DOE NEPA Policy (DOE 2002). DOE has lead agency authority for implementing CERCLA actions at the site, with input from the U.S. Environmental Protection Agency (EPA), the New York State Department of Environmental Conservation (NYSDEC), and public stakeholders. DOE invites input from the public and community as a vital element of its CERCLA process. Details of these outreach efforts are described in the Community Involvement Plan for the F-Complex (DOE 2022b).

This EE/CA is being prepared in accordance with *Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA* (EPA 1993). The EE/CA describes the site background, nature and extent of contamination, potential risks to human health and the environment, and appropriate removal action objectives (RmAOs). It also describes various alternatives being considered for the disposition of the F-Complex and evaluates those alternatives with respect to their effectiveness, implementability, and cost.

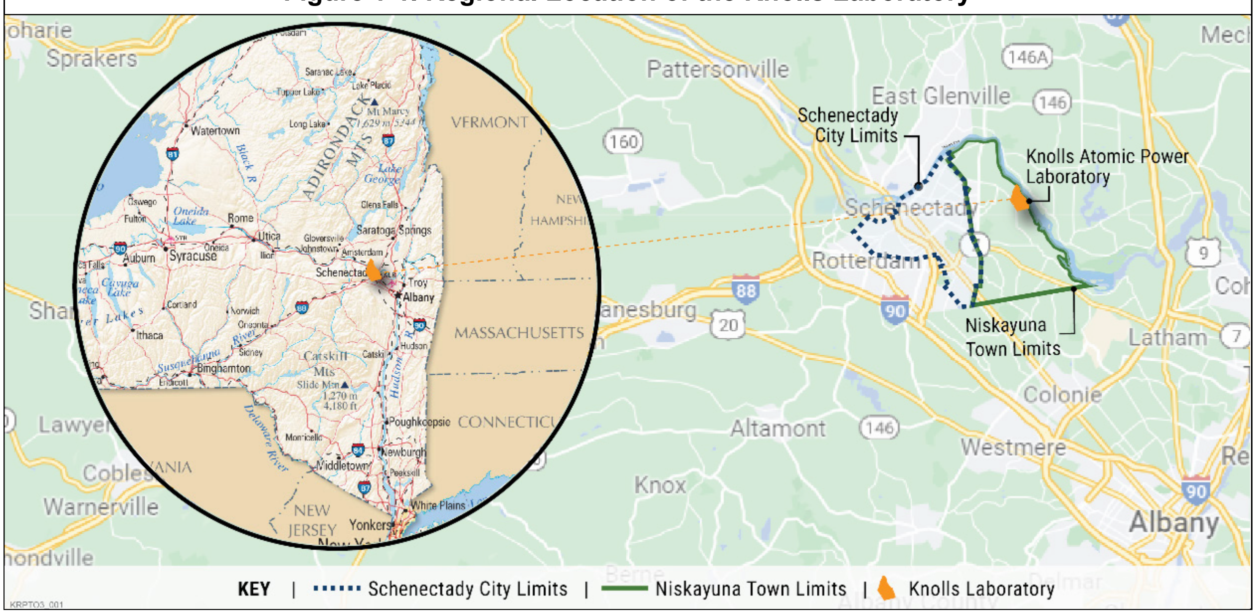
> For the F-Complex project, the No Action alternative is Alternative 1, Continued Legacy Facility Management. This alternative would continue surveillance and monitoring and include necessary building maintenance.

1.1 Site Characterization

1.1.1 Site Description and Background

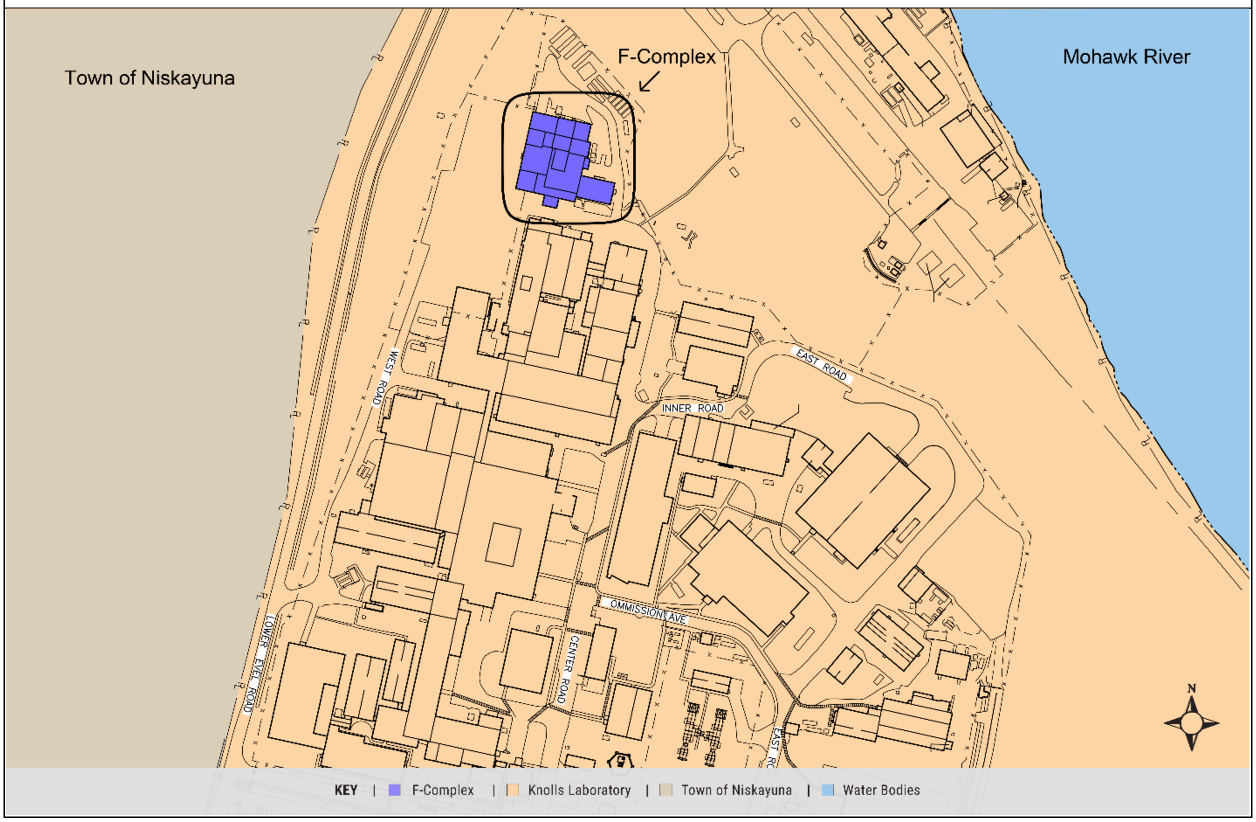
The Knolls Laboratory site, located in Niskayuna, NY (Figure 1-1), was established in May 1946. The principal function at the Knolls Laboratory is research and development in the design and operation of naval nuclear propulsion plants. The Knolls Laboratory is owned by DOE and operated by their

Figure 1-1. Regional Location of the Knolls Laboratory



contractor, Fluor Marine Propulsion, LLC. It is situated on 170 acres of land on the south bank of the Mohawk River. Facilities at the Knolls Laboratory include administrative offices; machine shops; a sewage pumping station; a boiler house; oil storage facilities; cooling towers; waste storage facilities; and chemistry, physics, and metallurgical laboratories. The F-Complex is located in the northwest portion of the upper level of the Knolls Laboratory site (Figure 1-2).

Figure 1-2. Location of F-Complex on the Knolls Laboratory Site

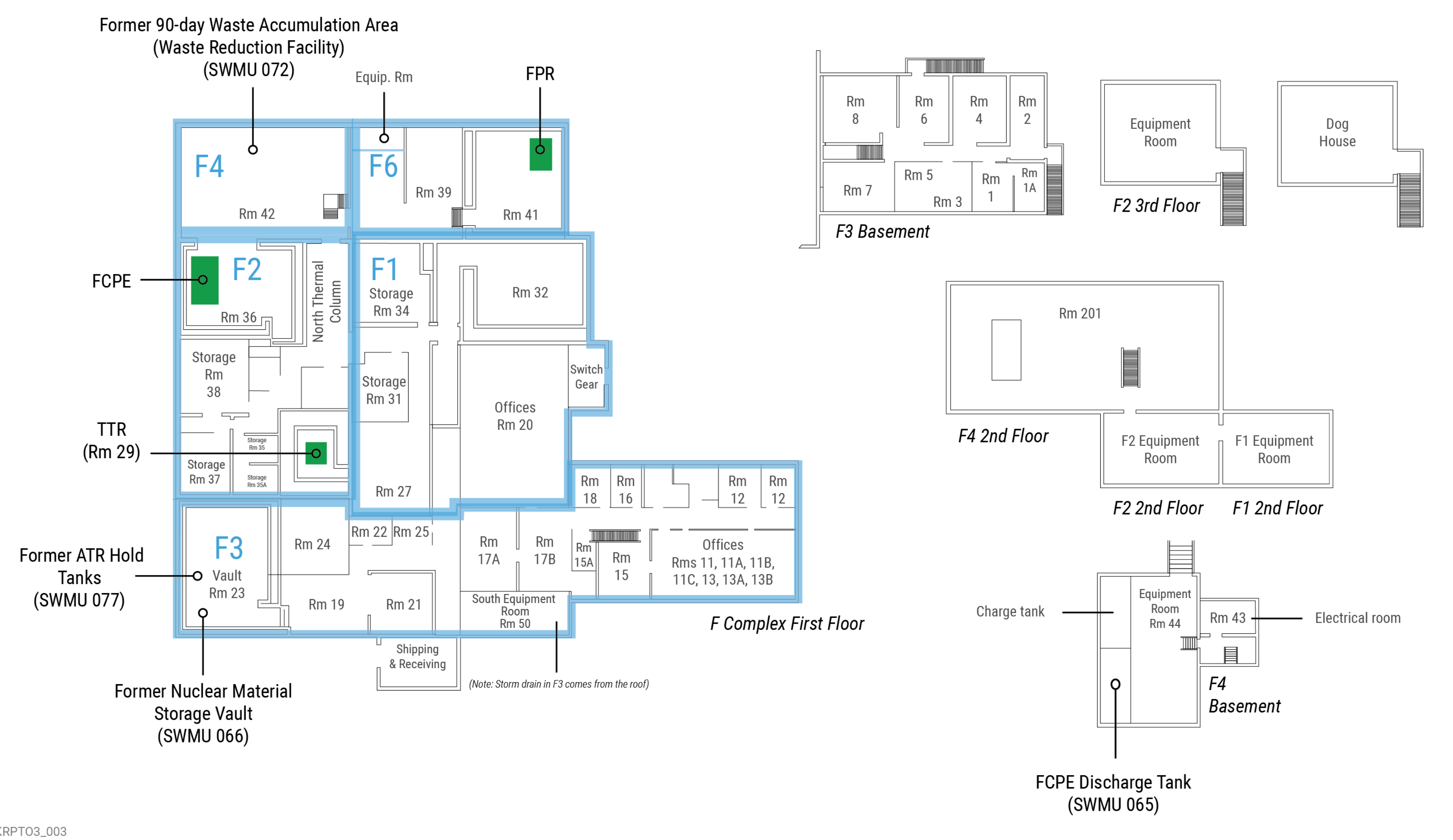


The F-Complex is comprised of five integrally connected masonry and steel frame buildings (F1, F2, F3, F4, and F6; F5 was demolished in 1978), as shown in Figure 1-3. The F-Complex includes a total building area of 31,094 sf. The buildings were constructed between 1951 and 1970 and supported the Knolls Laboratory mission over their lifetime. From the early 1950s to the 1980s, the F-Complex housed a variety of test research reactors, three of which remain in place—the Thermal Test Reactor (TTR) located in Building F2, which operated at up to 10kW; the Flexible Plastic Reactor (FPR) located in Building F6, which operated at zero power; and the Full Core Physics Experiment (FCPE) located in Building F2, which also operated at zero power. These reactors have been defueled and placed in a lay-up (inactive) condition designed to minimize the required level of attention.

The **TTR, FPR, and FCPE reactors** were developed and used for research purposes. At the end of the research phase for each reactor, the nuclear fuel was removed leaving all or portions of the “reactor assembly” in place. TTR, FPR, and FCPE are now inactive, defueled, research reactor assemblies, referred to in this document as “**defueled assemblies**.”

Zero-power is a controlled operating condition where a reactor sustains a safe, stable fission chain reaction at low neutron flux. Due to the low neutron flux, the reactor does not generate significant heat or radiation.

Figure 1-3. Layout of the F-Complex



KEY | Defueled Assemblies

Several areas within or near the F-Complex that formerly stored or managed solid waste are identified as Solid Waste Management Units (SWMUs) in the Hazardous Waste Management Permit (6 NYCRR Part 373 Resource Conservation and Recovery Act of 1976 [RCRA] Permit) for the Knolls Laboratory. The location of four of these SWMUs interior to F-Complex are shown on Figure 1-3. While Section 1.1.3 provides additional information on the SWMUs, the disposition of the SWMUs is addressed under the Corrective Action provisions of the Knolls Laboratory RCRA permit.

1.1.2 Description of F-Complex

The buildings within the F-Complex have basement levels and multi-height, above-grade levels. All buildings have roofs constructed of precast concrete planks with rigid insulation board and multi-ply roofing. Several rooms have a dense amount of residual equipment; other rooms have recently served as office space. The buildings are now mostly vacant, except for the three defueled assemblies and rooms containing residual equipment. Various quantities of regulated and hazardous materials (e.g., asbestos, lead, and PCBs) are present in items such as insulation, floor and ceiling tiles, paint, electrical equipment (e.g., switches, wiring). Various levels of beryllium and residual radioactivity (beta-gamma and alpha) are present in inaccessible areas throughout the buildings (e.g., above ceilings, overhead ducts) and in some piping and isolated ventilation systems. The highest radioactivity levels are associated with the defueled assemblies. Selected photos of the F-Complex are provided as Figures 1-4 – 1-10 throughout this section.

Building F1, built in 1951, is a one- to one-and-a-half-story, 8,108-sf masonry and steel-framed structure on a concrete slab (Figure 1-4). Structural steel walls in office areas are enclosed with cement-asbestos siding over rigid insulation board. Building F1, Room 32, previously housed the Preliminary Pile Assembly (PPA) and Solid Homogeneous Assembly (SHA) test reactors, both of which have been dismantled and removed. The room, which had subsequently served as a former Container Storage Facility, has 5- to 6-ft thick concrete walls and a 5-ft wide x 7-ft tall x 3-in thick solid steel swinging door. A former fuel vault located within Building F1, Room 34, was previously emptied and is no longer in use; the former fuel vault has 1-ft thick concrete walls and a 3-ft x 6.5-ft steel vault door. Building F1 also contains a former control room (partially dismantled) for the TTR. Until recently, several rooms within Building F1 were used by DOE for offices, meetings/conferences, waste storage, and mechanical and electrical equipment operations.

Figure 1-4. Buildings F1 (center) and F6 (right) with F2 and FCPE Tower in Background

Building F2, built in 1954, is a 4,460-sf combination multi-story, masonry, and steel-framed structure. Building F2 supported operations of the TTR and FCPE assemblies, both of which are now defueled and inactive. A few rooms within Building F2 had been used until recently by DOE for waste storage and mechanical/electrical equipment operations. Figure 1-5 provides a view of the TTR.

The TTR was a test reactor that used clad fuel disks in configurations that allowed operations ranging from 1 W to 10 kW thermal. It was unpressurized, water cooled, and water moderated with carbon neutron reflectors. Its mission was to evaluate reactivity coefficients, conduct neutron spectrum studies and activation experiments, and measure detector response characteristics. Two components with radiation levels greater than or equal to 100 mrem/hr remain within the TTR cell and are shielded in place (a loading plug and two resin columns). The cell walls are 5- to 6-ft thick reinforced concrete with a 2-ft thick concrete sliding door.

Figure 1-5. Thermal Test Reactor (TTR) in Building F2, Room 29

The FCPE was a pressurized, zero-power test reactor (Figure 1-6). The FCPE used clad and unclad fuel for mockups and method qualification data for several propulsion reactor designs. The FCPE cell is large and fairly complex, with considerable support/auxiliary systems. The pressurizer, two air receiver tanks, and reactor head lifting mechanism drive motors (and their associated lubricating oil system) are located on the mezzanine on top of the reactor cell (about four stories above grade). The fuel has been removed from the reactor and fluid systems have been drained. In addition, the control rod drive mechanisms, power supplies, empty cells, reactor control instrumentation, and material storage racks have also been removed. The FCPE pressure vessel and head assembly measures approximately 12-ft in diameter x 20-ft tall and weighs about 120 tons. The FCPE reactor has a basement and a sub-basement extending about 20-ft below-grade and the above-grade portions extend up approximately four stories.

Building F2, Room 36, which houses the FCPE, previously housed three other test reactors: the Proof Test Reactor (PTR), the Alternate Coolant Mockup Experiment (ACME), and the Plastic Moderated Assembly (PMA). These former reactors have been dismantled and removed.

Figure 1-6. FCPE in Building F2, Room 36

Building F3, built in 1954, is a 11,501-sf multi-story, masonry structure (Figure 1-7). The east wing has a basement that is approximately 15-ft below grade, which previously contained small-scale shop/assembly facilities. Two basement rooms contained equipment for counting beta-gamma activity on irradiated materials and for gamma scanning fuel strips and plates from the reactor assemblies. All such equipment has been removed. Several rooms within Building F3 were used by DOE for offices, restroom facilities, radiological waste storage, and mechanical/electrical equipment operations. On the south side of Building F3 is a masonry block high bay annex that was used for shipping and receiving.

The former Advanced Test Reactor (ATR), which has been dismantled and removed, had been housed in Building F3. The former ATR area was subsequently used as a Special Nuclear Material (SNM) storage area and contains a Vertical Reciprocating Conveyor. It has 2- to 3-ft-thick reinforced concrete walls and a 2-ft thick concrete sliding door. DOE has removed the SNM.

Figure 1-7. Building F3 with F2 and Full Core Physics Experiment (FCPE) Tower in Background

Building F4, built in 1970, is a 4,766-sf two-story masonry and steel-framed structure, a portion of which includes a basement level that is approximately 10-ft below grade. It originally served as the Assembly Room for the FCPE and later as a satellite Waste Reduction Facility and a light-duty shop space. Currently the area is empty. The Assembly Room walls are structural steel enclosed with corrugated aluminum siding with a steel-framed, steel-deck mezzanine on the second level. Other rooms in Building F4 had been used by DOE for mechanical/electrical equipment operation and building sump operations.

The Mechanical Equipment Room, located in the basement of Building F4, contained support equipment for the FCPE. This room contains the inactive gas-fired boiler, charging pumps, circulating pumps, demineralizer pumps, control rod drive mechanism cooling pumps, chemical injection tank and pump, fill pump, heat exchangers, demineralizer system (consisting of one demineralizer tank and two prefilters), and associated piping and valves. The demineralizer media and filter elements have been removed. Figure 1-8 provides a photo of Building F4, Room 42.

Figure 1-8. Assembly Room in Building F4, Room 42

Building F6, built in 1959, is a one- to one-and-a-half-story, 2,259 sf masonry and steel-framed structure on a concrete slab. Building F6 houses the FPR, a zero-power test reactor that was operated dry and had no associated fluid systems. The FPR is currently encased in a five-sided (no bottom) wood box with a sheet metal covering to prevent the migration of contamination. The walls of the FPR cell are 2 ft thick, except for the west wall, which is 4 ft thick. Portions of Building F6 had previously been used by DOE to house a radiation detection, indication, and computation (RADIAC) Calibration Shop and radiological calibration operations. An electrical equipment operations room in Building F6 was used for equipment storage. Figure 1-9 is a photo of Buildings F6 and F4 with F2 and the FCPE tower in the background. Figure 1-10 shows the FPR located in Building F6, Room 41.

Figure 1-9. Buildings F6 (left) and F4 (right) with F2 and FCPE Tower in Background

Figure 1-10. Flexible Plastic Reactor (FPR) Enclosure in Building F6, Room 41

1.1.3 Previous Actions (Deactivation After Shutdown)

All of the earlier test reactors in the F-Complex have been shut down and removed. The TTR and FCPE assemblies in Building F2 have been defueled and deactivated, and the fluid systems have been drained. The FPR in Building F6, which had no fluid system, has also been defueled and deactivated. The former fuel vaults in Buildings F1 and F3 have been emptied.

Four former SWMUs located within the F-Complex footprint have been closed. NYSDEC has determined that no further action is required. These SWMUs are listed in Table 1-1.

Table 1-1. F-Complex Buildings Solid Waste Management Units
SWMU-065, FCPE Discharge Tank
• Located in Building F4, Room 44 (Mechanical Equipment Room) • Discharge tank is located adjacent to a similar charging tank; each tank is 8 ft wide x 15 ft long x 13 ft deep; the bottom 10 ft of each tank is lined with stainless steel • Charge tank was used to store coolant prior to use, and the discharge tank was used to store coolant subsequent to use • Tanks were drained and taken out of service in August 1995; less than an inch of residue remains in the tanks • No spills or releases to the environment • No further action
SWMU-066, Former Nuclear Material Storage Vault
• Located in Building F3, Room 23; consists of a concrete fuel storage vault measuring ~40 ft wide x 30 ft long • Initially used to store SNM; when fuel storage operations ceased, the vault was briefly used during 1994 and 1995 to store construction and demolition debris • Vault is designated as a SWMU from its past use for storage of construction and demolition debris • No spills or releases to the environment • No further action
SWMU-072, Former 90-Day Waste Accumulation Area (Waste Reduction Facility [WRF])
• Located in Building F4, SWMU-072, also referred to as the Waste Reduction Facility (WRF), was a 90-day waste accumulation area that operated from July 1996 to May 2015 and was closed in accordance with State regulations • Consisted of ~1,600 sf of floor area equipped with a welded stainless steel secondary containment structure • Recyclable materials were prepared for off-site recycling in the vicinity of the building; preparation included disassembly, segregation, and/or paint stripping • Wastes generated from preparation activities were containerized and stored in this area • No spills or releases to the environment • No further action
SWMU-077, Former ATR Hold Tanks
• Two above-ground, stainless-steel tanks were located within the Building F3, Room 23 ATR area • Tanks were 3.5 ft in diameter and 6 ft high and had a combined capacity of 750 gallons • ATR and the hold tanks were disassembled and shipped to another DOE facility for use • No spills or releases to the environment • No further action

1.2 Sources, Nature, and Extent of Contamination

This section includes a summary of any known and potential radiological and chemical contamination associated with the F-Complex. DOE has prepared a detailed description in the F-Complex HSA of the nature and extent of hazardous substances and potentially hazardous materials within the F-Complex, including radiological contamination, chemical contamination, contaminated materials, and construction materials such as asbestos containing floor tile (DOE 2022a).

Known and Potential Radiological Contamination. Based on historical information and predictive modeling, the total activity contained within the F-Complex is estimated at approximately 1 Ci. One-half a Curie is estimated to exist within the defueled assemblies and one-half a Curie from known fixed contamination, inaccessible areas, pipe runs, and closed tank systems. The highest radioactivity levels are associated with the following defueled assemblies housed within the buildings. There is potential for low, but detectable, levels of radioactive contamination on surfaces that may become newly exposed.

- **TTR.** Contamination levels of 200,000 pCi/100 cm² beta/gamma radiation remain within the core structural housing of the TTR reactor. This is at least 400 times greater than normally accepted surface contamination levels. Shielded components located within the reactor cell include two resin columns (3,000 mrem/hr unshielded, 2.5 mrem/hr shielded) and a loading plug (4,000 mrem/hr unshielded, 0.3 mrem/hr shielded), both of which are posted High Radiation Areas (≥100 mrem/hr).

Nearly all of the estimated one-half Curie of radioactivity in the F-Complex is contained within these two resin columns. There is no loose surface contamination in accessible areas of the TTR reactor.

- **FCPE.** There is no loose surface contamination in accessible areas of the FCPE reactor. Low-level alpha contamination may exist in system piping, components, and inaccessible areas. The FCPE reactor cell is a Radiologically Controlled Area (uranium control system) and Radioactive Material Storage Area.
- **FPR.** The core structural components of the FPR have low- to medium-level alpha contamination. The entire defueled assembly is encased in a five-sided wooden box for contamination control that includes a sheet metal covering for fire protection.

In addition, access controls are in place in several rooms within the F-Complex to prevent unnecessary and unmonitored worker exposure. Accessible areas are maintained at <20 pCi/100 cm^2 alpha and <450 pCi/100 cm^2 beta-gamma. Localized higher levels are known or suspected in inaccessible areas, including above ceilings. One room in Building F2, Room 29, that contains the TTR, is a posted radiation area, >1mrem/hr.

Plutonium-alpha transuranic isotopes were identified on the original concrete floor of the F3 South Equipment Room (Room 50) from contaminated tools and equipment. The contamination has been isolated by covering the floor tiles.

Chemical Contamination. Various quantities of hazardous substances (e.g., lead, PCBs, and beryllium), contaminated materials, and potentially hazardous materials (e.g., asbestos, beryllium, lead, and PCBs) are present in discrete areas throughout the buildings and in some piping and ventilation systems. Friable and non-friable asbestos is present in thermal insulation, floor and ceiling tiles, transite, paint, caulk/sealant, and the gas-fired boiler within the FCPE Mechanical Equipment Room. Some of the asbestos containing materials (ACM) have been abated from the former Mechanical Equipment Room located in the basement of Building F4; however, a significant amount is still associated with the gas-fired boiler. A former machine shop area in Building F1 has low, but detectable beryllium dust contamination in the overhead areas (ceiling) primarily on overhead beams, ductwork, and other inaccessible locations. Lead is present in lead shielding around reactor components, lead anchors in masonry walls, lead-based paint, and various equipment (switches, relays, wiring, piping, meters, fluorescent lamps, batteries). PCBs are present in some paints and in light ballasts. Mercury contamination is likely to be found in old utility switches and gauges throughout the F-Complex.

1.2.1 Potential Migration Pathways and Release Mechanisms

Potential migration pathways from the F-Complex include any penetrations or openings in slabs, walls, and roofs leading outside the buildings. This includes existing doors, windows, drains, and ventilation systems to the outside.

> A **Migration Pathway** means natural geologic or cultural features such as swales, rock fractures, water mains, sewage laterals, drain tiles, roadbeds, etc., that allow the movement of a hazardous substance.
>
> A **Release Mechanism** is the way in which a contaminant travels from its source to the environment, such as by a spill, release, leak, emission, or a combination of those mechanisms.

Other potential release mechanisms include the degradation of the F-Complex structure over time, or a catastrophic event, i.e., flood, tornado, earthquake, that severely damaged the structure, exposing radiological-, chemical-, and asbestos-contaminated areas to the environment.

Under current conditions, contaminant migration outside of the F-Complex is unlikely due to the fixed nature of the contaminants and the intact structure. In addition, current LFM activities reduce the likelihood of contaminant migration to surface water or groundwater via runoff or infiltration through preventive maintenance. The ongoing environmental monitoring program is also designed to identify any increases in contaminants present in liquid and gaseous effluent from the Knolls Laboratory.

Consistent with the RCRA Permit for the Knolls Laboratory , there are no known chemical spills or releases to the environment. The HSA found no evidence of contaminant migration outside the F-Complex.

1.2.2 Risk Assessment

This section evaluates the potential risks due to uncontrolled exposure to the contamination described in the HSA for the F-Complex (DOE 2022a). The potential risks are evaluated qualitatively to identify the relative levels of risk ("low," "medium," or "high") that could be encountered. The risk evaluation uses available sampling and survey data from the site to identify the specific contaminants of concern, provides an estimate of how and to what extent people might be exposed to them, and provides an assessment of the health effects associated with them. The risk evaluation predicts the relative potential risk of health problems that might occur if no removal action is taken at the site.

The F-Complex contains levels of radiological and chemical contamination, hazardous substances and potentially hazardous materials that could cause adverse health effects to persons potentially exposed to them in the environment. Table 1-2 summarizes these contaminants of concern, their potential health effects, and the qualitative level of risk associated with them.

The potential risks are currently low as a result of shielding, access controls, and monitoring that is routinely performed within the F-Complex. However, the potential risks could become medium to high if these protections were to be removed and people were to become directly exposed to the contaminants in the future. Therefore, the potential future risks are unacceptable, and a removal action is warranted to minimize that potential exposure.

Table 1-2. Risk Evaluation

Contaminant	Potential Risk	Risk Level
Radionuclides – Contains approximately 1 Ci of radioactivity in associated process equipment, piping, and as loose or fixed contamination on building/ equipment surfaces	• Chronic external radiation exposure is known to increase the rate of cancer in humans • Internal exposure can cause cancer when radioactive materials enter the body through inhalation, ingestion, or absorption (dermal contact) routes	• **Low** if shielding remains in place, if radionuclides are not disturbed, and if appropriate access controls and monitoring are maintained inside the buildings • **Medium to high** if these protections are removed and the buildings are allowed to deteriorate
Asbestos – Friable (easily crumbled) asbestos is present in insulation materials; non-friable asbestos is present in construction materials	• Known to cause lung cancer when fine asbestos fibers are inhaled	• **Low** risk from non-friable asbestos if left undisturbed • **High** risk of potential exposure from friable asbestos • **High** risk if the ACM becomes crushed and the asbestos becomes friable
Beryllium – present in inaccessible overhead areas in Building F1	• Known carcinogen when fine beryllium particles are inhaled	• **Low** if left undisturbed • **Medium** to **high** if overhead areas are disturbed and environmental releases occur
Lead – present in paint throughout F-Complex, may be found in other limited locations	• Known to cause neurological and developmental effects in children and in the fetus of pregnant women	• **Low** if left undisturbed • **Medium** to **high** if overhead areas are disturbed and environmental releases occur
PCBs – present in paint and or electrical equipment (e.g., light ballasts)	• Certain PCBs are known carcinogens, and others are associated with systemic toxic effect • PCBs persist in the environment and bioaccumulate (increase in concentration) as they are passed up the food chain	• **Low** if left undisturbed • **Medium** if the paint or equipment is disturbed and environmental releases were to occur

2.0 REMOVAL ACTION OBJECTIVES

This section identifies the scope, goals, and objectives of the F-Complex removal action, including conceptual schedule or milestones for project implementation. In addition, applicable or relevant and appropriate requirements (ARARs) are identified that govern implementation of the removal action.

> Identifying **Applicable or Relevant and Appropriate Requirements (ARARs)** is a method to categorize regulatory or other requirements for cleanup activities under CERCLA. ARARs establish the regulatory compliance requirements for actions taken under CERCLA.

2.1 Removal Action Scope, Goals, and Objectives

The scope of the removal action is to address the residual contamination within the F-Complex (Buildings F1, F2, F3, F4, and F6), which includes the three defueled assemblies housed within the buildings (TTR, FCPE, and FPR). The scope includes the structural components of the buildings themselves (roofs, walls, slabs, basements); the equipment and components within the buildings; utilities; and incidental soil beneath or adjacent to the building foundations or in the immediate vicinity of the F-Complex. Any groundwater contamination adjacent to and underlying the F-Complex will be addressed, if needed, after the removal action has been completed, in accordance with the Knolls Laboratory RCRA Permit.

DOE’s goal for the F-Complex is to select a removal action alternative that is consistent with the continuing research mission at Knolls Laboratory and is protective of human health and the environment. Any removal actions would include the buildings (and incidental soil, if encountered) but would not involve the groundwater.

Specific RmAOs developed for the F-Complex are as follows:

- Minimize direct exposure to contamination by onsite workers under future industrial use on a DOE continuing-mission site.
- Minimize potential releases to the environment and future migration of contaminants to soil, surface water, groundwater, or air from the source facilities.

2.2 Identification of Applicable or Relevant and Appropriate Requirements

CERCLA actions have unique methods to categorize regulatory or other requirements for cleanup activities, known as ARARs. ARARs establish the compliance requirements for actions taken under CERCLA. “Applicable” requirements specifically address a hazardous substance, pollutant, contaminant, action, location, or other circumstance found at a specific CERCLA site. “Relevant and appropriate” requirements are cleanup standards; standards of control; and other requirements, criteria, or limitations that have been promulgated under federal or state environmental or facility siting laws. The relevant and appropriate requirements identified for a specific CERCLA site have historically addressed issues sufficiently similar to those encountered at the site.

In addition to ARARs, lead and support agencies may, as appropriate, identify other guidance sources to inform remedy selection. The ‘to be considered’ (TBC) category consists of advisories, criteria, or guidance that were developed by EPA, other federal agencies, or states that may be useful in developing CERCLA remedies. Table 2-1 contains the F-Complex ARARs and TBC list.

> The **“to be considered” (TBC) category** includes DOE Orders and practices that are mandatory for projects implemented by DOE. Therefore, the TBC guidance cited in Table 2-1 are not optional; rather, DOE requires its contractors to follow these Orders and practices.

Table 2-1. Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) Guidance for the F-Complex Removal Action

Requirement	Citation	Description of Requirement	Type of Requirement	Reason for Inclusion
Chemical-Specific ARARs				
Radiation Protection of the Public and the Environment	DOE Order 458.1	Regulates exposure of members of the public. Radionuclide emissions must not exceed a total effective dose of 100 mrem/yr	To Be Considered	Establishes dose limit for members of the public
Location-Specific ARARs				
National Historic Preservation Act (NHPA)	36 Code of Federal Regulations (CFR) 800	Regulates impacts to historic properties and provides requirements to avoid, minimize, or mitigate adverse effects to historic properties	Applicable	Buildings F1, F2, F3, and F6 are contributing elements to the Knolls Laboratory Historic District; Building F4 is non-contributing
Action-Specific ARARs				
Occupational Radiation Protection	10 CFR 835	Regulates radiation exposure to workers and provides radiation protection standards for controlling exposures to as low as reasonably achievable (ALARA); control and limitations on removal of material, labeling, posting, dosimetry, etc.	Applicable	Applies to general construction activities. Establishes dose limits for workers and members of the public during direct, onsite access
Radiation Protection of the Public and the Environment	DOE Order 458.1	Establishes requirements for management of DOE radiological material or property that can result in exposures to the public to radiation or radioactive materials	To Be Considered	Applies to general construction activities, including decontamination of radiologically contaminated equipment and building structures
National Primary and Secondary Air Quality Standards	40 CFR 50	Regulates air emissions and provides national primary and secondary ambient air quality standards for the protection of public health (including lead and particulate matter)	Applicable	Applies to general construction activities for management of exhaust and fugitive dust, including during demolition
National Environmental Standards for Hazardous Air Pollutants	40 CFR 61	Regulates air emissions, including asbestos and radionuclides. Emissions of radionuclides (other than radon) to the ambient air must not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/yr	Applicable	Applies to general construction activities for control hazardous air pollutants, including during demolition activities
New York Air Pollution Control Regulations	6 NYCRR Part 200 and 211	Regulates air emissions and establishes air pollution control requirements – provisions and prohibitions	Applicable	Applies to general construction activities for general prohibitions on air pollution, including if asbestos is present

Table 2-1. Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) Guidance for the F-Complex Removal Action

Requirement	Citation	Description of Requirement	Type of Requirement	Reason for Inclusion
New York Ambient Air Quality Standards	6 NYCRR Part 256 and 257	Regulates air emissions and provides emission controls to maintain established air quality standards	Applicable	Applies to general construction activities to control emissions to avoid affects to human health, or interfere with the enjoyment of property, or adversely affect plant or animal life
Clean Water Act – Water Classification – National Pollution Discharge Elimination System (NPDES)	40 CFR 122	Regulates water pollution control (substantive aspects of a NPDES permit) 122.26	Potentially Applicable	Applies to general construction activities to control runoff and avoid impacts to waters of the state, if land disturbance could cause runoff
Clean Water Act – State Pollutant Discharge Elimination System (SPDES)	New York Codes, Rules and Regulations (NYCRR), Title 6, part 750	Regulates water pollution control (substantive aspects of a SPDES permit)	Potentially Applicable	Applies to the use of the Knolls Laboratory Industrial Wastewater system to treat captured runoff water, if applicable, and avoid impacts to waters of the state.
Clean Water Act – State Pollutant Discharge Elimination System (SPDES) Stormwater Management and Sediment Control, Small Municipal Separate Storm Sewer (MS4)	New York Codes, Rules and Regulations (NYCRR), Title 6 part 750	Regulates stormwater management and sedimentation control (substantive aspects of a general permit for discharges to MS4s)	Potentially Applicable	Applies to general construction activities for control of stormwater or other waters that could be discharged to the Mohawk River (e.g., dewatering excavations)
Hazardous Waste Management System	40 CFR 260-264, 268	Regulates the characterization, storage, management, and disposal of solid and hazardous waste	Applicable	Applies to waste management if regulated solid and/or hazardous wastes are present
New York Hazardous Waste Regulations	6 NYCRR Part 370 series	Regulates the treatment, storage, and disposal of hazardous waste	Applicable	Applies to waste management and disposal if hazardous or mixed hazardous/radioactive waste is generated
Radioactive Waste Management	DOE Order 435.1	Establishes requirements for management of DOE radioactive waste	To Be Considered	Applies to waste management if radioactive waste is generated
New York Solid Waste Management Facility Rules	6 NYCRR Part 360 and 364	Regulates solid waste management, including transfer, processing, recovery, storage, reclamation and disposal, and solid waste transportation	Applicable	Applies to waste management and disposal if solid waste is generated
Toxic Substances Control Act – PCBs	40 CFR 761	Regulates toxic substances, and identifies cleanup levels and disposal requirements for PCBs and PCB-containing materials and management of PCB wastes	Applicable	Applies to waste management if PCB wastes are present

Table 2-1. Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) Guidance for the F-Complex Removal Action

Requirement	Citation	Description of Requirement	Type of Requirement	Reason for Inclusion
U.S. DOT – Hazardous Materials Transport Regulations	49 CFR 171-180	Regulates packaging, labeling, placarding, and transportation of hazardous materials	Applicable	Applies to offsite waste transportation
Packaging and Transportation Safety	DOE Order 460.1D	Establishes requirements for packaging and transportation of DOE hazardous materials, including radioactive materials	To Be Considered	Applies to offsite waste transportation if hazardous or radioactive waste materials are generated and transported offsite for disposal
Radioactive Material Transportation Practices	DOE Manual 460.2-1	Establishes requirements for transportation of DOE radioactive materials	To Be Considered	Applies to offsite waste transportation if radioactive waste materials are generated and transported offsite for disposal

Note: The DOE Orders and practices identified as “To Be Considered” are not optional on DOE projects and must be followed by all DOE contractors.

The ARARs are based on the following considerations:

- Removal actions must be conducted in a manner such that contamination will not reach the Mohawk River or the surrounding community, either by air, water, or accidental releases.
- Removal actions will involve the buildings and incidental soil but will not involve underlying groundwater.
- There are no threatened or endangered (T&E) species and no critical habitat for any listed T&E species in the F-Complex area that may be affected by the removal action.
- The Knolls Laboratory will remain an industrial site with no residential land use.
- There are no wetlands, floodplains, or archaeological sites that will be affected by the removal action.
- Potential removal actions for the F-Complex may include continued LFM activities; removal of defueled assembly components, equipment, and residual waste materials; decontamination of building surfaces; and/or demolition and removal of the structures and associated debris.

ARARs and TBC guidance are divided into three groups: chemical-specific, location-specific, and action-specific. The following summarizes each group.

Chemical-specific ARARs establish an acceptable amount or concentration that may remain in or be discharged to the ambient environment. Chemical-specific ARARs provide health- or risk-based concentration limits or discharge limitations in various environmental media (i.e., surface water, groundwater, soil, and air) for specific hazardous substances, pollutants, or contaminants. Chemicals that are in inert, controlled, or stabilized do not have ARARs. When the chemicals are disturbed, such as with demolition activities, action-specific ARARs would be triggered. One chemical-specific TBC guidance that applies to F-Complex is DOE Order 458.1 on Radiation Protection of the Public and the Environment.

Location-specific ARARs include restrictions placed on conducting activities solely because they occur in special locations such as wetlands, floodplains, historic properties, or critical habitat. Location-specific requirements may establish restrictions on permissible concentrations of hazardous substances or establish requirements for how activities will be conducted, or mitigated, because they are in special locations. An example location-specific ARAR that is applicable to F-Complex is the National Historic Preservation Act of 1966 (NHPA) because Knolls Laboratory is eligible as a Historic District for listing on the National Register of Historic Places under Criterion A of the NHPA (36 CFR 800), which includes “areas of engineering and military for contribution to the advancement of America’s nuclear technology in the mid-Twentieth century.” Buildings F1, F2, F3, and F6 are contributing elements to the Historic District. Adverse effects to these properties from the removal action would need to be mitigated through compliance with the Knolls Laboratory Programmatic Agreement under the NHPA (NYSHPO 2017).

Action-specific ARARs are technology- or activity-based requirements or limitations on actions taken with respect to hazardous substances or other particular circumstances at a site. Action-specific ARARs include operation, performance, and design requirements or limitations based on the waste types, media, and removal action activities. Action-specific ARARs identified for the F-Complex removal action include requirements related to general construction activities, building demolition, waste management, and waste material transportation.

General construction activities are regulated by ARARs governing radiation protection, air quality, and water quality. Radiation controls must be implemented to ensure radiation protection standards would be met in accordance with 10 CFR 835. Materials for unrestricted release must meet DOE Order 458.1, Radiation Protection of the Public and the Environment, which are DOE requirements for residual surface radioactive contamination. Removed building sites (footprints) with radioactively contaminated soil-like rubble must consider radiation protection requirements and use administrative procedures or engineering controls to reduce or achieve doses that are ALARA. Requirements under the Clean Air Act of 1970, as amended (CAA), must be met, including requirements for control of asbestos and radionuclide emissions (40 CFR 61) to meet specific air quality standards per 40 CFR 50. New York State Department of Environmental Conservation (NYSDEC) requirements must be met for the control of fugitive dust and storm water runoff.

> **ALARA** stands for "as low as reasonably achievable" and is the guiding principle of radiation safety. ALARA means avoiding exposure to radiation that does not have a direct benefit, even if the dose is small, by minimizing time spent near a radioactive source, maximizing distance from a radioactive source, and putting something between you and the radiation source (shielding).

Waste management activities may include characterization, waste storage, and treatment and disposal of materials generated during the F-Complex alternative. Potential waste streams may include solid or hazardous waste (e.g., mercury switches, lead paint) regulated under RCRA; low-level waste (LLW) for radioactively contaminated wastes managed under requirements of DOE Order 435.1, Radioactive Waste Management; asbestos-containing waste materials regulated by 40 CFR 61; and PCB wastes in fluorescent light ballasts, capacitors, or drained equipment regulated under the Toxic Substances Control Act of 1976 (TSCA) (40 CFR 761). Primary wastes (e.g., demolition debris, removed waste materials) and secondary wastes (e.g., contaminated personal protective equipment or decontamination wastes) generated during building decontamination or demolition activities must be appropriately characterized and managed in accordance with requirements specific to the waste type (e.g., 40 CFR 761 for PCB wastes).

Nearby areas on the Knolls Laboratory site may be used for waste staging and temporary storage of materials removed from the F-Complex for implementation of the removal action. Those proximate facilities would be deemed "onsite" under CERCLA Section 121(e)(1) [see also 40 CFR 300.400(e)(1)]. In addition, CERCLA Section 121(d)(3) provides that any hazardous substance, pollutant, or contaminant generated during CERCLA response actions be sent to a treatment, storage, or disposal facility that complies with applicable federal and state laws and has been approved by the EPA for acceptance of CERCLA waste.

Transportation activities may include offsite shipment of contaminated waste and debris for disposal. Wastes transported in commerce along public rights-of-way must meet the transportation requirements of various regulations, depending on the type of waste (e.g., RCRA or PCB). These include U.S. Department of Transportation (DOT) packaging, labeling, marking, manifesting, and placarding requirements for hazardous materials at 49 CFR 171–180 et seq and requirements of DOE Order 460.1D, Packaging and Transportation Safety, and DOE Manual 460.2-1, Radioactive Material Transportation Practices.

3.0 IDENTIFICATION AND ANALYSIS OF REMOVAL ACTION ALTERNATIVES

This section presents a detailed analysis of removal action alternatives for the NTCRA of the F-Complex. The alternatives address potential release and short-term threats to worker safety and health during removal activities as well as potential long-term threats to achieving site-specific RmAOs. The alternatives are evaluated in terms of effectiveness, implementability, and cost in accordance with the EPA *Guidance on Conducting NTCRAs Under CERCLA* (EPA 540R93-057). The detailed analysis complies with the nine criteria required in the NCP. For completeness, the detailed analysis also incorporates the evaluation criteria in EPA's Feasibility Study (FS) guidance (EPA/540/G-85/003).

The detailed analysis also incorporates an evaluation of NEPA values as found in DOE Policies on Application of NEPA to CERCLA and RCRA Cleanup Actions (DOE 2002). Consistent with that guidance, cumulative effects considered for the F-Complex include air quality and climate change, water quality, and groundwater quality. Offsite impacts include noise, traffic, transportation, aesthetics, and waste disposal. Socioeconomic impacts, including environmental justice, are also evaluated. Impacts to historic properties are considered a NEPA value, which is discussed under the ARARs analysis for compliance with the NHPA. Waste management impacts are considered a NEPA value which is discussed under the ARARs analysis for compliance with waste management regulations. Impacts to visual/ aesthetics, soil, land use, and utilities are briefly discussed, proportionate to their impacts.

Each removal action alternative includes an "effectiveness" analysis which includes a review of the NEPA values. Pursuant to the DOE guidance on NEPA values incorporation into the CERCLA process, CERCLA documents include a discussion of potential environmental impacts. The potential environmental impacts of implementing each of the alternatives have been identified for F-Complex and are discussed as a part of the "Effectiveness" section for each alternative.

The NEPA values discussion describes the potential impacts that could result if an alternative were to be implemented. The potential impacts of these actions are analyzed in qualitative rather than quantitative terms, using descriptors (e.g., negligible or minor) that provide a relative magnitude of the potential impact. The range of the impacts described, from negligible to major, provide a type of bounding analysis for the alternatives. The majority of impacts for F-Complex are negligible. Engineering and administrative controls and other mitigation measures are also highlighted to indicate how potential impacts could be avoided.

Qualitative Descriptors used in the NEPA values evaluation of alternatives:

Negligible:	Potential impacts would not affect the environmental resource, or the effects would be at or below the level of detection and short in duration; the changes would be so slight that they would not be of any measurable or perceptible consequence.
Minor:	Potential impacts would be detectable, although the effects would be localized, relatively small, and short in duration; changes would be so small that they would be difficult to measure and have barely perceptible consequences. Mitigation measures, if needed, would be simple and effective.
Moderate:	Impacts would be readily detectable, longer in duration, and localized, with consequences to the immediate area surrounding the F-Complex. Mitigation measures, if needed, would be more extensive and likely effective.
Major:	Impacts would be readily detectable and longer in duration; changes could have substantial and permanent consequences. Mitigation measures would be more extensive, yet relatively effective.

A screening process was conducted to assess potentially viable and readily available technologies and approaches for removal actions implemented at the Knolls Laboratory site. These technologies and approaches were in the following categories:

- **Administrative and engineering controls.** Administrative and engineering controls include actions such as continued monitoring (personnel, radiation, or indoor air quality); access restrictions to radiological areas; shielding of contaminated facilities or equipment; and similar actions. These controls are currently in use at the Knolls Laboratory as part of the LFM activities and are appropriate and effective in protecting the public, onsite workers, and the environment. This approach, while considered a temporary measure, was retained for development of alternatives due to its ease of implementation and relative success over the past few decades.
- **Containment or entombment.** In-place containment or entombment of inactive reactor facilities has been considered at both the DOE's Savannah River Site and the Oak Ridge National Laboratory and has been implemented at the DOE Hanford Reservation. The defueled assemblies within the F-Complex are smaller and more accessible than the much larger inactive reactor facilities at the other sites. Encapsulation media (e.g., concrete) could deteriorate over the long term, allowing contaminant migration into the environment. The technology is therefore considered a temporary measure until the contamination can be safely removed. Because contamination within the F-Complex buildings can be safely removed in their current state, the containment or entombment approach was screened out.
- **Physical treatment.** Physical treatment technologies (e.g., scabbling or pressure washing) are typical approaches used in radiological and chemical decontamination from building surfaces. Size reduction technologies (e.g., crushing or sorting) are incidental approaches typically used for waste disposal and waste minimization. Physical treatment of the more highly contaminated areas would be appropriate and effective in protecting the public, onsite workers, and the environment, especially if combined with other technologies such as administrative or engineering controls. This approach was therefore retained for development of alternatives.
- **Chemical treatment.** Chemical treatment technologies involve using chemicals to reduce the amount, toxicity, or mobility of contaminants. Chemical treatment may be viable as an incidental agent during decontamination of building surfaces or equipment but is not considered viable as a stand-alone technology. Therefore, this approach was screened out.
- **Removal.** Removal technologies involve the physical dismantling, demolition, packaging, and offsite disposal of the contaminated building materials and equipment. The technology is effective and applicable in permanently eliminating the contamination present in the defueled assemblies as well as the remaining F-Complex. The technology has been successfully used in removing other facilities from the Knolls Laboratory site. This approach was therefore retained for development of alternatives.

The technologies and approaches retained were then combined into removal action alternatives. The following sections describe the alternatives that were developed, the rationale for identifying each alternative, and a detailed analysis of each alternative (i.e., effectiveness, implementability, and cost).

The "no action" alternative for F-Complex is Alternative 1, Continued LFM. Continued LFM provides a benchmark to enable decision makers and the public to compare the levels of environmental effects of the alternatives. Although the continued LFM alternative includes actions, it meets the regulatory definition and requirement for performing a no action alternative analysis pursuant to NEPA.

3.1 Alternative 1: Continued Legacy Facility Management – "No Action"

Under Alternative 1, all structures and defueled assemblies would remain in their current state, and LFM activities would be continued. For this EE/CA, a 30-year duration was assumed for costing purposes. This alternative was developed because it is comparable to ongoing LFM activities at the Knolls Laboratory.

Routine surveillance activities would include access controls, radiation monitoring, air monitoring, and personnel monitoring. Maintenance activities would include necessary repairs, deferred maintenance activities, and routine maintenance activities such as the following:

- Repair and/or replacement of roofing systems
- Repair of building structural elements and building shell maintenance
- Repair of internal and external doors and windows
- Repair of peeling paint on walls
- Repair and/or replacement of ceiling tiles and asbestos floor tiles
- Maintenance of electrical and mechanical equipment
- Maintenance of ductwork, piping, and water and sewer service
- Maintenance of lighting systems
- Maintenance of building fire protection systems
- Maintenance of weeds or vegetation threatening building integrity
- Maintenance of radiation shielding and containment systems

The following subsections provide a detailed analysis of the effectiveness, implementability, and cost for Alternative 1, which are summarized in Table 3-1.

Table 3-1. Summary of Alternative 1 Effectiveness, Implementability, and Cost

Effectiveness	Effective for the assumed 30-year period, provided administrative and engineering controls remain in place. Risk to human health and the environment would be low.
Implementability	Readily implementable. Administrative and engineering controls already in place would continue.
Cost	$17.5M (estimated)

3.1.1 Effectiveness

The Continued LFM alternative would be protective of human health and the environment for the assumed 30-year duration required by CERCLA. Current administrative and engineering controls (shielding, monitoring, and access controls) would continue, such that radiation and chemical exposure to workers would continue to meet applicable protective limits. Building maintenance would include routine repair of building systems, including roof, walls, windows, utilities, and service systems to prevent deterioration and thereby minimize the threat of an uncontrolled release.

Residual risks under this alternative would be low, similar to current conditions. The residual risk from potential exposure to radiation or radionuclides is considered low if shielding remains in place, if radionuclides in building components are not disturbed, and if appropriate access controls and monitoring are maintained inside the buildings. The residual risk from potential exposure to chemical contamination, hazardous substances, and potentially hazardous materials is considered low if the chemical-containing materials are left undisturbed.

Cumulative impacts (water quality, air quality, climate change, soil, and groundwater) and offsite impacts (visual/aesthetic, noise, traffic, transportation, disposal) would be negligible since there would be no change from current conditions. Use of utilities and services would be unchanged; there would be no utility impacts. Land use impacts would not change; Knolls Laboratory is an industrial facility with an ongoing mission. However, due to the presence and arrangement of the defueled assemblies, as well as areas of residual contamination, the use of F-Complex would be limited in meeting mission needs. There would be no disproportionate impacts to Environmental Justice communities. Socioeconomic impacts would not change and there would be no impact to cultural resources. Human Health Impact would remain protective and unchanged. No ecological/biological impacts are identified for the Continued LFM alternative; F-Complex does not have any T&E species or provide critical habitat for any listed T&E species.

The Continued LFM alternative would comply with ARARs. The alternative would comply with radiation protection requirements in addition to controlling radiation exposures to ALARA. The alternative would not cause any adverse effects to the buildings, and actions would occur in compliance with the Project Review Process of the Knolls Atomic Power Laboratory Programmatic Agreement (NYSHPO 2017). General construction requirements, including dust control, would be complied with during any construction activity. Routine waste management and waste transport activities would comply with existing waste management requirements.

The alternative would be effective in achieving RmAOs in the short term, although controls would need to remain in effect for the assumed 30-year duration. Shielding, monitoring, and access controls would minimize exposure to contamination by onsite workers. Building maintenance would minimize the threat of an uncontrolled release and thereby minimize potential future migration of contaminants to soil, surface water, groundwater, or air from the source facilities.

However, the alternative does not provide a permanent remedy. There would be no reduction in the toxicity, mobility, or volume of contamination at the source areas. Those source areas would ultimately need to be removed to achieve permanent site closure.

3.1.2 Implementability

The Continued LFM alternative could be readily implemented, as the LFM program activities are already in place. The current LFM program activities have been ongoing successfully in recent years as the facilities reached inactive status. Prior to LFM, general maintenance was performed for decades in the active facilities following test reactor shutdown. These successful maintenance activities demonstrate that they are relatively easy to operate, perform effectively in protecting worker health and safety, and are applicable to the conditions within the reactor cells and the remainder of the F-Complex. Equipment, personnel, and resources are readily available to continue the LFM activities. Administrative and engineering controls (shielding, monitoring, and access controls) are in place and would continue uninterrupted.

3.1.3 Cost

Capital costs associated with Alternative 1, Continued LFM (No Action), include items currently needing repairs and are estimated at $2.1M. Operation and maintenance (O&M) costs would be similar to current LFM program costs for administrative and engineering controls and building maintenance and repair, including deferred maintenance activities. O&M costs were therefore estimated using DOE's Facility Information Management System report, which identifies typical maintenance activities for the F-Complex buildings from 2012. The O&M costs were then escalated to 2022 dollars using an average inflation rate of 2.25%/year for that historical period. A present worth analysis approach was used to calculate the total present worth of the O&M costs over the assumed 30-year O&M period by applying a discount rate of 7%.

O&M costs of Alternative 1 are estimated at $1.24M/year for the assumed 30-year O&M period. Corresponding present worth O&M cost of Alternative 1 (assuming a 7% discount rate) is estimated at $15.4M. Total present worth cost of Alternative 1 is therefore estimated at $17.5M. Detailed cost estimates are provided in Appendix B.

3.2 Alternative 2: Cleanout of Defueled Assemblies

Alternative 2 would involve cleanout of the defueled assemblies by removing the tanks, equipment, and piping within the test reactor cells. Following equipment removal, the former test reactor cells would be decontaminated. This alternative was developed because it would eliminate the highest sources of radioactivity, resulting in a reduced level of LFM activities.

The following presents a conceptual approach for the disassembly and removal of the three defueled assemblies to provide a basis for developing the cost estimate. While these conceptual approaches are considered feasible and implementable, alternate approaches could be developed during final design.

Cleanout of the TTR. Cleanout of the former TTR reactor cell would involve removing two high radiation components that are shielded in place—a loading plug and two resin columns. Appropriate measures would be taken to prevent the spread of contamination during removal of these items and to maintain worker exposure to ALARA levels. To prepare the room for removal of the TTR, temporary, localized ventilation would be installed, and the waste transfer path would be prepared by removing any obstructions and providing contamination control measures (i.e., Herculite® sheeting on floors and walls, absorbent booms, etc.). Facility surveys, sampling, and analysis to characterize the former TTR reactor cell in detail would be performed to support cleanout and waste disposition.

The TTR would then be systematically disassembled and removed. Characterization of the TTR would be conducted as portions of the TTR are made accessible. Most of the disassembly would be “hands-on” work with the removed items being wrapped in Herculite® and/or plastic bags. The former test reactor, waste management areas, and the waste transfer path would then be surveyed to determine the levels of any residual radioactivity and the extent of additional decontamination required. Areas identified as needing decontamination would be decontaminated using a graded approach from least invasive/ destructive (e.g., wiping, washing, or fixing) to more invasive approaches (e.g., paint stripping, scrabbling, grinding) to reduce levels of both removable and fixed contamination and thereby achieve RmAOs.

Cleanout of the FCPE. The FCPE is the most complex and largest of the three defueled assemblies housed within the F-Complex, requiring considerable planning and engineering during final design. Cleanout of the former FCPE reactor cell would involve removal of considerable support/auxiliary systems, including the pressurizer, two air receiver tanks, and reactor head lifting mechanism drive motors (and their associated lubricating oil system). It is anticipated that portions of Building F2, and possibly Building F4, would be removed to allow removal of the reactor vessel and associated support systems. Thorough characterization of the FCPE system/components would be conducted first to establish baseline conditions. A comprehensive vent and purge activity would be conducted to ensure all systems and/or components have been drained and all systems de-energized and/isolated. Facility surveys, sampling, and analysis would be performed to characterize the former FCPE reactor cell in detail to support cleanout and waste disposition.

A mobile crane placed on the west side of the F-Complex would likely be used for removal of the various components of FCPE (the 60-ton reactor head, the 14-ton pressurizer, and the 60-ton reactor pressure vessel). The existing FCPE reactor head lead screw lift mechanisms are likely inoperable after years of lay-up, requiring the use of a mobile crane.

All equipment and piping would then be removed from the former Core Assembly Room (Building F4) and from the former Mechanical Equipment Room (Building F2 basement) to provide laydown and maneuvering space. Structural shoring of the former Core Assembly Room floor would be added to support its use as a laydown and/or waste size reduction area. A size reduction area would then be set up on the floor of the former Core Assembly Room. A temporary containment structure would be provided over this area for weather protection (to prevent rainwater from entering the building) and contamination control. Part of the west wall of the Building F2 tower would be removed to allow rigging and removal of the FCPE components with the mobile crane.

The FCPE components would then be removed. The pressurizer, air receivers (two tanks), and miscellaneous equipment and piping would first be removed from the uppermost levels of Building F2. The reactor head lifting apparatus would then be disassembled and removed. Next, miscellaneous equipment and piping would be removed between the intermediate levels of the building. The reactor vessel head would be rigged and removed from the lowest levels of the building and placed in the temporary size reduction area where the remaining reactor internals would be removed, and the reactor head size reduced and packaged for disposal. The reactor pressure vessel would be cut in-situ into manageable-sized rings for removal; the rings would be rigged and removed from the building and placed in the temporary size reduction area where they would be further size reduced and packaged for disposal. Measures would be taken to seal up the building structure after removal of the FCPE.

After the reactor vessel and FCPE support equipment have been removed, the former reactor cell and the size reduction area would then be surveyed to determine the extent of any decontamination required and any identified areas would be decontaminated using a graded approach.

Cleanout of the FPR. Cleanout of the former FPR reactor cell would involve removal of the FPR, including its wooden box with sheet metal covering. To prepare the former test reactor for removal, the double-wide exterior doorway would be modified to allow waste box ingress/egress. Temporary weather protection over the modified doorway would be added. Temporary localized ventilation would be installed, and the waste transfer path would be prepared by removing any obstructions and providing contamination control measures (i.e., Herculite® sheeting on floors and walls, absorbent booms, etc.). Facility surveys, sampling, and analysis would be performed to characterize the former FPR reactor cell in detail to support cleanout and waste disposition.

The FPR would be disassembled by removing internal components. After their removal, the remainder of FPR structure would be cut up and disassembled. Most of the disassembly would be “hands-on” work with the removed items being wrapped in Herculite® and/or plastic bags. The former reactor cell and the waste transfer path would then be characterized to determine the extent of any decontamination required and any identified areas would be decontaminated using a graded approach.

Waste Management. Wastes generated during this removal action alternative would be characterized and segregated by waste type (e.g., LLW, mixed LLW, hazardous, and nonhazardous). Contaminated equipment, piping, concrete, and demolition debris wastes would be transported offsite. All waste shipments would be containerized according to U.S. DOT requirements and transported using established commercial truck routes and rail lines.

Cleanout of the reactors would generate approximately 840 cy of LLW. The cost estimate assumes that the LLW would be disposed at an existing, permitted disposal facility specifically authorized to accept the wastes generated. The LLW would be shipped from the project site by truck or rail to the final disposal facility via rail. In addition, Cleanout would likely generate small amounts of non-radioactive debris (approximately 92 cy of RCRA regulated/hazardous waste and approximately 35 cy of general debris), which would be shipped to their respective permitted disposal facilities using containers or trucks appropriate for the waste type.

Continued LFM. LFM program activities would continue under this alternative, but potentially at a reduced level of effort because the highest sources of radioactivity would have been removed. For costing purposes in this EE/CA, it is assumed that LFM activities would cost approximately 10% less than those described for Alternative 1; a duration of 30 years for the LFM activities is also assumed. Demolition of the remaining buildings would still be required in the future (beyond the assumed 30-year period), but those costs are not included here.

The following subsections provide a detailed analysis of the effectiveness, implementability, and cost for Alternative 2, which are summarized in Table 3-2.

Table 3-2. Summary of Alternative 2 Effectiveness, Implementability, and Cost	
Effectiveness	Effective to protect human health and the environment for the assumed 30-year duration provided engineering and administrative controls remain in place. Risk to human health and the environment would be low.
Implementability	Could be implemented within 47 months.
Cost	$38.4M

3.2.1 Effectiveness

The Cleanout Alternative would be protective of human health and the environment for the assumed 30-year duration. Dismantling of the tanks, equipment, and piping within the defueled assemblies (TTR, FCPE, and FPR), followed by decontamination of the former reactor cells (Rooms 29, 36, and 41) would remove the defueled assemblies and the radiological contamination associated with them, which accounts for roughly half of the total radioactivity present in F-Complex, and thereby reduce risk of occupational radiation exposure exceeding limits during subsequent LFM activities.

The alternative would reduce the volume (total mass) of radioactive materials. Chemical contamination and potentially hazardous materials present in the buildings would remain unchanged in areas outside the cleanout activities. Administrative and engineering controls (monitoring and access controls) would protect workers from exposure to the remaining residual radiation and/or chemical contamination on building surfaces and equipment. Building maintenance would include routine repair of building systems, including roof, walls, windows, utilities, and service systems to prevent deterioration and thereby minimize the threat of an uncontrolled release.

Residual risks under this alternative would be less than current conditions. The residual risk from potential exposure to the remaining radiation or radionuclides would be low if radionuclides in building components are not disturbed and if appropriate access controls and monitoring are maintained inside the buildings.

The residual risk from potential exposure to chemical contamination, hazardous substances, and potentially hazardous materials would be low if the areas are left undisturbed. While activities associated with Alternative 2 could result in minimal and temporary impacts to water resources, the impacts would be negligible. Any operations with the potential to affect water quality would be performed in compliance with local, state, and federal requirements. In addition, water quality impacts would be minimized by implementing sedimentation and erosion controls, protecting storm drains, preventing sheet flow runoff, and applying other appropriate controls needed to protect water quality.

Activities associated with Alternative 2 would result in some air emissions; those emissions would have a negligible effect on air quality. Air quality impacts during decontamination would be minimized through use of appropriate engineering controls. Air quality impacts and greenhouse gas emissions during offsite waste transportation would be minimized by using proper packaging for containment of waste loads and by using vehicles with effective emission control systems and reducing idling times.

Impacts to soil and groundwater would be negligible during reactor cleanout and decontamination and during loading of containers into trucks for waste shipment.

Impacts to climate change would be negligible. A screening analysis conducted pursuant to the DOE Transportation Impact Screening Analysis (DOE 2022c) was performed to model greenhouse gas emissions associated with the rail and truck shipments. The calculated emission is 15 metric tons of equivalent carbon dioxide. This amount is negligible in comparison to the 5,222,400,000 metric tons of annual U.S. transportation emissions reported for 2020 in the EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2020 (EPA 2022a).

Offsite impacts (visual/aesthetic, noise, traffic, transportation, disposal, utilities) would be negligible or minor. Visual and aesthetic impacts would be negligible; F-Complex, with the exception of the very top of the FCPE tower in Building F2, is minimally visible from offsite. Demolition activities and truck haul traffic would have minor (minimal and temporary) impacts on noise levels in the community. Traffic impacts would be minor, and further minimized by scheduling truck trips in consideration of commuting peak times, school bus routes and schedules, road and street maintenance, etc. Offsite impacts occurring due to waste transportation would be minor. There would be no impacts from disposal as existing, permitted facilities would be used (whose impacts have already been evaluated); no new disposal facilities would be required. Existing commercial truck routes and waste disposal facilities would be used for the removed equipment and decontamination waste. Impacts from waste management activities would be minimal. Sound waste management practices are routinely incorporated into business management and operational practices and seek to minimize waste, prevent pollution, and encourage recycling.

There would be no impact to offsite utility systems; existing utilities would continue to be used. Land use would not change; the Knolls Laboratory is an industrial facility with an ongoing mission. However, due to the areas of residual contamination that would remain, the use of F-Complex would be limited in meeting mission needs.

There would be no adverse socioeconomic impacts to underrepresented or underserved populations from decontamination, waste transportation, or disposal. Transportation routes would use established commercial rail and truck routes. Waste materials would be disposed of at existing permitted facilities so that no new disposal facilities would be required. There may be a potential minor beneficial impact, since most construction equipment and labor would come from local vendors employing local labor. No negative impact has been identified to local population, neighborhoods, public facilities, or services and no environmental justice concerns (such as adverse effects to underrepresented or underserved populations) have been identified for the Cleanout Alternative. An EPA "EJScreen" Environmental Justice Screening and Mapping tool (EPA 2022b) query was run for Niskayuna. No communities were identified as Environmental Justice populations, nor would any one group be more adversely affected than another along potential transportation routes.

Alternative 2 would result in the removal of a section of the Building F2 wall, impacting the building's exterior. Compliance with NHPA requirements would be met by implementing the measures identified in the Knolls Laboratory Programmatic Agreement under the NHPA to mitigate any adverse effects that the removed wall section would have on the Historic District. The NHPA impacts would be minor.

A screening analysis performed pursuant to the DOE NEPA Transportation Impact Screening Analysis (DOE 2022c), to model probability of traffic accidents and fatalities for offsite shipment of wastes from Knolls Laboratory to potential permitted disposal facilities for each type of waste (LLW, regulated/hazardous, and debris) and assumed transport method (truck or rail). Accident risks are independent of the type of cargo and reflect the national accident and fatality rate from truck and/or rail shipments as a function of miles traveled. The calculated probability of accidents (1E-7) is very small (less than one in a million probability). The calculated accident fatalities (5E-4) are significantly less than one.

The screening analysis also modeled the increased risk of developing a lethal cancer from radiation exposure associated with shipments of low-level radioactive waste under Alternative 2. The calculated increased cancer risk is very small, at 6E-5 latent cancer fatalities (LCF) for the general population and 3E-5 for the trucking/rail crew, significantly less than one.

Based on the screening analyses, DOE has determined that the impacts of the proposed action would be negligible. not resulting in significant transportation-related impacts, and that the level of analysis is sufficient for assessing NEPA impacts and to aid the understanding of the public or decision makers.

No ecological/biological impacts are identified for the cleanout Alternative; F-Complex does not have any T&E species or provide critical habitat for any listed T&E species.

The cleanout Alternative would comply with ARARs and thereby minimize risks during implementation of the removal action. The alternative would comply with Federal and DOE radiation protection requirements for controlling radiation exposures to ALARA and would thereby minimize risks of exposure to radiation.

General construction ARARs, including dust and runoff control, would be complied with during any construction activity (e.g., equipment removal and decontamination operations), thereby further reducing risks of exposure to workers, the public, and the environment to radiological contamination, chemical contamination, hazardous substances, and potentially hazardous materials. Best management practices tailored to the project would be employed as a further measure of diligence. Because this alternative includes minor demolition of the Building F2 wall, ARARs governing building demolition apply to that portion of the removal action. Dust, asbestos, and radionuclide emissions would be controlled so as to comply with all applicable air quality requirements. These controls would avoid the spread of radiological or chemical contamination outside of F-Complex. During decontamination, radiation protection measures would be provided to achieve doses that are ALARA.

The alternative would comply with waste management requirements for characterization of hazardous and/or radioactive wastes, waste packaging, labeling, manifesting, placarding, transport, and disposal at an approved disposal facility. Wastes generated during this alternative would be characterized and segregated by waste type (e.g., low-level radioactive, mixed low-level radioactive, hazardous, and nonhazardous). All waste shipments would be containerized according to U.S. DOT requirements.

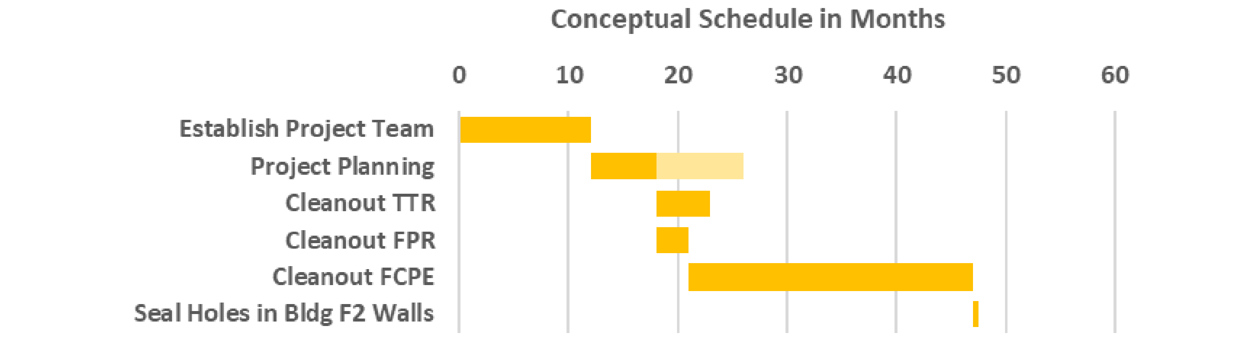
The alternative would be effective in achieving RmAOs in the short term, although some controls would need to remain in effect for the assumed 30-year duration. Monitoring and access controls would minimize direct exposure to residual contamination by onsite workers. Building maintenance would minimize the threat of an uncontrolled release, thereby minimizing potential future migration of contaminants to soil, surface water, groundwater, or air from the source facilities.

However, the alternative does not provide a permanent remedy. There would be residual radioactive and chemical contamination within areas of the buildings, including beryllium in inaccessible areas, PCBs in light ballasts, lead in paint, and potential miscellaneous contamination in drain piping systems. This residual contamination would ultimately require removal to achieve permanent site closure.

3.2.2 Implementability

The Cleanout Alternative could be readily implemented. Construction activities would require an estimated duration of 47 months to complete (Figure 3-1). Technologies for safely dismantling, containerizing, and removing reactor components and accessory equipment and piping within the reactor cells are well established and have been used in removing other facilities at the Knolls Laboratory. Because much of the radiological contamination is located inside pipes, tanks, and internal surfaces of the reactor assemblies, there would be potential short-term risk of contamination release during disassembly and decontamination of the reactor cells, potentially impacting demolition workers. Therefore, the cleanout activities would require specialized expertise and protocols to operate and effectively protect worker health and safety; however, the specialized equipment, personnel, and resources are readily available, though resource constraints may periodically occur.

Figure 3-1. Conceptual Schedule for Cleanout Alternative



Administrative and engineering controls to address the residual contamination (monitoring and access controls) are already in place and would be reduced as applicable for the reduced contamination levels. The current LFM program activities have been ongoing successfully for the past few decades following test reactor shut down, demonstrating that they are relatively easy to operate, perform effectively in protecting worker health and safety, and are applicable to the conditions within the reactor cells and the remainder of the F-Complex. Equipment, personnel, and resources are readily available to continue the LFM program activities for an assumed 30-year O&M period.

Contaminated equipment, piping, concrete, and demolition debris wastes would be transported offsite. Wastes would be disposed of at existing permitted facilities so that new permits would not be required for waste disposal.

3.2.3 Cost

Capital costs associated with Alternative 2 would include costs to (1) clean out the more highly contaminated tanks, equipment, and piping; (2) decontaminate the more highly contaminated building surfaces within the reactor cells; (3) dispose of the associated wastes; and (4) implement needed building repairs. Capital costs are estimated at $24.5M. O&M costs of Alternative 3 are estimated at $1.11M/year for the assumed 30-year O&M period, for a corresponding present worth O&M cost (assuming a 7% discount rate) of $13.8M. The total present worth cost of Alternative 2 is estimated at $38.4M. Detailed cost estimates are provided in Appendix B.

3.3 Alternative 3: Demolition of F-Complex

Alternative 3 would involve demolishing the entire F-Complex (Buildings F1, F2, F3, F4, and F6), including removing the defueled assemblies located in them. This alternative was developed because it would remove all hazardous substances, radiological and chemical contamination, and potentially hazardous materials from the buildings, provide a site suitable for use by DOE in continuing its mission, and eliminate the need for further LFM activities. DOE would retain ownership of the area and would control land use consistent with its continuing research mission at the Knolls Laboratory.

Alternative 3, similar to Alternative 2, would involve removing tanks, equipment, and piping associated with the defueled assemblies as described in Section 3.2. Decontamination and stabilization would be conducted to clean highly contaminated areas and minimize the potential for hazardous material becoming airborne during demolition of the equipment and structures. The remainder of Buildings F1, F2, F3, F4, and F6 would then be demolished. Subgrade demolition would involve removal of utilities that have been isolated and/or rerouted. Small quantities of incidental soil would be removed in conjunction with the subgrade demolition. Once demolition is completed, the below-grade excavations would be assessed to determine if any residual contamination remains that requires removal. Following any additional contaminated soil removal, the excavation would be backfilled with clean backfill material and compacted. Backfill material could include imported soil, clean excavated onsite soil, or clean concrete.

Construction activities under the Demolition Alternative include demolition as well as several other types of construction such as reactor removal, decontamination, utility relocation, soil excavation and backfilling. The general term "construction" is used to encompass all these different types of construction.

The following presents a conceptual approach for the cleanout and demolition of the F-Complex buildings to provide a basis for developing the cost estimate. While this conceptual approach is considered feasible and could be implemented, alternate approaches could be developed during final design by a demolition contractor.

Cleanout of F-Complex Reactors. The conceptual approach for the disassembly and removal of the three defueled assemblies would be the same as described in Section 3.2 for the TTR, FPR, and FPCE.

Pre-Demolition Activities. Prior to building demolition, existing utilities and service systems (e.g., water, sewer, drain lines, air and gas lines, fire protection services, electrical service systems, ventilation systems, etc.) would be rerouted and/or isolated to separate the F-Complex from other active facilities at the Knolls Laboratory. Facility surveys, sampling, and analysis would be performed to characterize the buildings in detail to support demolition and waste disposition. Asbestos abatement would be performed in accordance with requirements under the CAA for asbestos control to remove all friable or non-friable ACM prior to demolition. Any other potentially hazardous materials (e.g., PCB light ballasts) would also be removed during the pre-demolition activities.

Building Demolition. Building demolition would include systematic dismantling and removing all utilities and service systems and demolition of the roofs and walls. For costing purposes, the buildings to be demolished are separately identified either as single-story (Buildings F1, F4, and F6); multi-story (Buildings F2 and F3); or minor (a small building annex south of Building F3). Robust building demolition would include demolition of the 2- to 5-ft thick walls surrounding the former reactors and former fuel vault. The building slabs would be removed, including basement structures in Buildings F3 and F4 to a depth of approximately 12-ft below grade, and in Building F2 within the FCPE reactor pit to a depth of approximately 20-ft below grade. Slab removal would include removal of incidental soil adjacent to the slabs or footings, which is defined for costing purposes as three ft out in each direction from the building perimeter and 3 ft deep.

Once the building, rubble, and incidental soil are removed, the soil would be surveyed, sampled, and characterized to identify any areas of residual contamination. Further excavation of soil to remediate the F-Complex area to meet cleanup standards would be implemented, pending the soil characterization results. The building footprint would then be backfilled with compacted clean backfill material to support future development of the site by DOE.

Waste Management. Wastes generated during this removal action alternative would be characterized and segregated by waste type (e.g., low-level radioactive, mixed low-level radioactive, hazardous, and nonhazardous). The remaining contaminated equipment, piping, concrete, and demolition debris wastes would be transported offsite. All waste shipments would be containerized according to U.S. DOT requirements and would be transported using established commercial truck routes.

Demolition of the buildings, including cleanout of the defueled assemblies, is anticipated to generate approximately 10,307 cy of LLW; 2,467 cy of RCRA regulated/hazardous waste; and 6,362 cy of non-hazardous solid waste and debris. The cost estimate assumes that the LLW would be disposed at a permitted DOE-approved disposal facility specifically authorized to accept the waste generated. The LLW would be shipped from the project site by truck in intermodals for transport via truck or rail to the disposal facility. RCRA regulated/hazardous waste and/solid waste or debris would be shipped via truck or rail to their respective permitted disposal facilities.

The following subsections provide a detailed analysis of the effectiveness, implementability, and cost for Alternative 3, which are summarized in Table 3-3.

Table 3-3. Summary of Alternative 3 Effectiveness, Implementability, and Cost	
Effectiveness	Most effective and protective alternative. Permanent and eliminates risks.
Implementability	Could be implemented within 53 months.
Cost	$68.4M

3.3.1 Effectiveness

The Demolition Alternative would be protective of human health and the environment and would permanently remove the defueled assembly cells as well as any radiological contamination associated with the remainder of the F-Complex. This alternative would also permanently remove hazardous substances and potentially hazardous materials. The Demolition Alternative would be permanent and reliable, eliminating the need for further administrative and engineering controls.

There would be no residual risks associated with the F-Complex under this alternative, as all radiological and chemical contamination, hazardous substances, and potentially hazardous materials would be removed from the buildings. Any residual soil or groundwater contamination would be addressed after completing the removal action.

Cumulative impacts to water quality and air quality would be negligible. Water quality impacts associated with Alternative 3 could result in minimal and temporary impacts to water resources, and operations with the potential to affect water quality would be performed in compliance with local, state and federal requirements. In addition, water quality impacts would be minimized through the implementation of sedimentation and erosion controls, protection of storm drains, prevention of sheet flow runoff and other appropriate controls needed to protect water quality.

While activities associated with Alternative 3 would result in some air emissions, those emissions would have negligible effect on air quality. Air quality impacts during building demolition would be minimized by using appropriate engineering controls, such as misting to reduce dust emissions, asbestos abatement protocols, and personnel protection. Air monitoring would be conducted at the point of dust generation within the buildings and adjacent to the F-Complex to verify that engineering controls are effective. Air quality and associated climate change impacts during waste transportation offsite would be minimized by using DOT-compliant waste packaging, vehicles with effective emissions control systems and reduced idling time.

Impacts to climate change would be negligible. A screening analysis performed pursuant to the DOE NEPA Transportation Impact Screening Analysis (DOE 2022c) was used to model greenhouse gas emissions associated with the rail and truck shipments. The calculated emission is 21 metric tons of equivalent carbon dioxide. This amount is negligible in comparison to the 5,222,400,000 metric tons of annual U.S. transportation emission reported for 2020 in the EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks 1997-2020 (EPA 2022b).

Soil impacts would be negligible; soil in the F-Complex has been previously disturbed. Groundwater impacts would be negligible. Over the long term, impacts to soil or groundwater would be eliminated because contamination sources would be removed and the ground surface in F-Complex footprint would be stabilized to minimize sediment-laden runoff.

Offsite impacts (visual, noise, traffic, transportation, disposal, utilities) would be negligible or minor. Visual and aesthetic impacts would be negligible; the F-Complex, except for the very top of the FCPE tower in Building F2, is only minimally visible offsite. Demolition activities and truck haul traffic would have minor (minimal and temporary) impact on noise levels in the community. Traffic impacts would be minor, and further minimized by scheduling truck trips in consideration of commuting peak times, school bus routes and schedules, road and street maintenance, etc. Offsite impacts occurring due to waste transportation would be minor. There would be no impacts from disposal as existing, permitted facilities would be used (whose impacts have already been evaluated); no new disposal facilities would be required. Impacts from waste management activities would be minimal. Sound waste management practices are routinely incorporated into business management and operational practices and seek to minimize waste, prevent pollution, and encourage recycling.

There could be a minor, temporary increase in utilities (electricity, water) during demolition; however, long term utility use would decrease because there would be no long-term LFM activities. Land use would not change. In the long term there could be positive impacts. The former site of the F-Complex would be suitable for use as part of DOE's continuing research mission at the Knolls Laboratory.

There would be no adverse socioeconomic impacts to underrepresented or underserved populations during decontamination, demolition, waste transport, or disposal. Transportation methods and routes would be evaluated and selected to minimize, to the extent practicable, the impacts on these communities and would use established commercial rail and truck routes. There could be potential minor beneficial impact, since most construction equipment and labor would come from local vendors employing local labor. There would be no impact to local population, neighborhoods, public facilities, or services. Potential minor socioeconomic benefit could accrue from job creation during implementation of the removal action for contractors using local labor and equipment suppliers. No environmental justice concerns (such as impacts to underrepresented or underserved populations) have been identified for the Demolition Alternative. An EPA "EJScreen" Environmental Justice Screening and Mapping tool (EPA 2022b) query was run for Niskayuna. No communities were identified as Environmental Justice populations, nor would any one group be more adversely affected than another along potential transportation routes.

The demolition alternative would result in the removal of Buildings F1, F2, F3, and F6, which are contributing facilities to the Knolls Laboratory Historic District. Compliance with NHPA requirements would be met through implementing the measures identified in the Knolls Laboratory Programmatic Agreement (NYSHPO 2017) to mitigate any adverse effects that the demolition of the buildings would have on the Historic District.

A screening analysis was performed pursuant to the DOE NEPA Transportation Impact Screening Analysis (DOE 2022c), to model the probability of traffic accidents and fatalities for offsite shipment of wastes from the Knolls Laboratory to potential permitted disposal facilities for each type of waste (LLW, regulated/hazardous, and debris) and assumed transport method (truck or rail). Accident risks are independent of the type of cargo and reflect the national accident and fatality rate from truck and/or rail shipments as a function of miles traveled. The calculated probability of accidents (2E-6) is small (one in a million probability). The calculated accident fatalities (6E-3) are significantly less than one.

The screening analysis also modeled the increased risk of developing a lethal cancer from radiation exposure associated with shipment of LLW under Alternative 3. The calculated increased cancer risk is very small, at 7E-4 for the general population and 4E-4 for the trucking/rail crew. These risks are significantly less than one.

Based on the screening analyses above, DOE has determined that the impacts of the proposed action would be negligible, not resulting in significant transportation-related impacts, and that the level of analysis is sufficient for assessing NEPA impacts and to aid the understanding of the public or decision makers.

No ecological/biological impact is identified for the Demolition Alternative. F-Complex does not have any T&E species or provide critical habitat for any listed T&E species.

The Demolition Alternative would comply with ARARs and thereby minimize risks during implementation of the removal action. The alternative would comply with Federal and DOE radiation protection requirements for controlling radiation exposures to ALARA and would thereby minimize risks of exposure to radiation.

General construction ARARs, including dust and runoff control, would be complied with during any construction activity, equipment removal, and demolition, thereby further reducing the risks of exposure to workers, the public, and the environment to radiological and chemical contamination, hazardous substances, and potentially hazardous materials. This alternative includes demolition of the entire F-Complex. Dust, asbestos, and radionuclide emissions would be controlled so as to comply with all applicable air quality requirements. These controls would avoid the spread of radiological or chemical contamination outside of the F-Complex and therefore be protective of the public and the environment.

The Demolition Alternative would comply with waste management requirements for characterization of hazardous and/or radioactive wastes, waste packaging, labeling, manifesting, placarding, transport, and disposal at an approved disposal facility. Wastes generated during this alternative would be characterized and segregated by waste type (e.g., low-level radioactive, mixed low-level radioactive, hazardous, and nonhazardous). All waste shipments would be containerized according to U.S. DOT requirements. Clean, reusable materials would meet DOE requirements for unrestricted release for residual surface radioactive contamination.

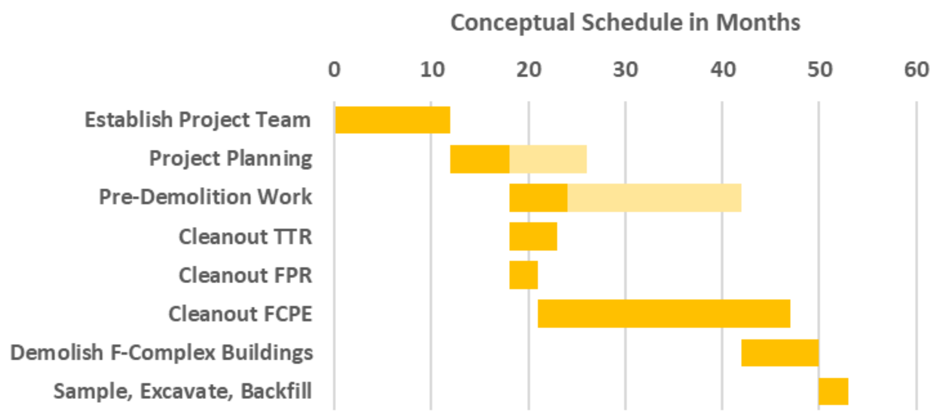
The alternative would be effective in achieving RmAOs by entirely removing the source facilities. Demolition of the F-Complex would eliminate potential exposure to radiological or chemical contamination, hazardous substances, or potentially hazardous materials, and eliminate potential future migration of contaminants to soil, surface water, groundwater, or air. The soil would be surveyed, sampled, and characterized to identify any areas of residual contamination, and any further excavation of soil to remediate the F-Complex area to meet cleanup standards would be implemented, pending the soil characterization results.

Alternative 3 provides a permanent remedy; there would be no residual radioactive or chemical contamination.

3.3.2 Implementability

The Demolition Alternative could be readily implemented. Construction activities, including cleanout of the defueled assemblies and building demolition, would require an estimated 53 months to complete (Figure 3-2). Technologies for safely dismantling, containerizing, and removing reactor components and accessory equipment and piping within the reactor cells are well established and have been used previously to remove other facilities at the Knolls Laboratory. Because much of the radiological contamination is located inside pipes, tanks, and internal surfaces of the defueled assemblies, there would be potential short-term risk of airborne release of contamination during disassembly and decontamination of the defueled assemblies and equipment, and during subsequent building demolition, potentially impacting demolition workers and the public. Therefore, the removal activities would be planned and executed by professionals with specialized expertise to operate and effectively protect worker health and safety; however, the specialized equipment, personnel, and resources are readily available. Similarly, removal of hazardous substances, chemically contaminated building materials, and other potentially hazardous materials would require specialized expertise, including training and certification and air circulation system operation, monitoring, and control. However, the specialized equipment, personnel, and resources are readily available within the marketplace.

Figure 3-2. Conceptual Schedule for Demolition Alternative



During demolition activities, there would also be potential short-term risk of release of contaminants into underlying soils or drains due to rainfall into the partially demolished structure or during misting for dust control. Therefore, removal activities include plugging and capping sumps and drains and capturing any runoff water for characterization prior to release.

Wastes would be disposed at existing permitted facilities so that no new permits would be required for waste disposal. Contaminated equipment, piping, concrete, and demolition debris wastes would be transported offsite.

3.3.3 Cost

Capital costs associated with Alternative 3 would include costs to clean out the radiologically-contaminated defueled assemblies, tanks, equipment, and piping within the former reactor cells; to remove the chemically contaminated building materials, hazardous substances, and other potentially hazardous materials ; to demolish the structure; and to dispose of the associated wastes. Capital costs are estimated at $68.4M. There would be no O&M costs associated with Alternative 3. Correspondingly, the total present worth cost of Alternative 3 is estimated at $68.4M. Detailed cost estimates are provided in Appendix B.

4.0 COMPARATIVE ANALYSIS OF REMOVAL ACTION ALTERNATIVES

This section presents a comparative analysis of the three removal action alternatives for the F-Complex that were developed in Section 3. Similar to the individual analysis presented in Section 3, the alternatives are evaluated in terms of effectiveness, implementability, and cost. The comparative analysis evaluates the relative performance of each alternative in accordance with those criteria and identifies the advantages and disadvantages of each alternative relative to one another so that key tradeoffs that would affect the remedy selection can be identified. Appendix A summarizes the comparative analysis, listing key considerations for each evaluation criteria and for each removal action alternative.

In accordance with DOE's 1994 Secretarial Policy Statement on NEPA, DOE CERCLA documents incorporate NEPA values such as analysis of cumulative, off-site, ecological and socioeconomic impacts to the extent practicable. (DOE 1994). NEPA values have been incorporated into this EE/CA for the F-Complex are discussed in this comparative analysis of alternatives and are factors in DOE decision-making. In addition to the resource areas above, impacts on the Historic District are considered a NEPA value in addition to being an ARAR. Cumulative effects considered for the F-Complex include air quality and climate change, water quality, and groundwater quality. Offsite impacts include noise, traffic, transportation, aesthetics, and waste disposal. Socioeconomic impacts, including environmental justice, are also evaluated. . Human health effects are included in the effectiveness evaluation. Impacts to visual/aesthetics, soil, land use, and utilities are briefly discussed, proportionate to their impacts.

The no action alternative, Continued LFM, includes actions to continue to maintain F-Complex, and provides a benchmark to enable decision-makers and the public to compare the levels of human health and environmental effects of the alternatives.

Table 4-1 highlights the results of the comparative analysis. State and community acceptance, both important to the CERCLA process, are assessed as a part of the overall public and community involvement process, including the public comment period.

Table 4-1. Highlights of the Comparative Analysis

Criterion	Alternative 1: Continued LFM – No Action	Alternative 2: Cleanout of Defueled Assemblies	Alternative 3: Demolition of F-Complex
Effectiveness			
Overall Protection of Human Health and the Environment	Protective in the short term (30 years)	Protective in the short term (30 years)	Protective and permanent
NEPA Values	Negligible adverse impacts	Minor adverse impact to Historic District (mitigated), possible beneficial impacts (socioeconomics)	Minor adverse impact to Historic District (mitigated), possible beneficial impacts (socioeconomics and land use)
ARARs Compliance	Complies with ARARs	Complies with ARARs	Complies with ARARs
Ability to Achieve RMAOs	Effective in the short term	Effective in the short term	Effective and permanent
Implementability			
Technical Feasibility	Feasible	Feasible	Feasible
Availability of Resources	Available	Available	Available
Administrative Feasibility	Feasible	Feasible	Feasible
Cost			
Total Present Worth	$17.5M	$38.4M	$68.4M

4.1 Effectiveness

4.1.1 Overall Protectiveness of Human Health and the Environment

Alternative 1, Continued LFM (the no action alternative), would be protective in the short term. Administrative and engineering controls (e.g., shielding, monitoring, access controls) would continue to protect human health and the environment from exposure to radiation from reactor components and to chemical contamination on building surfaces and equipment, hazardous substances, and potentially hazardous materials. Building maintenance would prevent deterioration to minimize the threat of release to the environment. LFM would be effective for the assumed 30-year period, provided these controls remain in place. Residual risks to would be low, similar to current conditions.

Alternative 2, Cleanout of Defueled Assemblies, would be more protective than LFM because the defueled assemblies and associated radiological contamination representing approximately half of the radioactivity within the F-Complex would be removed. However, residual radiological contamination would remain, and chemical contamination, hazardous substances, and potentially hazardous materials would remain unchanged. Administrative and engineering controls would protect workers from this residual contamination.. Alternative 2 would also be effective for the assumed 30-year period, provided these controls remain in place. Residual risks to human health and the environment would thereby be kept low.

Alternative 3 offers the most protectiveness of any of the alternatives. The alternative would be effective and permanent, eliminating the risks associated with the chemical and radiological contamination, hazardous substances, and potentially hazardous materials. No long-term LFM controls would be required to protect human health or the environment. Residual soil would be surveyed, sampled, and characterized, and any residual contamination would be remediated , thereby eliminating the risk of future environmental releases.

4.1.2 Incorporation of NEPA Values

Cumulative Impacts:

- Water quality impacts would be limited. No impacts would occur under Alternative 1. Water discharges would be controlled per Knolls Laboratory permitted outfall requirements under Alternatives 2 and 3. There could be minor potential impact under Alternative 3 during demolition, but with controls impacts would be negligible Surface runoff would be mitigated though engineering controls, such as silt fences, to meet permitted outfall requirements.
- Cumulative impacts to air quality due to air emissions and greenhouse gas emissions would be negligible. While air emissions occur under Alternatives 2 and 3 during decontamination, asbestos abatement, beryllium abatement, and waste transportation, these air quality impacts would be minimized by using appropriate engineering controls and compliance with ARARs. Additionally, air quality impacts would be further reduced appropriate engineering controls and compliance with ARARs.
- Greenhouse gas emissions contributing to climate change would occur during waste transportation offsite, but would be minimized by using proper containers, vehicles with effective emissions control systems, and by minimizing the time vehicles are idling. Air quality impacts would be greater under Alternative 3 due to demolition of the five buildings and greater volumes of waste to be disposed offsite. Localized air impacts during building demolition would be minimized through use of appropriate engineering controls, such as misting to reduce dust emissions, asbestos abatement protocols, and personnel protection. Screening analyses performed pursuant to the DOE NEPA Transportation Impact Screening Analysis (DOE 2022c) were used to model greenhouse gas emissions associated with the rail and truck shipments for Alternatives 2 and 3. The calculated emissions for Alternative 2 and 3 were 15 and 21 metric tons equivalent carbon dioxide, respectively.

These amounts are negligible in comparison to the 5,222,400,000 metric tons of annual U.S. transportation emission reported for 2020 in the EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks 1997-2020 (EPA 2022b).

- No impacts to soil or groundwater are expected under Alternative 1 because the contamination sources would remain contained and continued LFM activities would prevent uncontrolled releases. There would be negligible impact to soil or groundwater under Alternative 2 during reactor cleanout and decontamination and during loading of containers into trucks for waste shipment. There would be negligible impact under Alternative 3 to soil or groundwater. Under Alternative 3, over the long-term, impacts to soil or groundwater would be eliminated because the contamination sources would be removed and the ground surface in the F-Complex footprint would be covered with gravel to minimize sediment-laden runoff.

Offsite Impacts:

- There would be no visual/aesthetic impact for Alternative 1. For Alternatives 2 and 3, there would be negligible visual/aesthetic impacts, since the F-Complex, except for the FCPE tower, is minimally visible from surrounding public areas.
- While noise impacts due to traffic are minor under Alternatives 2 and 3, Alternative 3 would result in the greatest potential offsite noise impact due to the larger amount and duration of demolition activities and higher number of truck haul traffic trips. However, impacts are expected to be minor and last only for the duration of demolition. Alternative 2 would pose lesser potential impact to noise levels due to the lower amount and shorter duration of demolition activities and lower number of truck haul traffic trips. Alternative 1 would continue to have negligible noise impacts.
- Traffic impacts would be negligible for Alternative 1 and minor for Alternatives 2 or 3. In the short term, a temporary increase of truck traffic to and from the site would be expected during implementation of Alternative 2 or 3.
- Transportation impacts are negligible for Alternative 1, and minor for Alternatives 2 or 3. Analysis of transportation risks account for routes, distance, and mode of transport. To further reduce already low risks, haul routes would be planned to reduce traffic impacts to the local community during peak traffic hours and to consider factors such as road maintenance. The amounts of waste materials and of clean imported soil required would be minimized to the extent practicable. Alternative 3 would have greater impacts due to the greater volume of waste to be disposed and the greater number of trips. Alternative 3 would generate approximately 10 times more LLW, 20 times more regulated/hazardous waste, and nearly 200 times more non-hazardous solid waste and debris than Alternative 2. While the risk of a traffic accident is small under Alternatives 2 and 3 (about one in a million or less probability), the greater number of trips by rail and truck under Alternative 3 would pose a slightly higher risk of a potential offsite traffic accident or injury and higher vehicle emissions that are expected to have negligible impact on local air quality. Likewise, calculated greenhouse gas emissions are negligible for both alternatives in comparison to the annual U.S. transportation emissions, as noted above under Cumulative Impacts.
- There would be no offsite disposal impacts from any of the alternatives. Waste materials would be disposed at existing, permitted disposal facilities (whose impacts have already been evaluated). No new disposal facilities would be required.
- There would be no potential impacts on utilities and service systems under Alternative 1 because ongoing LFM activities would continue to use existing facilities. Under Alternatives 2 and 3, a minor temporary increase in utilities such as electricity and water may be required for implementation of the selected removal action. In the long term, impacts to utilities and service systems would decrease

under Alternative 3 because there would be no LFM activities. In consideration of both the long and short term, utility impacts would be negligible.

Land Use:

- There would be no change in land use under any of the alternatives; the Knolls Laboratory is an industrial facility with an ongoing mission. However, under Alternative 1 the presence of the defueled assemblies and residual contamination would significantly restrict the use of the buildings. Under Alternative 2, the residual contamination would restrict building use. For both Alternatives 1 and 2, the ability to meet the continuing research mission needs would be limited. Land use would be positively impacted under Alternative 3; the site of the former buildings would be suitable for use as part of DOE's continuing research mission at the Knolls Laboratory.

Socioeconomics and Environmental Justice:

- There would be no impacts to Environmental Justice populations. Alternative 1 would have no change. For Alternatives 2 and 3, an EPA "EJScreen" Environmental Justice Screening and Mapping tool (EPA 2022b) query was run for Niskayuna and no communities were identified as Environmental Justice populations.
- There would be no adverse socioeconomic impact under Alternative 1; ongoing LFM activities would continue. There may be minor potential beneficial impacts under Alternatives 2 and 3, because most construction equipment and labor would come from local vendors employing local labor. The associated increase in business to vendors (including construction equipment rental vendors) who serve the construction trade would be in amounts typical of a construction project of an equivalent size. If specialized non-local labor forces were to be used, there would be associated local socioeconomic benefit from money spent on hotels, rental cars, and meals. In the long term, none of the alternatives would affect population, housing, lifestyles, neighborhood character or stability, property values, local tax base, employment, industry, or commerce. In addition, none of the alternatives would impact public services such as police, fire, schools, parks, or require the displacement of businesses or farms.

Cultural Resources – see Compliance with ARARs (Section 4.1.3)

Human Health see Protection of Human Health and the Environment (Section 4.1.1)

Ecological/Biological:

- No ecological/biological impacts are identified for any of the alternatives. The F-Complex does not have any T&E species and does not provide critical habitat for any listed T&E species. T&E species that may be found in the area include the following:
- The Monarch Butterfly (*Danaus plexippus*) is a candidate species and not yet listed or proposed for listing under the Endangered Species Act (50 CFR 402). As of this writing, no critical habitat has been designated. Monarchs lay their eggs on obligate milkweed host plants (primarily *asclepias spp*.); no obligate environments that could provide habitat are present within the F-Complex.
- Bald eagles (*Haliaeetus leucocephalus*) may be present periodically along the Mohawk River but would not be impacted by an F-Complex removal action. Several species of Birds of Conservation Concern were identified through coordination with the U.S. Fish and Wildlife Service (DOE 2022d) and may be found in the project area during their migration and breeding seasons. There is no habitat for any of these species on F-Complex. Areas to the northeast of F-Complex could provide tree cover for breeding and nesting; impacts would not occur in these areas during implementation of any of the alternatives. Impacts from demolition activities under Alternative 3 would be mitigated through implementation of emission and runoff controls, as well as best management practices to control dust and erosion.

4.1.3 Compliance with ARARs

All three alternatives would comply with chemical-specific ARARs. Compliance with radiation protection requirements would occur and control radiation exposures to ALARA and thereby minimize risks to workers, the public, and the environment.

Alternative 1 would not adversely affect the Historic District, because the buildings would not be disturbed. Alternatives 2 and 3 would result in visible changes to the F-Complex. Buildings F1, F2, F3, and F6 are contributing facilities to the Knolls Laboratory Historic District. DOE would implement the previously identified mitigation measures pursuant to the Programmatic Agreement to mitigate adverse effects to the Historic District and thereby comply with the NHPA ARAR.

All three alternatives would comply with NYSDEC general construction requirements, including dust control, during any construction activity to minimize short-term risks to workers or releases to the environment. Alternatives 2 and 3 would also comply with CAA requirements for control of asbestos and radionuclide emissions. Radiation protection measures would be implemented to reduce occupational radiation exposure to ALARA.

Alternative 1 would comply with waste management and waste transportation requirements during routine maintenance and repair. Alternatives 2 and 3, while involving greater volumes of waste, would comply with ARARs for characterization of hazardous and/or radioactive wastes, waste packaging, labeling, manifesting, placarding, and disposal at an approved disposal facility. Waste shipments would be containerized according to U.S. DOT requirements, complying with those respective ARARs.

4.1.4 Ability to Achieve RmAOs

All three alternatives would achieve RmAOs. Alternatives 1 and 2 would be effective for the assumed 30-year period, provided controls remain in place. Alternative 3 would be the most effective and would be permanent; risks to both workers and the environment would be eliminated by removing the contamination from the site. Following building demolition under Alternative 3, the soil would be characterized to identify any areas of residual contamination, and any further remediation would be implemented to meet cleanup standards, pending the soil characterization results.

Each of these action alternatives would achieve RmAOs at the completion of construction, which is estimated as immediately for Alternative 1, 47 months for Alternative 2, and 53 months for Alternative 3.

The three alternatives vary in the amount of residual contamination left onsite. There would be no reduction in radiological or chemical contamination, hazardous, or potentially hazardous materials under Alternative 1. Alternative 2 would remove approximately half of the radioactivity in F-Complex by removing the radiologically-contaminated defueled assemblies and associated equipment, but would leave residual radiological and chemical contamination, hazardous substances, and potentially hazardous materials.

4.2 Implementability

Each of the alternatives could be readily implemented. Alternative 1 could be readily implemented, as the administrative and engineering controls to be implemented are already in place. Current LFM activities have been ongoing successfully for the past few decades in the F-Complex, demonstrating that they are applicable to the conditions within the buildings.

Alternative 2 could be readily implemented within 47 months and Alternative 3 within 53 months, the longer time frame due to the greater volumes of demolition materials to be removed and disposed offsite. The remedial technologies to be implemented under Alternatives 2 and 3 are similar. Technologies for safely dismantling, containerizing, and removing reactor components and accessory equipment and piping are well established; specialized expertise would be required under both alternatives to protect construction worker health and safety. Technologies for building demolition are conventional and well-established technologies. These technologies have been used successfully in dismantling and demolishing other facilities at the Knolls Laboratory and would be applicable to the F-Complex as well.

4.3 Cost

Of the three alternatives, Alternative 1 would have the least cost, and Alternative 3 would have the greatest cost. Alternative 1 would have an estimated capital cost of $2.1M to implement building repairs, and an estimated operational cost of $1.24M/year for LFM over the assumed 30-year period, for an estimated total present worth cost of $17.5M. Alternative 2 would have an estimated capital cost of $24.5M to dismantle and remove the defueled assemblies and to implement building repairs, as well as an estimated operational cost of $1.11M/year over the assumed 30-year period, for an estimated total present worth cost of $38.4M. Alternative 3 would have the highest estimated capital cost of $68.4M to demolish the entire F-Complex, including the dismantling and removal of the defueled assemblies. However, Alternative 3 would have no long-term operational cost, so that its estimated total present worth cost would also be $68.4M.

5.0 RECOMMENDED REMOVAL ACTION ALTERNATIVE

DOE recommends that Alternative 3, Demolition of the F-Complex, be selected as the preferred removal action. Although it would cost more than the other options and would take longer to complete the capital construction activities, it would be an effective and permanent remedy that is readily implemented with demonstrated technologies, would not require any post-construction long-term LFM, and would make the building footprint available for future development by DOE in continuing its research mission at the Knolls Laboratory. The Demolition Alternative fully satisfies RmAOs by eliminating the sources of contamination, both radiological and chemical. There would be no residual risk under Alternative 3.

This recommendation is based on the detailed comparative analysis provided in this EE/CA. The recommended alternative considers the tradeoffs between alternatives, with the goal of optimizing effectiveness in meeting the RmAOs and ease of implementation, while minimizing impacts and estimated cost.

While it is recognized that this alternative presents a greater potential for certain impacts than the other alternatives, the majority of the impacts are negligible or minor. Numerous best management practices would be employed to mitigate these impacts. For example, potential noise impacts during construction, particularly demolition, are expected to be minor due to the location of the F-Complex at the northern end upper level of the Knolls Laboratory, away from any residential areas. These impacts would be managed by controlling noise-generating equipment and scheduling work during optimal hours to ease disturbance. Potential air quality impacts during asbestos removal and building demolition would be minimized through use of appropriate engineering controls and compliance with ARARs to protect against offsite release. Potential offsite impacts would be negligible, as the removed equipment, waste, and debris would be disposed of in existing, permitted, facilities authorized to accept such wastes. Potential transportation impacts and risks would be greater than other alternatives due to the greater volume of wastes to be disposed offsite and the greater number of trips. However, transportation risks would be minimized by using established haul routes. Traffic impacts would be minimized by scheduling trips in consideration of commuting peak times, school bus routes and schedules, road and street maintenance, etc. Additional waste management optimization measures such as segregating wastes by waste type, and reusing or recycling materials to the extent practicable, would also be implemented so as to minimize both traffic and transportation impacts.

The recommended alternative would be planned, designed, and implemented to achieve compliance with action-specific ARARs governing general construction practices, building demolition, waste management, and waste transportation. The alternative would comply with radiation protection requirements in controlling radiation exposures to ALARA. The alternative would comply with the location-specific ARAR for NHPA, notably through completing the mitigation measures identified in the Knolls Laboratory Programmatic Agreement to mitigate any adverse effects that the demolition of the buildings would have on the Historic District.

This EE/CA will be made available for public review and comment in accordance with CERCLA requirements. EPA, State, and community acceptance of this recommended alternative will be assessed following the public comment period. Response to those comments will be presented in a Responsiveness Summary, which will be included as part of a future CERCLA Action Memorandum for the F-Complex.

REFERENCES

DOE 1994 — *DOE Secretarial Policy Statement on the National Environmental Policy Act,* Memorandum from H. O'Leary, Secretary of Energy, to DOE Secretarial Officers and Heads of Field Elements, June 13, 1994

DOE 2002 — *DOE Policies on Applications of NEPA to CERCLA and RCRA Cleanup Actions*. Memorandum from B. Cook, Assistant Secretary, Environment, Safety and Health, to DOE Secretarial Officers and Heads of Field Organizations. July 11, 2002.

DOE 2022a — *Historical Site Assessment for the F-Complex*. DOE Environmental Management Consolidated Business Center – New York Project Office. 2022.

DOE 2022b — *Community Involvement Plan for the F-Complex*. DOE Environmental Management Consolidated Business Center – New York Project Office. 2022.

DOE 2022c — DOE NEPA Transportation Impact Screening Analysis. Office of Regulatory Compliance, Office of Environmental Management, version 3, 6/22/2022.

DOE 2022d — *List of threatened and endangered species that may occur in your proposed project location or may be affected by your proposed project.* Letter from the United States Department of the Interior, Fish and Wildlife Service, New York Ecological Services, September 14, 2022.

DOE and EPA 1995 — *Policy on Decommissioning Department of Energy Facilities Under CERCLA*. Memorandum from S. Herman (EPA), E. Laws (EPA), and T. Grumbly (DOE) to multiple DOE and EPA offices, divisions, directors, and regions. May 22, 1995.

EPA/540-R-93-057 — *Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA*. U.S. Environmental Protection Agency, Washington, D.C. August 1993.

EPA 2022a — EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2020. https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks.

EPA 2022b — "EJScreen" U.S. Environmental Protection Agency Environmental Justice Screening Tool, 2022 version. https://www.epa.gov/ejscreen.

NYSHPO 2017 — *Programmatic Agreement Among the U.S. Department of Energy – Naval Reactors Laboratory Field Office at the Knolls Atomic Power Laboratory and the New York State Historic Preservation Office*. New York State Historic Preservation Office, signed by M. Lynch, Director, Division for Historic Preservation. February 17, 2017.

APPENDIX A
DETAILED SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

Criterion	Alternative 1: Continued Legacy Facility Management – No Action Alternative	Alternative 2: Cleanout of Defueled Assemblies	Alternative 3: Demolition of F-Complex
Effectiveness			
Overall Protectiveness of Human Health and the Environment			
Protectiveness of Worker Health and Safety	Effective for assumed 30-year period. Administrative and engineering controls (shielding, monitoring, access controls) would protect workers and the environment from exposure to radiological and chemical contamination, hazardous substances and potentially hazardous materials above regulatory limits.	Effective for assumed 30-year period. Dismantling of the tanks, equipment, and piping within the defueled assemblies (TTR, FCPE, and FPR), followed by decontamination of the former reactor cells (Rooms 29, 36, and 41) would remove the approximately half of the radioactivity in the F-Complex and thereby reduce risk of exceeding occupational radiation exposure limits by workers radiation during subsequent LFM activities. Administrative and engineering controls (monitoring and access controls) would protect workers from exposure to residual contamination,	Effective and permanent. Worker exposure eliminated by removing contaminated facilities
Protectiveness of Human Health and Safety	Effective for assumed 30-year period. Building maintenance would prevent deterioration; access controls would prevent inadvertent access by onsite intruders.	Effective for assumed 30-year period. Approximately half of the radioactivity would be removed. Building maintenance would prevent deterioration; access controls would prevent inadvertent access by onsite intruders.	Effective and permanent. Human health and safety protected by removing contaminated facilities.
Protectiveness of the Environment	Effective for assumed 30-year period. Building maintenance would prevent deterioration to minimize threat of uncontrolled release to the environment.	Effective for assumed 30-year period. Approximately half of the radioactivity in F-Complex would be removed. Building maintenance would prevent deterioration to minimize threat of uncontrolled release to the environment.	Effective and permanent. Potential threat of release to environment eliminated by removing contaminated facilities.
Effectiveness in Reducing Inherent Risks	Moderately effective for 30-year period. Administrative and engineering controls would prevent exposure by workers and maintain risks at low levels. Inherent risks due to radiological and chemical contamination, hazardous substances, and potentially hazardous materials would be unchanged.	Moderately effective for assumed 30-year period. Inherent risks due to radioactivity would be reduced by removing approximately half of the radioactivity in the F-Complex . Administrative and engineering controls would preventexposure by workers to residual radiological and chemical contamination, hazardous substances, and potentially hazardous materials.	Effective and permanent. Inherent risks eliminated by removing contaminated facilities.

Criterion	Alternative 1: Continued Legacy Facility Management – No Action Alternative	Alternative 2: Cleanout of Defueled Assemblies	Alternative 3: Demolition of F-Complex
Reliability During Operation	Reliable as long as controls remain in effect.	Reliable as long as controls remain in effect.	Reliable and permanent with no long-term controls or operation required.
NEPA Values			
Cumulative Impact: Water Quality	No impact identified. No change from current conditions.	Negligible impact controlled through compliance with the Clean Water Act NPDES and SPDES requirements.	Negligible impact controlled through compliance with the Clean Water Act NPDES and SPDES requirements.
Cumulative Impact: Air Quality and Climate Change	No impact identified. No change from current conditions.	Negligible impact. Air quality impacts during decontamination would be minimized by using appropriate engineering controls. Air quality impacts during waste transportation would be minimized by using approved waste containers, vehicle emissions control systems, and reduced idling times.	Negligible impact. Air quality impacts during demolition would be minimized by using appropriate engineering controls. Air quality impacts during waste transportation offsite would be minimized by using approved waste containers, vehicle emissions control systems, and reduced idling times.
Cumulative Impact: Soil or Groundwater	No impact identified. Contamination sources would remain contained and LFM activities would prevent uncontrolled releases to soil or groundwater.	Negligible impact during reactor cleanout and decontamination. Surface runoff to soil negligible during loading of containers into trucks for waste shipment. Water discharges controlled per Knolls Laboratory RCRA-permitted outfall requirements. Contamination and potentially hazardous materials outside the defueled assemblies would remain contained and LFM activities would prevent uncontrolled releases to soil or groundwater.	Negligible impact during demolition and incidental soil removal. Surface runoff to soil mitigated though engineering controls such as silt fences. Water discharges controlled per Knolls Laboratory RCRA-permitted outfall requirements. Long-term contamination sources would be removed, and the surface covered with gravel to minimize sediment-laden runoff.
Offsite Impact: Aesthetics/Visual	No impact identified; no change from current conditions.	Negligible impact; F-Complex, except for FCPE tower, is only minimally visible from offsite.	Negligible impact; F-Complex, except for FCPE tower, is only minimally visible from offsite.
Offsite Impact: Noise	No impact identified. No change from current conditions.	Minor impact due to construction activities and truck haul traffic.	Minor impact due to due to construction activities and truck haul traffic.
Offsite Impact: Traffic	No impact identified. No change from current conditions.	Minor adverse impact. Mitigated through consideration of community traffic patterns, schedules, and coordinated planning to minimize the number of trucks.	Minor adverse impact. Mitigated through consideration of community traffic patterns, schedules, and coordinated planning to minimize the number of trucks.
Offsite Impact: Transportation	Negligible impact. No change from current conditions.	Minor impact. Mitigated through engineering measures and transportation planning. Low risk of vehicle accidents during offsite transportation of moderate quantities of waste materials. Waste transportation would comply with DOT requirements and haul routes would use established commercial truck routes and rail lines.	Minor impact. Mitigated through engineering measures and transportation planning. Low risk of vehicle accidents during offsite transportation of greater volumes of waste. Waste transportation would comply with DOT requirements and haul routes would use established commercial truck routes and rail lines.

Criterion	Alternative 1: Continued Legacy Facility Management – No Action Alternative	Alternative 2: Cleanout of Defueled Assemblies	Alternative 3: Demolition of F-Complex
Offsite Impact: Disposal	No impact identified. No change from current conditions.	No impact. Waste materials would be disposed at existing, permitted disposal facilities (whose impacts have already been evaluated). No new disposal facilities would be required.	No impact. Waste materials would be disposed at existing, permitted disposal facilities (whose impacts have already been evaluated). No new disposal facilities would be required.
Offsite Impact: Utilities	No impact identified. No change from current conditions.	No impact identified; existing utilities would continue to be used.	Minor temporary increase in utilities (electricity, water) during demolition. Long term utility use would decrease because there would be no long term LFM activities. Overall, impacts are negligible.
Offsite Impact: Waste Management	See analysis discussed under Compliance with action-specific ARARS: Waste Management		
Land Use Impact	No impact identified. No change in land use; the Knolls Laboratory is an industrial facility with an ongoing mission. However, due to the presence and arrangement of the defueled assemblies, as well as areas of residual contamination, the use of F-Complex would be limited in meeting mission needs.	No impact identified. No change in land use; the Knolls Laboratory is an industrial facility with an ongoing mission. However, due to the areas of residual contamination, the use of F-Complex would be limited in meeting mission needs.	No impact identified. No change in land use; the Knolls Laboratory is an industrial facility with an ongoing mission. A future positive impact could occur; the site of the former buildings would be suitable for Knolls Laboratory mission uses.
Socioeconomic Impact: Environmental Justice	No impact identified. No change from current conditions.	No impact identified. No communities identified as Environmental Justice populations. No one group would be more adversely affected than another along potential transportation routes.	No impact identified. No communities identified as Environmental Justice populations. No one group would be more adversely affected than another along potential transportation routes.
Socioeconomic Impact	No impact identified. No change from current conditions.	Potential minor beneficial impact: most construction equipment and labor would come from local vendors employing local labor. No impact to local population, neighborhoods, public facilities, or services.	Potential minor beneficial impact: most construction equipment and labor would come from local vendors employing local labor. No impact to local population, neighborhoods, public facilities, or services.
Cultural Resources Impact	See analysis discussed under Compliance with location-specific ARARS: NHPA.		
Human Health Impact	See analysis discussed under Overall Protectiveness of Human Health and the Environment and Ability to Achieve RmAOs.		
Ecological / Biological Impact	No impact identified; No known threatened or endangered species are present, and no critical habitat is found onsite.	No impact identified. No known threatened or endangered species are present, and no critical habitat is found onsite.	No impact identified. No known threatened or endangered species are present, and no critical habitat is found onsite.

Criterion	Alternative 1: Continued Legacy Facility Management – No Action Alternative	Alternative 2: Cleanout of Defueled Assemblies	Alternative 3: Demolition of F-Complex
Compliance with ARARs			
Compliance with chemical-specific ARARs	Would continue to comply with radiation protection requirements in controlling exposures to ALARA.	Would continue comply with radiation protection requirements in controlling exposures to ALARA.	Would comply with radiation protection requirements in controlling exposures to ALARA.
Compliance with location-specific ARARs: NHPA	No impact identified. Building would continue to be maintained in current state.	Negligible adverse impact. DOE would comply with NHPA by implementing mitigation measures specified in the Knolls Laboratory Programmatic Agreement to mitigate any adverse effects that the removed F2 wall section would have on the Knolls Laboratory Historic District.	Adverse impact mitigated through DOE compliance with NHPA by implementing the mitigation measures specified in the Knolls Laboratory Programmatic Agreement to mitigate adverse effects that building demolition would have on the Knolls Laboratory Historic District. Buildings F1, F2, F3, and F6 are contributing elements to the District.
Compliance with action-specific ARARs: General Construction	Would continue to comply with NYSDEC general construction requirements, including dust control during any building repair.	Would comply with NYSDEC general construction requirements, including dust control during building repair and equipment removal and decontamination. Would comply with CAA requirements for control of asbestos and radionuclide emissions. Radiation protection measures would be provided to keep occupational radiation exposures ALARA. Compliance with construction ARARs would control the spread of contamination outside of F-Complex.	Would comply with NYSDEC general construction requirements, including dust control and runoff control during equipment removal and decontamination and building demolition operations. Would comply with CAA requirements for control of asbestos and radionuclide emissions. Clean, reusable materials would meet DOE requirements for unrestricted release for residual surface radioactive contamination. Radiation protection measures would be implemented to keep occupational radiation exposures ALARA. Compliance with construction ARARs would control the spread of contamination outside of F-Complex.
Compliance with action-specific ARARs: Waste Management	Would continue to comply with waste management and waste transportation requirements during LFM.	Would comply with waste management and waste transportation requirements for characterization of hazardous and/or radioactive wastes, waste packaging, labeling, and storage. Wastes would be characterized and segregated by waste type.	Would comply with waste management and waste transportation requirements for characterization of hazardous and/or radioactive wastes, waste packaging, labeling, and storage. Wastes would be characterized and segregated by waste type.
Compliance with action-specific ARARs: Waste Transportation	Would continue to comply with waste management and waste transportation requirements during LFM.	Would comply with waste manifesting, placarding, and disposal at an approved disposal facility. Waste shipments would meet U.S. DOT requirements.	Would comply with waste manifesting, placarding, and disposal at an approved disposal facility. Waste shipments would meet U.S. DOT requirements.

Criterion	Alternative 1: Continued Legacy Facility Management – No Action Alternative	Alternative 2: Cleanout of Defueled Assemblies	Alternative 3: Demolition of F-Complex
Ability to Achieve RmAOs			
Minimize Exposure by Workers	Effective for the assumed 30-year period. Administrative and engineering controls would protect workers from exposure to radiological and chemical contamination.	Effective for the assumed 30-year period. Removal of approximately half of the radioactivity in F-Complex and subsequent administrative and engineering controls (monitoring, and access controls) would protect workers from exposure to the residual levels of contamination.	Effective and permanent. Worker exposure eliminated by removing.
Minimize Migration to Environment	Effective for the assumed 30-year period. Building maintenance would prevent deterioration to minimize threat of uncontrolled release of contamination to the environment.	Effective for the assumed 30-year period. Approximately half of the radioactivity would be removed. Building maintenance would prevent deterioration to minimize threat of uncontrolled release of contamination to the environment.	Effective and permanent. Potential threat of release of hazardous substances to environment eliminated by removing contaminated facilities and contaminated soil.
Level of Treatment/ Containment	Engineering controls (shielding) would protect against exposure to radiation related to defueled assemblies' components. from reactor components. There is no action to treat or otherwise contain contamination.	Approximately half of the radioactivity would be removed. Chemical contamination, hazardous substances, and potentially hazardous materials would remain unchanged. Treatment and/or containment would be implemented to meet requirements at the offsite disposal facility.	Contamination would be removed. Treatment and/or containment would be implemented to meet requirements at the offsite disposal facility.
Level of Residual Concern	Level of radiological and chemical contamination would remain unchanged. Administrative and engineering controls would prevent exposure by workers and maintain risks within allowable thresholds.	Approximately half of the radioactivity in F-Complex would remain as residual contamination. Chemical contamination, hazardous substances, and potentially hazardous materials would remain unchanged. Administrative and engineering controls would prevent exposure by workers and maintain risks within allowable thresholds.	Contamination would be removed. Contaminated soil would be remediated to meet soil cleanup standards. No residual contamination would remain.
Level of Control to Long-Term Remedy	Effective administrative and engineering controls for the assumed 30-year period, when the long-term remedy would be implemented upon site closure.	Effective administrative and engineering controls for the assumed 30-year period for the residual contamination.. Long-term remedy would be implemented upon site closure.	Effective and permanent. No controls required during continued operation of Knolls Laboratory.
Long-Term Protectiveness and Permanence	Not effective over the long term; no permanent remedy implemented.	Not effective over the long term; no permanent remedy implemented. Residual chemical contamination, hazardous substances, and potentially hazardous materials would ultimately need to be removed to achieve permanent site closure.	Effective over the long term; permanent.
Reduction of Toxicity, Mobility, or Volume	No reduction in toxicity, mobility, or volume.	Onsite volume of radioactivity reduced by approximately one-half.	Onsite volume of contamination removed entirely.

Criterion	Alternative 1: Continued Legacy Facility Management – No Action Alternative	Alternative 2: Cleanout of Defueled Assemblies	Alternative 3: Demolition of F-Complex
Short-Term Effectiveness	Effective for the assumed 30-year period; administrative and engineering controls in place to protect workers.	Effective for the assumed 30-year period; administrative and engineering controls in place to protect workers.	Effective and permanent.
Performance over Useful Life	Effective for the assumed 30-year period; administrative and engineering controls would remain useful over that time period.	Effective for the assumed 30-year period; reduced levels of administrative and engineering controls would remain useful over that time period.	Effective and permanent.
Implementability			
Technical Feasibility			
Ease of Construction and/or Operation	Readily implemented; administrative and engineering controls already in place.	Readily implemented within 47 months. Technologies for safely dismantling, containerizing, and removing reactor components and accessory equipment and piping are well established. Specialized expertise required to protect construction worker health and safety. Administrative and engineering controls to address residual contamination are already in place and would continue at a reduced level.	Readily implemented within 53 months. Technologies for safely dismantling, containerizing, and removing reactor components and accessory equipment and piping are well established. Technologies for building decontamination and demolition are also well established. Specialized expertise required to protect construction worker health and safety.
Demonstrated Performance, Reliability	Current LFM program activities have been ongoing successfully for several years, demonstrating that they can perform effectively and can be reliably maintained.	Technologies for safely dismantling, containerizing, and removing reactor components and accessory equipment and piping have been demonstrated previously in the removal of other facilities at Knolls Laboratory. Current LFM program activities have been ongoing successfully for several years, demonstrating that they can perform effectively and can be reliably maintained.	Technologies for safely dismantling, containerizing, and removing reactor components and accessory equipment and piping have been demonstrated previously in the removal of other facilities at Knolls Laboratory. Technologies for building decontamination and demolition have also been demonstrated in the removal of the other facilities.
Applicability to Site Conditions	Current LFM program activities have been ongoing successfully for several years, demonstrating that they are applicable to the conditions within the reactor cells and the remainder of the F-Complex	Technologies for safely dismantling, containerizing, and removing reactor components and accessory equipment and piping are applicable to this alternative. Current LFM program activities have been ongoing successfully for several years, demonstrating that they are applicable to the conditions within F-Complex.	Technologies for safely dismantling, containerizing, and removing reactor components and accessory equipment and piping are applicable to this alternative. Technologies for building decontamination and demolition are applicable to the F-Complex.
Time to Complete Removal	Readily implemented; administrative and engineering controls already in place and would be continued.	Readily implemented within 47 months.	Readily implemented within 53 months.

Criterion	Alternative 1: Continued Legacy Facility Management – No Action Alternative	Alternative 2: Cleanout of Defueled Assemblies	Alternative 3: Demolition of F-Complex
Time to Achieve RmAOs	RmAOs would be achieved immediately; but protectiveness relies on controls continuing uninterrupted for assumed 30-year period.	RmAOs would be achieved upon removal of the defueled assemblies, but protectiveness relies on controls continuing uninterrupted for assumed 30-year period.	RmAOs would be achieved upon completion of demolition and removal of any residual contaminated soil.
Availability of Resources			
Availability of Equipment, Personnel, or Services	Equipment, personnel, and resources are readily available to continue LFM program activities.	Specialized equipment, personnel, and resources are readily available for dismantling, containerizing, decontaminating, and disposal of wastes. Equipment, personnel, and resources are also readily available to continue LFM program activities at a reduced level.	Specialized equipment, personnel, and resources are readily available for dismantling, containerizing, decontaminating, and disposal of wastes. Conventional equipment, personnel and resources are readily available for building demolition.
Availability of Treatment or Disposal	No action or controls implemented that might require treatment or disposal.	Waste materials would be disposed at existing, permitted disposal facilities having sufficient capacity; no new disposal facilities required.	Waste materials would be disposed at existing, permitted disposal facilities having sufficient capacity; no new disposal facilities required.
Administrative Feasibility			
Feasibility of Institutional Controls	Feasible; current institutional controls have been successful for several years and would be continued.	Feasible; current institutional controls have been successful for several years and would be continued at a reduced level.	Feasible; no long-term institutional controls implemented.
Feasibility of Obtaining Permits	No additional permits required.	No additional permits required.	No additional permits required.
State Acceptance	State Acceptance to be assessed following the public comment period. Response to State comments on this EE/CA will be presented in the Responsiveness Summary.		
Community Acceptance	Community Acceptance to be assessed following the public comment period. Response to public comments on this EE/CA will be presented in the Responsiveness Summary.		
Cost			
Capital Cost	$2.1M	$24.5M	$68.4M
O&M Cost	$1.24M/yr for 30 years	$1.11 M/yr for 30 years	$0
Present Worth Cost	$17.5M	$38.4M	$68.4M

APPENDIX B
SUMMARY OF ESTIMATED COSTS FOR THE REMOVAL ACTION ALTERNATIVES

Cost Category	Unit Cost	Unit	Alternative 1: Continued LFM – No Action Alternative		Alternative 2: Cleanout of Defueled Assemblies		Alternative 3: Demolition of F-Complex	
			Quantity	*Cost*	*Quantity*	*Cost*	*Quantity*	*Cost*
Capital Costs								
1.1 Building Repairs	$2.079	ls	1	$2,079	1	$2,079	0	$–
TTR Cleanout								
2.1 Project Management	$3.090	day	–	$–	101	$312	101	$312
2.2 Project Support	$6.030	day	–	$–	101	$609	101	$609
2.3 Preparation	$490	ls	–	$–	1	$490	1	$490
2.4 Field Work	$1,508	ls	–	$–	1	$1,508	1	$1,508
2.5 Waste Management Support	$7.600	day	–	$–	71	$540	71	$540
2.6 Waste Transportation & Disposal (LLW)	$1.250	cy	–	$–	81	$101	81	$101
FPCE Cleanout								
3.1 Project Management	$3.090	day	–	$–	579	$1,789	579	$1,789
3.2 Project Support	$6.030	day	–	$–	579	$3,491	579	$3,491
3.3 Preparation	$975	ls	–	$–	1	$975	1	$975
3.4 Field Work	$6,158	ls	–	$–	1	$6,158	1	$6,158
3.5 Waste Management Support	$7.600	day	–	$–	480	$3,648	480	$3,648
3.6 Waste Transportation & Disposal (LLW)	$1.250	cy	–	$–	688	$860	688	$860
3.7 Waste Transportation & Disposal (HAZ)	$0.660	cy	–	$–	80	$53	80	$53
3.8 Seal Holes in Bldg F2 Walls	$64	ls	–	$–	1	$64	–	$–
FPR Cleanout								
4.1 Project Management	$3.090	day	–	$–	59	$182	59	$182
4.2 Project Support	$6.030	day	–	$–	59	$356	59	$356
4.3 Preparation	$651	ls	–	$–	1	$651	1	$651
4.4 Field Work	$236	ls	–	$–	1	$236	1	$236
4.5 Waste Management Support	$7.600	day	–	$–	39	$296	39	$296
4.6 Waste Transportation & Disposal (LLW)	$1.250	cy	–	$–	71	$89	71	$89
4.7 Waste Transportation & Disposal (HAZ)	$0.660	cy	–	$–	12	$8	12	$8
4.8 Waste Transportation & Disposal (debris)	$0.040	cy	–	$–	35	$1	35	$1
F-Complex Building Demolition								
5.1 Building Characterization	$0.120	sf	–	$–	–	$–	15,274	$1,833
5.2 Asbestos Abatement	$0.130	sf	–	$–	–	$–	23,677	$3,075
5.3 Building Demolition, single story	$0.200	sf	–	$–	–	$–	15,133	$3,027
5.4 Building Demolition, multi-story	$0.240	sf	–	$–	–	$–	15,961	$3,831
5.5 Building Demolition, annex	$0.080	sf	–	$–	–	$–	600	$48

Cost Category	Unit Cost	Unit	Alternative 1: Continued LFM – No Action Alternative		Alternative 2: Cleanout of Defueled Assemblies		Alternative 3: Demolition of F-Complex	
			Quantity	*Cost*	*Quantity*	*Cost*	*Quantity*	*Cost*
5.6 Robust Demolition Reactor Rooms	$0.480	sf	–	$–	–	$–	7,223	$3,467
5.7 Slab Demolition	$0.020	sf	–	$–	–	$–	23,979	$480
5.8 Basement/Subbasement Demo	$0.140	sf	–	$–	–	$–	3,300	$462
5.9 Basement Demolition	$0.100	sf	–	$–	–	$–	5,383	$538
5.10 Waste Transportation & Disposal (LLW)	$1.250	cy	–	$–	–	$–	9,306	$11,633
5.11 Waste Transportation & Disposal (HAZ)	$0.660	cy	–	$–	–	$–	2,268	$1,497
5.12 Waste Transportation & Disposal (debris)	$0.040	cy	–	$–	–	$–	6,327	$253
5.13 Project Management & Oversight	40%	%	–	$–	–	$–	40%	$12,060
Sample, Excavate, Backfill								
6.1 Project Management	$3.090	day	–	$–	–	$–	55	$170
6.2 Project Support	$6.030	day	–	$–	–	$–	55	$332
6.3 Preparation of Plans	$50	ls	–	$–	–	$–	1	$50
6.4 Mobilize to Site	10%	allow	–	$–	–	$–	10%	$298
6.5 Characterize Residual Soil	$2.290	ea	–	$–	–	$–	40	$92
6.6 Excavate Contaminated Soil	$0.510	cy	–	$–	–	$–	268	$137
6.7 Waste Transportation & Disposal (LLW)	$1.250	cy	–	$–	–	$–	161	$201
6.8 Waste Transportation & Disposal (HAZ)	$0.660	cy	–	$–	–	$–	107	$71
6.9 Backfill Excavation	$0.270	cy	–	$–	–	$–	9182	$2,479
Total Capital Cost				$2,079		$24,543		$68,385
O&M Costs								
Annual LFM	$1,063	$/yr	1	$1,240	1	$1,116	–	$–
Total O&M Cost				$1,240		$1,116		
Present Worth O&M Cost				$15,387		$13,848		
Total Present Worth Cost								
Total Present Worth Cost (Capital and O&M)				$17,466		$38,391		$68,385

Note: All reported costs are in $1,000s, shown as 2022 $. LLW = low-level waste HAZ = regulated/hazardous