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Buried TRU Wastes and TRU-Contaminated Soils at Oak Ridge National Laboratory

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ORNL/RAP-24

BURIED TRU WASTES AND TRU-CONTAMINATED SOILS AT OAK RIDGE NATIONAL LABORATORY

TRU WASTE PROGRAM
(Activity No. AR 05 15 20 0; ONL-WI76)
August 1987

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1.0 INTRODUCTION

1.1 OVERVIEW

This document provides the Oak Ridge National Laboratory (ORNL) response to comments in the General Accounting Office (GAO) report entitled Department of Energy's Transuranic Waste Disposal Plan Needs Revision (GAO 1986).

1.2 SCOPE

The GAO report indicated that additional information should include the following:

- plans for the permanent disposal of buried waste, contaminated soil, and difficult-to-certify waste;
- cost estimates for the permanent disposal of TRU waste, including options for buried waste, contaminated soil, and difficult-to-certify waste; processing and certifying newly generated TRU waste; decontaminating and decommissioning of TRU waste processing facilities; and interim operations.

In response, this document provides information and cost data on ORNL's plans and schedules for the permanent disposal of buried TRU-contaminated waste, TRU-contaminated soil, and difficult-to-certify TRU waste.

ORNL has 12 suspect buried TRU waste sites. Knowledge regarding waste inventories is generally incomplete, and it is difficult to specifically locate the TRU-contaminated waste within large waste disposal areas. Site characteristics are poor, with a humid climate, high water table, and extensive hydraulic communication with streams. Buried TRU-contaminated waste sites will be assessed and managed under provisions of Section 3004(u) of the Resource

Conservation and Recovery Act (RCRA). A Remedial Investigation (equivalent to Phase 2 of DOE Order 5480.14) and Corrective Measures Study (equivalent to Phase 3 of the DOE Order) program will be completed by 1992. At that time schedules for further actions will be determined.

2.0 ORNL SITE DESCRIPTION

Oak Ridge National Laboratory was established in 1943 on the 240 km^2 Oak Ridge Reservation in East Tennessee, 30 km west of Knoxville (see Figure 1). Since its establishment, various locations on the ORNL site have been used to dispose of the radioactive waste generated by ORNL programs. Between 1956 and 1962, ORNL also accepted commercial radioactive waste and, for a time, waste from other federal facilities for disposal. These wastes were buried in the same trenches as the ORNL radioactive waste.

ORNL and its accompanying buffer zone, encompassing 3550 ha, lie almost entirely within the White Oak Creek drainage basin (Figure 1). Soils range from 15 cm to 4.6 m deep and from silty loam to plastic clay. The site is underlain by sandstone, limestone, and shale. The ORNL area (Figure 2) is characterized by a humid, temperate climate and receives an annual average precipitation of 130 cm. Greater than 95 percent of precipitation occurs as rainfall, with peak amounts in December through March and in July. The water table ranges from less than 1 to as much as 10m below the surface, and the uppermost aquifers in the groundwater system are generally thought to outcrop to surface streams before leaving the Oak Ridge Reservation boundary. Stream flow is seasonally large and periods of accumulative winter precipitation often lead to a high water table in late March. Flooding can also be a local problem, and the relatively large amount of rainfall reduces the distance between groundwater recharge and discharge points as well as the length of the groundwater residence time. The groundwaters are neutral to slightly alkaline (pH 7 to 8.5) and enriched in Ca, Mg, and bicarbonate ions.

The two cations are only slightly diluted in surface waters and thus interfere with ^{90}Sr sorption on soils and sediments. The overall effect of these combined factors is to enhance the mobility of weakly sorbed contaminants such as ^{3}H and ^{90}Sr and to aggravate the management of such constituents in the ORNL environment. However, releases of TRU radionuclides are relatively small and make no significant contribution to off-site population exposures.

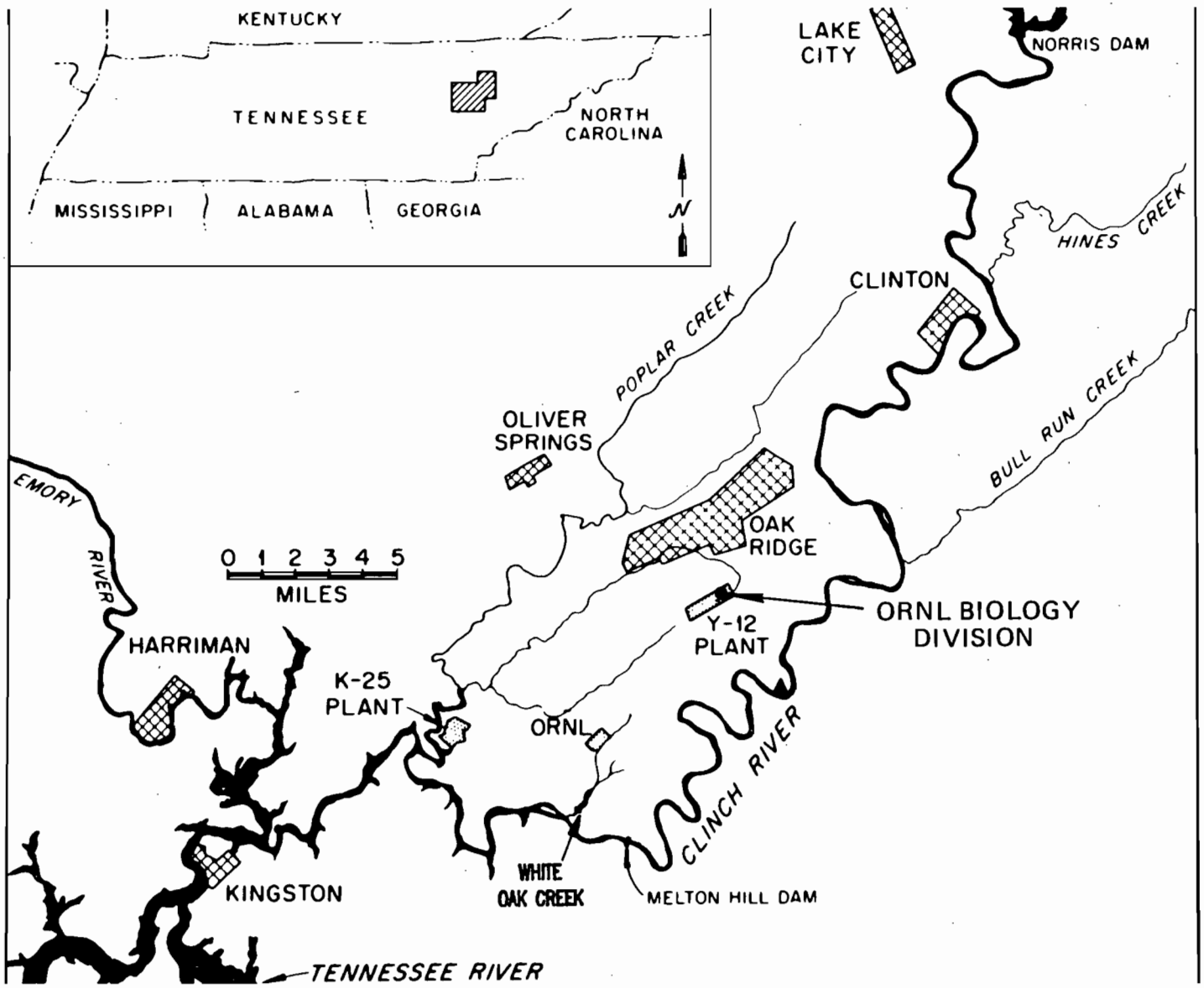

Figure 1. The Oak Ridge National Laboratory and Environs

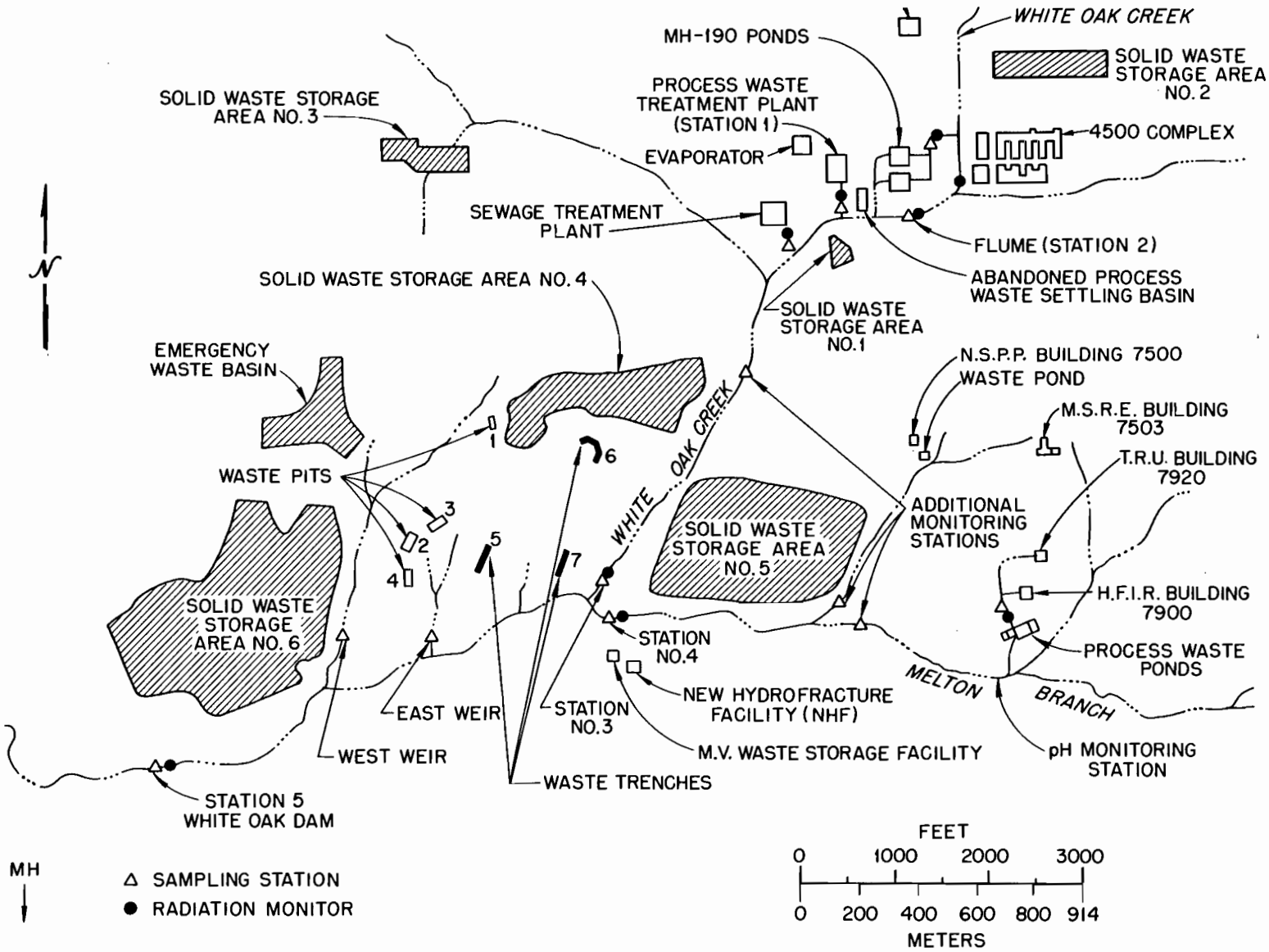

Figure 2. ORNL Waste Sites and Monitoring Locations

3.0 TRU WASTE SITE DESCRIPTIONS

3.1 BACKGROUND

The TRU-contaminated sites at ORNL are located in two parallel valleys that are oriented northeast-southwest and separated by Haw Ridge. Bethel Valley is on the north side of Haw Ridge, and is drained by White Oak Creek, a small tributary of the Clinch River (which also forms the southern boundary of the DOE Oak Ridge Reservation). The flow pattern of White Oak Creek is from Bethel Valley to Melton Valley through a gap in Haw Ridge, and then through the southwest portion of Melton Valley [past Solid Waste Storage Area 4 (SWSA 4), and then LLW Pits and Trenches Area] to the Clinch River. The northeast portion of Melton Valley is drained by the Melton Branch tributary of White Oak Creek, which receives effluents from SWSA 5 before it joins White Oak Creek (Figure 2).

SWSAs 1, 2, and 3 are located in Bethel Valley which is underlain by limestones of the Chickamauga Formation. Fractures and solution cavities in the Chickamauga limestones make predictions of transport difficult, but generally serve to enhance the movement of groundwater and dissolved waste constituents (Webster 1976). This tendency is enhanced even more in the areas adjacent to SWSAs 1 and 2 by the existence of numerous anthropogenic features (for example, gravel-filled pipeline trenches) which become preferred-flow pathways for rapid transport of waste constituents from groundwater to nearby tributaries of White Oak Creek.

SWSAs 4 and 5, waste pits 1, 2, 3, 4, and trenches 5, 6, and 7 are located in Melton Valley, which is underlain by the Conasauga Group (interbedded shale, siltstone, and limestone units with varying degrees of permeability and with a total thickness of approximately 600 m). These waste pits and trenches were used for liquid waste disposal operations during the period 1949 to 1965.

Soils in the ORNL area are characterized as silty, with considerable clay content, and a pH ranging from 4.5 to 5.7. The

weathered zone in Bethel Valley areas underlain by Chickamauga Limestone is thin, generally less than 3 m. The depth of weathering in areas underlain by the Conasauga Group is related to topography: thinning from ridge tops to low-lying areas. In SWSA 4, the weathered zone ranges from 1.2 to 4.9 m, while in SWSA 5, it ranges from < 1 to 12 m. The principal minerals in the weathered Chickamauga materials are kaolinite and illite, and in the Conasauga Group: illite, smectite, and vermiculite. Although these minerals have excellent sorptive properties for some radionuclides (^{137}Cs, in particular), the complex, fractured nature of some of the surface members and the relatively high porosity of weathered zones, coupled with unfavorable features of some waste disposal practices, permit appreciable releases of poorly sorbed radionuclides such as ^{3}H and ^{90}Sr (NAS 1985, Coobs and Gissel, 1986).

3.2 SPECIFIC WASTE CATEGORY DATA AND INVENTORIES

The estimated volumes and TRU radioactivity of buried waste and contaminated soil at ORNL are presented in Table 1. These estimates are based on fragmentary and limited information because few historical records exist for SWSAs 1 and 2; and the records of SWSAs 3, 4, and (parts of) 5 were destroyed by fire. The estimated inventory of TRU contaminants (270 Ci) was derived from accountability records. The volume estimate was derived by back-extrapolation using reasonable assumptions of trench size and number of trenches. The volume of contaminated soils resulting from solid waste burials was estimated to range from 12,000 to 60,000 m^3 (DOE 1985b). An additional 1000 m^3 of contaminated soil containing about 50 Ci of ^{239}Pu and unknown quantities of other TRU nuclides was estimated to have resulted from liquid waste disposal operations. Better estimates of inventories and volumes will be developed during site characterization studies. Remedial action costs presented in this document are based on the estimated volumes shown in Table 1.

Despite the absence of documentation on hazardous chemical inventories, radionuclides are expected to be the primary hazardous materials present at the majority of ORNL sites. In addition, the radionuclide inventories at all sites are dominated by fission products (^{90}Sr and ^{137}Cs), tritium, and activation products (for example, ^{60}Co) rather than by the transuranics.

Some of the underground grout sheets below the New Hydrofracture Facility also contain TRU-bearing materials, some in concentrations exceeding 100 nCi/g. The grout sheet waste is not addressed in this report and is not shown in the volume and radioactivity values because it is well isolated 300 m below the ground surface. The need for remedial actions involving the grout sheets will be evaluated as a part of ORNL's compliance with RCRA Section 3004(u).

Table 1. Estimated Volume and TRU Radioactivity Content of Buried Waste and Contaminated Soil at ORNL

Waste Site Description	Contaminant	Inventory [Ci (kg)]	Volume (m^3)
Solid Waste Storage Areas (SWSAs) 1, 2, 3, 4, and 5			
Buried TRU-Contaminated Wastes	^{233}U & ^{239}Pu	270 (5.6)[a]	6,200[a]
Contaminated Soil Proximate to Wastes	TRU	N/A	12,000 to 60,000[b]
LLW Seepage Pits and Trenches			
Sludges and soil at all 7 sites	TRU	N/A	≤1,000
Total		270	19,000 to 67,000

[a]Historical estimates obtained through the use of accountability records (inventories) and back-extrapolations (volumes), DOE 1985b.

[b]Historical estimates which are based on multiples (2 to 10 x) of the buried TRU waste volume estimate. This estimate also assumes that TRU-contaminated sites are isolable from LLW sites.

3.3 SPECIAL-CASE AND DIFFICULT-TO-CERTIFY TRANSURANIC WASTE

Historically, ORNL has identified a total volume of 1274 m^3 of special-case waste, as shown in Table 2. Of this total, 1270 m^3 is remoted-handled (RH) TRU waste stored in concrete casks or as sludges in underground tanks. This RH TRU waste has been listed as special-case (SC) or difficult-to-certify waste in prior inventories because it was not certifiable with existing technology and facilities. A facility designated as the Waste Handling Pilot Plant (WHPP) is being designed for the processing and certification of the RH TRU waste to the WIPP criteria. Capital funds for this facility will be requested in future DOE budgets. The facility will also be capable of processing and certifying remote-handled TRU waste from other DOE sites. Future inventory listings of special-case waste will not show ORNL's RH TRU waste as special case waste, but will instead include it in the Waste Isolation Pilot Plant (WIPP) inventory workoff schedule.

The remaining inventory of special case waste will consist of 4 m^3 of three other waste categories, as shown in Table 2.

Table 2.

ORNL Historical Inventory of Special-Case Waste

Waste Type	No. Packages	Total Vol (m^3)
RH TRU	4918	1270
CEUSP Uranium Oxide[a]	401	1.7
Miscellaneous Cans	200	0.3
Stainless Steel Capsules	13	1.5
TOTALS	5532	1274

[a] This material was previously considered to be recoverable scrap. However, due to high ^{232}U content and resulting radiation levels, no foreseeable use has been identified and disposal options are now being evaluated.

The Consolidated Edison Uranium Solidification Project (CEUSP) material consists of uranium oxide and chemical salts that do not meet the WIPP criteria due to high fissile material content. The miscellaneous cans contain mixed uranium oxides that will not meet WIPP criteria unless it is solidified. The material stored in capsules also has fissile quantities that exceed the WIPP criteria.

ORNL's strategy is to solidify the material in the miscellaneous cans, using an existing facility, and to request disposition of all waste in these three categories in WIPP or through the Federal Waste Management System (FWMS). Based on the above plans and strategy, ORNL does not expect to have any waste that cannot be certified to WIPP criteria at the end of the site inventory work-off period in the year 2013.

4.0 ENVIRONMENTAL SURVEILLANCE ACTIVITIES

4.1 BACKGROUND

The perimeter monitoring of both groundwater and surface water at inflow and discharge points for each geohydrologically defined waste area assures protection of human health and the environment. Based upon such monitoring data, further studies, principally directed toward the groundwater subsystem, can address individual sites or contaminant plumes that extend beyond the perimeter.

Thus, many aspects of environmental surveillance, including preliminary characterization, maintenance and surveillance, interim corrective actions, monitoring, and the Remedial Investigation/Feasibility Study (RI/FS) process itself, are now or will be oriented toward this geographic (and hydrogeologic) scale. Site characterizations will be performed for each area to identify significant sources of releases and evaluate both the need for interim corrective measures and the options for long-term stabilization actions (Section 5). Past and planned environmental monitoring and remedial activities associated with individual site categories are summarized in Table 3.

A system of water quality monitoring wells was installed in fiscal year (FY) 1985 at all active surface impoundments at ORNL. Although an extensive network of wells had also been constructed for studies of radionuclide migration in groundwater at a number of ORNL waste disposal sites, these were constructed prior to the development of RCRA standards for groundwater-monitoring well construction and placement. Much more comprehensive information on site geohydrologic characteristics and well development (materials, procedures) is now required to meet the new RCRA standards. The new standards require the placement of a rigorous network of hydrostatic head and piezometer wells to define the groundwater flow regime well in advance of the construction of groundwater monitoring wells.

Thus, a comprehensive program was initiated at the inception of the Remedial Action Program (RAP) in FY 1985 to develop the information that is needed to establish a satisfactory perimeter monitoring network of RCRA-quality wells in all ORNL waste areas for the RI/FS. Projected completion dates for the perimeter network of over 100 monitoring wells at buried TRU-contaminated waste sites (BIW) are given in Table 3. Also, the entire surface-water monitoring system at ORNL is currently being expanded and upgraded. New monitoring locations will be added during the execution of the RI/FS as appropriate perimeter-station locations are identified.

4.2 MONITORING RESULTS

Groundwaters in the ORNL waste disposal areas have been monitored routinely by quarterly sampling of more than 100 wells. Concentrations of fission and activation products are routinely measured and the samples are subjected to a gross alpha-particle count. Alpha activity seldom exceeds background by any significant amount, but samples that show unusual alpha activity are analyzed by spectrometer. Results to date have shown almost no detectable movement of TRU radionuclides in the groundwater.

Several sampling stations in the White Oak Creek watershed have been used to monitor surface waters (Figure 2). TRU radionuclide concentrations are routinely measured only at White Oak Dam, which is located near the ORNL site boundary and the terminus of the White Oak Creek drainage. All TRU-contaminated sites are upstream from this location and since their discharges become mixed and integrated before reaching White Oak Dam, it is not currently possible to distinguish individual site trends in TRU releases with time or their relative contributions to overall TRU releases.

The principal contributors to the <25 mrem/year dose commitment from ORNL site releases to the off-site population are ^{3}H, ^{60}Co, ^{90}Sr, and ^{137}Cs. Over 90 percent of the total dose commitment is attributable to ^{3}H and ^{90}Sr alone, with approximately equal

contributions from each nuclide. The dominant source of ^{3}H is SWSA 5 and the major sources of ^{90}Sr are the Main Plant Waste Area (which contains a large number of Remedial Action Sites, including SWSAs 1 and 2), SWSA 4 and SWSA 5. The integrated surface-water releases of TRU radionuclides from all ORNL sites, monitored at White Oak Dam: (1) have been very slight; (2) have remained relatively constant for the past decade; and (3) have not made significant contributions to calculated off-site population exposures (Martin Marietta Energy Systems 1986).

Table 3. Environmental Surveillance for TRU-Contaminated Sites at ORNL

Site	Surveillance Measures
LLW SEEPAGE PITS AND TRENCHES	
Pit 1 Pits 2, 3, and 4	All are asphalt capped; cap extension and groundwater diversion and monitoring are ongoing at Trench 7.
Trench 5 Trench 6	Perimeter groundwater monitoring wells are scheduled to be installed in FY 1988.
Trench 7	In situ vitrification studies for site stabilization are ongoing.
SOLID WASTE STORAGE AREAS	
SWSA 1 and SWSA 2	Surface-water is monitored at several locations downstream. Perimeter groundwater-monitoring wells will be installed in FY 1987.

Table 3. Environmental Surveillance for TRU-Contaminated Sites at ORNL (Continued)

Site	Surveillance Measures
SWSA 2	Regular erosion control is conducted. Soil coring in 1977 indicated no measurable contamination.
SWSA 3	Perimeter groundwater-monitoring well installation is scheduled for FY 1988 Fenced and grass-covered; runoff diversion is in place.
SWSA 4	Perimeter groundwater-monitoring wells are scheduled for completion in FY 1988 Fenced and grass-covered; surface runoff and groundwater controls are employed; trench-grouting studies are ongoing; surface-water monitoring is carried out.
SWSA 5	Perimeter groundwater-monitoring well installation is scheduled for FY 1987 Fenced and grass-covered; drainage ditches are employed; some trench corrective measures have been carried out; surface-water monitoring is in place.

5.0 REMEDIAL ACTION PROGRAM

5.1 BACKGROUND

From the inception of the Remedial Action Program (RAP), the overall strategy followed the guidance given in the DOE Orders covering surplus facilities management (Order 5820.2; DOE 1984), the Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA; Order 5480.14 (DOE 1985a)], and the National Environmental Policy Act (NEPA) because the Resource Conservation and Recovery Act (RCRA) was believed to apply only to a limited number of sites (that is, active surface impoundments). As part of this strategy, individual sites were being addressed according to estimated priorities for site characterization, remedial action, and decommissioning or closure planning. Integration of individual remedial actions was to be provided through a comprehensive site-wide environmental assessment, leading to development of an environmental impact statement (EIS) for remedial actions in the entire White Oak Creek watershed. This primarily CERCLA- and NEPA-oriented approach formed the basis for both long-range and current-year planning, and had been presented to representatives from appropriate regulatory agencies (State of Tennessee and EPA-Region IV) for consideration.

However, in April 1986, the EPA elected to enforce regulatory requirements for remedial actions through its RCRA authority rather than its CERCLA authority. Under this authority, any new RCRA permit for a hazardous waste management unit must adhere to the corrective action requirements of Section 3004(u) of the 1984 Hazardous and Solid Waste Amendments. Remedial actions will be required for <u>all</u> continuing releases of hazardous waste or constituents from <u>any</u> solid waste management unit, <u>regardless of when the waste was placed there.</u> At ORNL, the buried TRU-contaminated waste sites fall into these categories.

Proposed enforcement of the RCRA Section 3004(u) provisions involves a series of steps. The most significant of these is a Remedial Investigation [acronyms: RI(CERCLA) and RFI(RCRA), equivalent to Phase II in DOE Order 5480.14], followed by a Corrective Measures Study. CMS corresponds to the Feasibility Study (FS) conducted under CERCLA and to Phase III in the DOE Order. These provide the basis for determining the extent of contamination problems and the scope of needed corrective actions. This process begins with identification of sites either known to exhibit continuing releases or having the potential to do so.

The timing for the RI/FS sequence is not defined, but must be negotiated with EPA and State regulatory authorities through the RCRA permit application process. Based on the requirements of RCRA Section 3004(u), a modified RAP implementation strategy has been developed that is responsive to regulatory concerns.

5.2 PLANS, SCHEDULES, AND COSTS

The first step in the implementation process involves the establishment of a regulatory-approved inventory of sites that will be evaluated in preparation for future remedial actions and the development of a perimeter groundwater-monitoring capability for the major waste areas. Continued control over these sites will be provided through maintenance, surveillance, and interim corrective actions to ensure adequate protection of human health and the environment until final site disposition has been achieved. For each of the sites in the RAP inventory, a detailed characterization and assessment of site conditions and the potential for environmental and health impacts will then be performed. This study will include an evaluation of alternatives for accomplishing any corrective actions needed. These alternatives (for decommissioning or closure) will be screened for their applicability to ORNL environmental conditions, and field-scale technology demonstrations will be performed, where

necessary, at specific sites prior to full-scale implementation. Finally, site decommissioning or closure implementation will be carried out, according to priorities approved by regulatory authorities, to provide long-term management of residual contaminants.

The work-breakdown structure (WBS) developed to guide this effort is presented in Table 4, along with an estimate of the cost of the work associated with buried TRU-contaminated waste sites to be included in each program phase. This represents a significant fraction of the overall RAP effort in each phase over the period indicated because these sites contain most of the LLW and the TRU-contaminated waste inventories disposed of in the near-surface environment at ORNL. The pre-remedial-action costs associated with buried TRU-contaminated waste sites (that is, costs for actions required prior to decommissioning or closure) may be approximated by summing the costs in Table 4. This amounts to about 19 million dollars through FY 1991.

5.2.1 Schedules and Costs for RI/FS

The Remedial Investigation and Feasibility Study Phase, required by RCRA for sites exhibiting continuing releases of hazardous constituents, is anticipated to take approximately 5 years to complete. Initial estimates for the BIW-related sites indicate an expenditure of approximately $6.7 million over the lifetime of the entire effort, including both ORNL and subcontractor involvement (Table 4). This intensive 5-year program has been outlined to provide the DOE equivalent of the EPA's RI/FS sequence for all sites which are anticipated to require a detailed assessment (Figure 3). A the first step in this program, a RCRA Facilities Assessment (RFA), that is, an expanded version of the CERCLA Phase I exercise carried out in FY 1986, has been conducted for all contaminated areas to document the site characteristics and determine the need for follow-up efforts.

Preliminary schedules for completion of the RI/FS phase are provided in Table 5. Under the plan outlined in Fig. 3 and in Table 4, detailed Alternatives Assessments (AAs) would be prepared for each area following completion of the RI activities. These AAs would be tiered to a single Feasibility Study for ORNL, thus providing a comprehensive assessment of the need, priority, timing for, and extent of future remedial actions.

Table 4. Remedial Action Program Budget for TRU-Contaminated Sites--Work-Breakdown Structure

Work-Breakdown Structure	Projected Funding Requirements ($000)				
	FY 1987	FY 1988	FY 1989	FY 1990	FY 1991
I. Preliminary Assessment and Site Investigation	$ 920	$ 890	$ 760	$ 620	$ 130
II. Maintenance, Surveillance, and Corrective Actions	430	940	1,230	1,370	1,390[a]
III. Remedial Investigations and Feasibility Study	560	2,030	2,260	1,120	490[b]
IV. Technology Demonstrations	1,080	980	750	930	430
V. Program Strategy Development	50	0	0	0	0
VI. Site Decommissioning and Closure	0	0	0	0	0
Totals	$ 3,040	$ 4,840	$ 5,000	$ 4,040	$ 2,440

[a] Some activities in Phase II will continue beyond FY1991; since the nature of the activities and the costs are a function of the remedial alternatives and the schedule for remedial action, these cannot be projected at this time.

[b] An additional $230,000 wll be required in FY1992 for completion of the feasibility study.

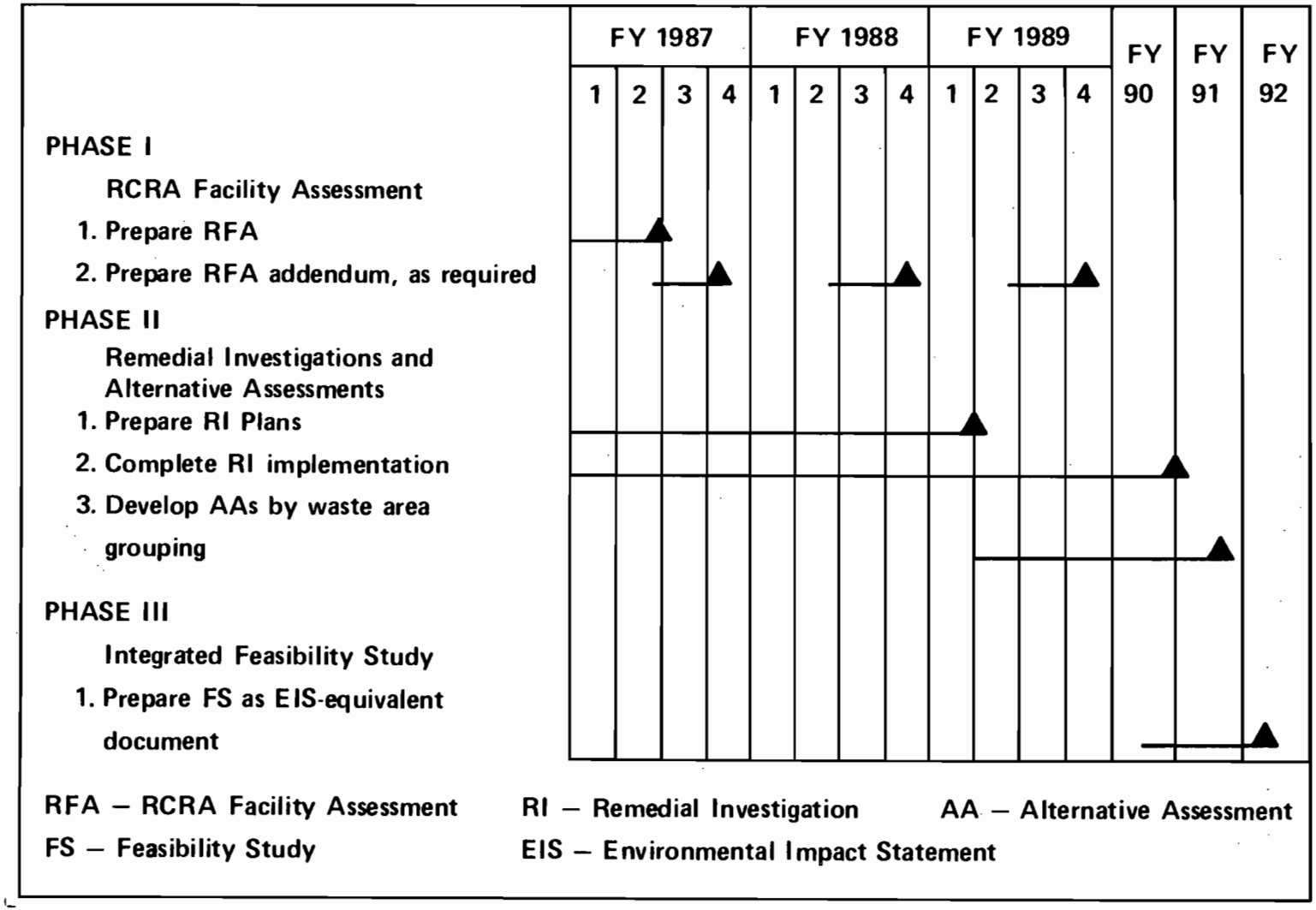

Figure 3. Proposed Schedule for Remedial Investigation/Feasibility Study Activities

Table 5. Preliminary Schedules for ORNL Remedial Investigations/Feasibility Study[a]

Waste Area	Completion Schedules by Phases[b,c] (month/year)				
	I	IIA	IIB	III	
	RFA	(RI or RFI)		AA	FS
Solid Waste Storage Areas 1 & 2	4/87	12/87	9/90	6/91	3/92
Solid Waste Storage Area 3	4/87	3/88	9/89	3/90	3/92
Solid Waste Storage Area 4	4/87	12/87	3/89	9/89	3/92
Solid Waste Storage Area 5	4/87	3/88	9/89	3/90	3/92
LLW Pits and Trenches Area	4/87	9/88	3/90	9/90	3/92

[a]Key to abbreviations:

AA	Alternatives Assessment
FS	Feasibility Study
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
RI	Remedial Investigation

[b]Comparison of phases in DOE Order 5480.14, CERCLA, and RCRA Section 3004(u):

Phase I is comparable to the EPA's RCRA Facility Assessment or the CERCLA Preliminary Assessment/Site Investigation. RFA covering all units was provided to EPA in April 1987 (ORNL 1987).
Phase IIA is comparable to the EPA's CERCLA Remedial Investigation Plan or the RCRA Facility Investigation Plan.
Phase IIB is comparable to the EPA's CERCLA Remedial Investigation or the RCRA Facility Investigation.
Phase III is comparable to the EPA's CERCLA Feasibility Study and the RCRA Corrective Measures Study. A single, comprehensive FS has been proposed to cover all of the Waste Area Groupings. Individual Alternatives Assessments will be prepared for each grouping prior to issuance of the final FS.

[c]All schedules following completion of Phase IIA (RI or RFI Plans) are tentative and subject to change based on (1) acquisition of new information from site characterization activities and (2) programmatic reviews by, and negotiations between, DOE and the regulatory agencies. All RCRA units within a grouping that are subject to new or interim-status permit requirements will also adhere to the applicable permit requirements.

5.2.2 Schedules and Costs for Decommissioning/Closure

Upon completion of the RI/FS sequence, major closure or decommissioning actions will be implemented according to priorities and schedules negotiated with the EPA and Tennessee State regulatory authorities. The magnitude of the efforts for long-term management of ORNL sites can only be roughly approximated because site-characterization information is currently preliminary in nature. Programmatic support responsibilities for the major undertaking represented by the Site Decommissioning and Closure phase of the RAP have not been formalized at this time. Initial projections indicated that long-term solutions for dealing with the entire inventory of RAP sites, of which the suspect TRU sites are a subset, would require a period of 15 to 20 years and the expenditure of approximately $1 billion (unescalated).

This initial cost estimate was based on the assumption that capping, hydrologic isolation, and limited in situ grouting, rather than in situ vitrification, would be used to stabilize TRU-contaminated areas. The resource requirement for in situ stabilization of TRU-contaminated sites at ORNL is estimated to range from $70 to $500 million, and includes $25 million for environmental monitoring, remedial backup, and performance evaluation over the 100-year period following site closure.

The total cost of the exhumation option for ORNL is heavily dependent on the degree to which TRU wastes and LLW (and corresponding contaminated soil fractions) can be segregated, mainly in the SWSAs. Since the information needed will be developed during the RI/FS phase of the RAP, the outcome, and thus the associated cost, is difficult to project. For purposes of estimation, it is assumed that suspect buried TRU wastes and contaminated soils can be localized within a waste and soil volume that is no greater than twice the sum of extant volume estimates. This case would thus require that a volume of 38,000 to 134,000 m^3 be exhumed, assayed, processed, and certified into equal portions (19,000 to 67,000 m^3)

of TRU waste and LLW, respectively. Based on such assumptions, expenditures for implementing the exhumation option at ORNL could range from $0.5 to $2 billion.

The current regulatory climate does not appear to permit serious consideration of a continuation of past waste management practices, along with an expanded monitoring effort (that is, a "leave-in-place" option) as an alternative to the RI/FS and, ultimately, site decommissioning and closure to meet new requirements. However, for the sake of comparison, a leave-in-place cost estimate ($50 to $150 million) for buried TRU-contaminated waste sites has been developed based on 100-year projections of unescalated costs for (1) environmental monitoring under new regulatory requirements and (2) conducting maintenance, surveillance, and limited corrective actions. The costs for the leave-in-place option thus fall within the lower end of the range of costs projected for implementation of in situ-stabilization.

Schedules for carrying out decommissioning or closure actions (equivalent to Phases IV and V under DOE Order 5480.14) will be developed during the latter phases of the RI/FS and submitted for DOE, EPA, and State approval. Because of the need to ensure functional equivalence of the RI/FS process with NEPA requirements, it is expected that most major actions will be carried out after completion of the entire RI/FS sequence. However, interim decommissioning or closure actions may also be necessary, and such actions will be identified on a case-by-case basis during execution of the sequence.

5.3 TECHNOLOGY DEMONSTRATION AND DEVELOPMENT

A variety of technology demonstrations, including field evaluations, are ongoing: (1) geophysical trench mapping (to assist in isolating potential suspect TRU-waste trenches from LLW trenches), (2) polyacrylamide grouting of buried suspect TRU-waste trenches and particulate grouting of LLW trenches in solid waste disposal areas,

and (3) grout-curtain hydrologic barriers at LLW Trench 7. Field tests are also planned for capping and hydrologic isolation of typical shallow-land burial trenches in one SWSA and for in-situ vitrification of TRU-contaminated sludges and soil in the LLW Pits and Trenches Area. A field demonstration designed to identify site-specific problems and characteristics of vitrified materials at ORNL sites has recently been completed using a surrogate waste form.

Other technological alternatives will be evaluated and costed during the execution of ORNL's RI/FS. These will include field evaluations of in-situ-TRU-assay technology after initial field trials, scheduled during FY 1987 at an Idaho National Engineering Laboratory site, have been carried out. In-situ assay equipment has the potential capability of determining the level of TRU contamination in buried waste and contaminated soil without extensive core sampling or exhumation. Use of this equipment would greatly reduce the worker exposures and associated hazards encountered during the remedial investigations and site characterization activities. The costs of technology demonstrations are included in Phase IV in Table 4.

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