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**Integration of Environmental Restoration and Waste Management Activities
for a More Cost-Effective Tank Remediation Program
Oak Ridge National Laboratory,
Oak Ridge, Tennessee**

By

Angie Brill, STEP, Inc.
Randy Clark, Lockheed Martin Energy Systems
Randy Stewart, Lockheed Martin Energy Research

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ABSTRACT

This paper presents plans and strategies for remediation of the liquid low-level radioactive waste (LLLW) tanks that have been removed from service (also known as inactive tanks) at Oak Ridge National Laboratory (ORNL), Oak Ridge, Tennessee. Much of the LLLW system at ORNL was installed more than 50 years ago. The LLLW system is a mix of over 70 singly and doubly contained tank systems constructed of various materials (stainless steel, mild steel, and Gunite) with capacities ranging from 100 to 170,000 gallons. Those tanks known to contain liquid contents that may fluctuate have level-monitoring equipment that are checked regularly.

The overall objective of the Inactive Tank Program is to remediate all LLLW tanks that have been removed from service to the extent practicable in accordance with the regulatory requirements. The program focuses on remediation of tank residues (i.e., contents after tank has been emptied) and tank shell. This has been accomplished cost effectively since 1995 when ORNL started remediating inactive tanks with capacities less than 25,000 gallons as maintenance actions using Waste Management Division (WM) standard operating procedures instead of extensive Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) planning documents. This requires a conservative risk assessment be performed to indicate to the regulators (and other stakeholders) that a rigorous and costly CERCLA process was not necessary to remediate "no risk" tanks. Additional cost savings were realized in 1996 when ORNL began integrating WM tank isolation activities with Environmental Restoration Division (ER) tank remediation activities.

Based on past experience, the integration of ER remediation activities with WM isolation activities has resulted in an estimated 50 percent reduction in cost and also in an accelerated schedule. This cost/schedule savings is due to the integrated isolation/remediation decision-making process resulting in a focused sampling effort; elimination of redundant ER/WM documentation; a single mobilization of a trained subcontractor; reduction in the amount of soil excavation and pipeline cutting and capping; minimization of secondary waste generation; and

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reduction of surveillance and maintenance activities. This paper will provide the frame work for the supporting remediation decision process and discuss the benefits of integrating ER and WM activities.

BACKGROUND

The ORNL is a multidisciplinary research facility that began operation in 1943 as part of the Manhattan Project and as a consequence of these associated research activities, heterogeneous wastes, including, solid and liquid radioactive, hazardous, and mixed wastes, have been generated in varying amounts over time. These activities (past and present) have generated LLLW that must be managed and ultimately remediated. The LLLW system is complex, with multiple facilities, users, and operators. The system is used for collection, neutralization, transfer, and concentration of aqueous radioactive waste solutions from generator facilities. Waste solutions are typically accumulated at source buildings, often in collection tanks located inside the buildings, and discharged to below-grade collection tanks that receive wastes from several different source buildings. A network of below-grade piping interconnects the various system components.

Much of the LLLW system was installed more than 50 years ago. The original system, installed during the early 1940s, and its subsequent modifications, were designed to minimize radiation exposure to LLLW system users and operators. The system includes features such as unvalved, gravity-drained transfer lines to prevent waste backup into generator areas; shielded lines and tanks; and provisions for remote operations to minimize personnel exposure. Design drawings exist for most of these tanks with only a few as-built drawings available. Over the years, tank systems were removed from service as their integrity was breached or as programs were terminated. New tank systems installed during the past 10 to 15 years incorporate secondary containment and cathodic protection and improved leak detection features. Thus the LLLW system is a mix of doubly-contained tank systems and singly-contained tank systems. The tank status (active or inactive), remediation status (in-place or removed), and locations in Bethel Valley, are shown in Figure 1. A summary of ORNL tank remediation activities, including tanks remaining to be remediated, is provided in Table 1. Additional detailed tank data and planning information is provided in two ORNL reports: *Inactive Tanks Remediation Program Strategy and Plans for ORNL*¹ and *Implementation Plan for the LLLW Tank Systems for Fiscal year 1998 at ORNL*².

<<<<Place **Figure 1** (Location map for Bethel Valley LLLW tanks) here.>>>>

<<<<Place **Table 1** (Overview of the ORNL's Inactive Tank Program) here.>>>>

REGULATORY STATUS

The Superfund Amendments and Reauthorization Act of the CERCLA requires a Federal Facility Act (FFA)³ (i.e., Tri-Party Agreement) for federal facilities placed on the National

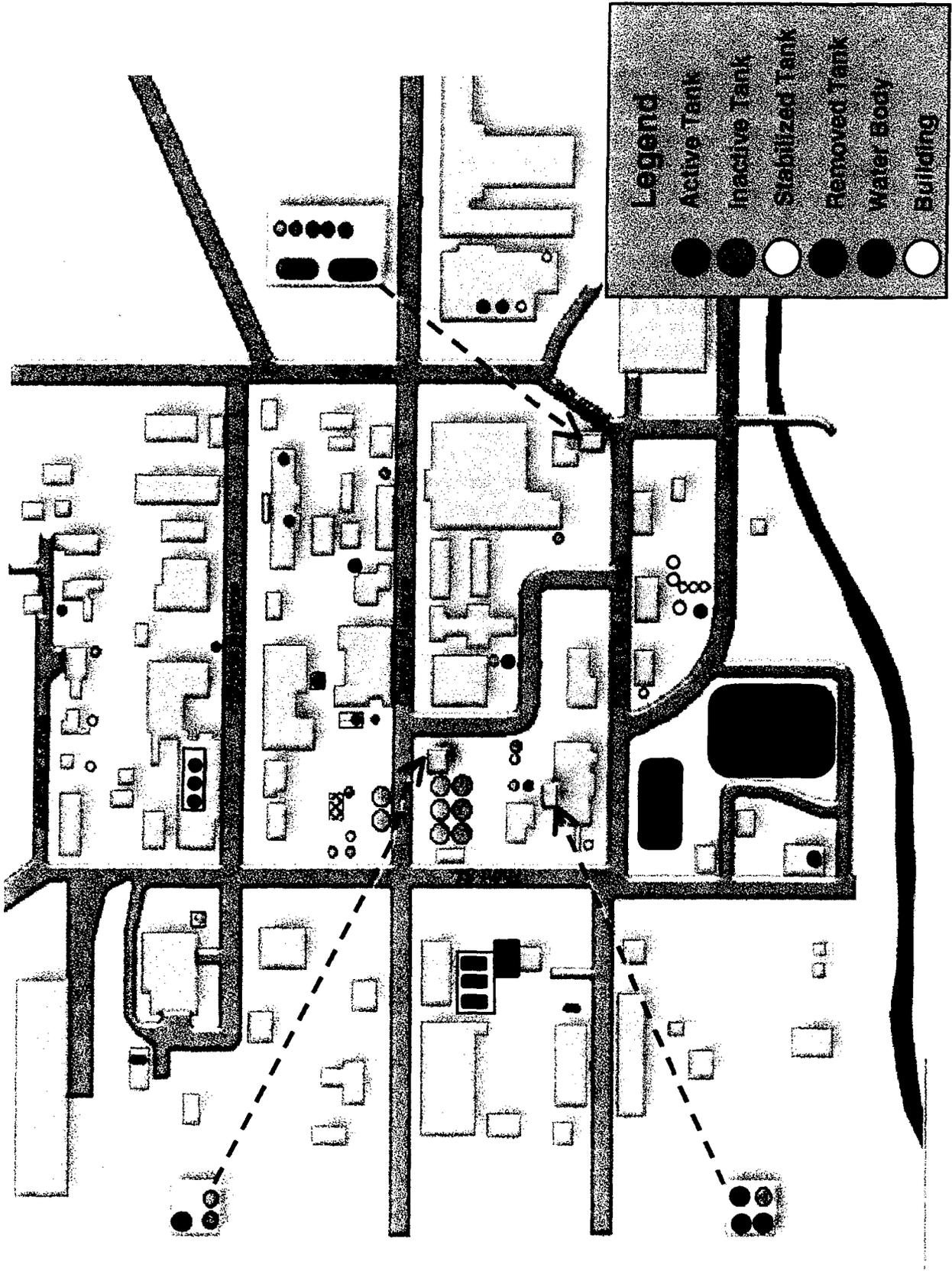
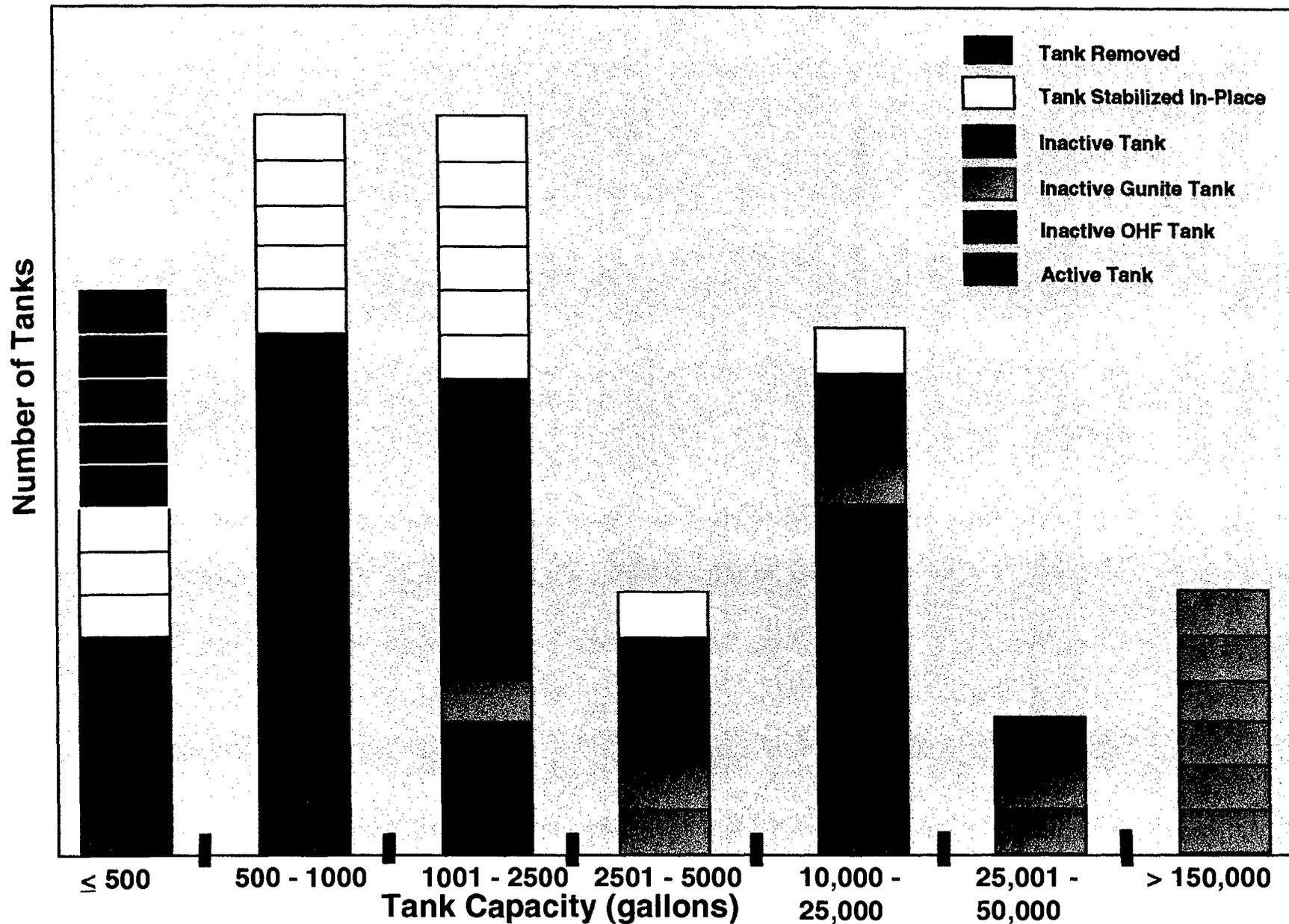


Figure 1. Location Map For Central Bethel Valley LLLW Tanks

Table I. Oak Ridge National Laboratory LLLW Tanks Remediation Summary



Priorities List (NPL). The Oak Ridge Reservation was placed on the NPL on December 21, 1989, and the agreement was signed in November 1991 by the DOE Oak Ridge Operations Office (ORO), EPA Region IV, and the TDEC (DOE 1992). The effective date of the FFA was January 1, 1992.

According to the FFA, within 90 days of the date on which a tank is declared inactive DOE must provide EPA and TDEC with a plan and schedule for characterizing the tank contents and the risks associated with the tank. On the basis of the results of waste and risk characterization, DOE must then provide EPA and TDEC with a plan and schedule for remediation of the inactive tank. For tanks or tank groupings that are actively in the CERCLA process, current remediation schedules are negotiated annually and published in Appendix E of the FFA.

Based on the July 11, 1996 revision to the FFA Appendix F, there are a total of 57 tanks that have been removed from service. These tanks are defined in Section IX (A)(d) of the FFA as Category D tanks because they are "existing tank systems without secondary containment that are removed from service." As such, some of these tank shells have been removed or stabilized in place (i.e., filled with grout) as indicated in Figure 1 and Table 1 or are currently being evaluated to determine the appropriate remediation strategy as discussed in the following sections.

REMEDICATION STRATEGY

The overall objective of the Inactive Tank Program is to evaluate and remediate all LLLW tanks that have been removed from service to the extent practicable in accordance with FFA requirements. As stated in Section IX.G.4 of the FFA, "to the extent practicable, the DOE shall remove or decontaminate, or otherwise remediate all residues, contaminated containment system components (liners, etc.), contaminated soils and structures and equipment associated with the tank system(s)." The primary task of the Inactive Tank Program is to remediate the tank residues and tank shell. Other contaminated equipment and soil associated with the tank system will be remediated in conjunction with similar remediation activities for adjacent areas and/or watershed Record of Decisions (RODs) so that consistent and cost-effective remediation of the area can be achieved. The Bethel Valley ROD, scheduled for approval by the end of fiscal year 2000 will address the remediation of these other components (e.g., piping and valve pit). The following paragraphs will discuss the current remediation strategy for the ORNL inactive LLLW tanks and supporting risk assessment assumptions.

Risk Assessment Strategy

The ORNL Inactive Tank Program risk assessment strategy is based on an incremental approach in which quantitative decision rules are used to help ensure a conservative method with a minimum of modeling⁴. This conservative screening-level risk assessment process is used as a decision tool to determine if a tank can be remediated as a maintenance action. The primary radionuclide contaminants of potential concern (COPC) which are evaluated include: cesium-137, cobalt-60, curium-244, plutonium-239, strontium-90, tritium, and uranium-238. Inorganic

COPC are also factored into the risk evaluation but due to their low concentrations they usually are negligible risk contributors. As stated in many ORNL CERCLA documents, the primary risk drivers are the radionuclides. Ingestion of groundwater is the only exposure pathway that is evaluated for the future residential exposure scenario. Because leached COPC in groundwater are assumed to be at 100 percent concentration in the drinking water, this pathway reflects the most conservative risk evaluation as compared to other potential residential exposure pathways (i.e., inhalation or dermal contact). Additional conservative assumptions for the ingestion through the groundwater pathway are a 2-liter per day intake rate for a 350 days per year exposure frequency. Calculated contaminant concentrations in groundwater are used to estimate projected risk by comparison to risk-based screening levels (also referred to as preliminary remediation goals, PRGs).

The site conceptual model for this exposure assessment is presented in Figure 2. This exposure assessment assumes tank failure (either localized or general) has occurred and contaminants have been released to the surrounding environment. After release from the tank, contaminants are transported to the groundwater interface at the saturated zone by precipitation/infiltration through the unsaturated soil. Precipitation/infiltration into tanks has been modeled using Oak Ridge Reservation-specific precipitation rates. Infiltration rates are assumed to equal precipitation rates. Initially, vertical fate and transport modeling of contaminant migration into groundwater is performed using the Disposal Unit Source Term (DUST) code developed at the Brookhaven National Laboratory for the Nuclear Regulatory Commission. In the DUST code, general failure is estimated to occur immediately (i.e., time = 0) at which time the container is assumed to no longer provide a barrier for contaminant releases.

<<<<Place **Figure 2** (Site conceptual model for the inactive tank human health risk assessment).>>>>

If the DUST model results in an unacceptable contaminant concentration (risk $>10^{-6}$), flow through the saturated zone (groundwater medium) is performed using the FTWORK model. This is a three-dimensional, finite-difference model that is used to simulate groundwater flow and solute transport process under confined and unconfined conditions. The FTWORK was developed for the Savannah River Site to simulate the groundwater flow through large, complex, multilayered, fully saturated, porous hydrogeologic systems. The model has been calibrated by ORNL hydrogeologists to simulate groundwater flow underlying the ORNL main plant area and the flow scenario to White Oak Creek (i.e., the nearest stream that transports water off site).

In summary, this conservative risk assessment model assumes that the tank fails, the tank residual waste leaches into the unsaturated-saturated zone interface, and an on-site resident consumes 2-liters per day of the contaminated groundwater. If this risk exceeds or is within the EPA range of concern, more realistic assumptions are made (i.e., groundwater modeling using FTWORK is performed to include dilution of contaminants horizontally through the soil column to the nearest surface water source) and the risk re-evaluated to determine if the tank should be addressed through a more rigorous CERCLA risk assessment/remediation process. These

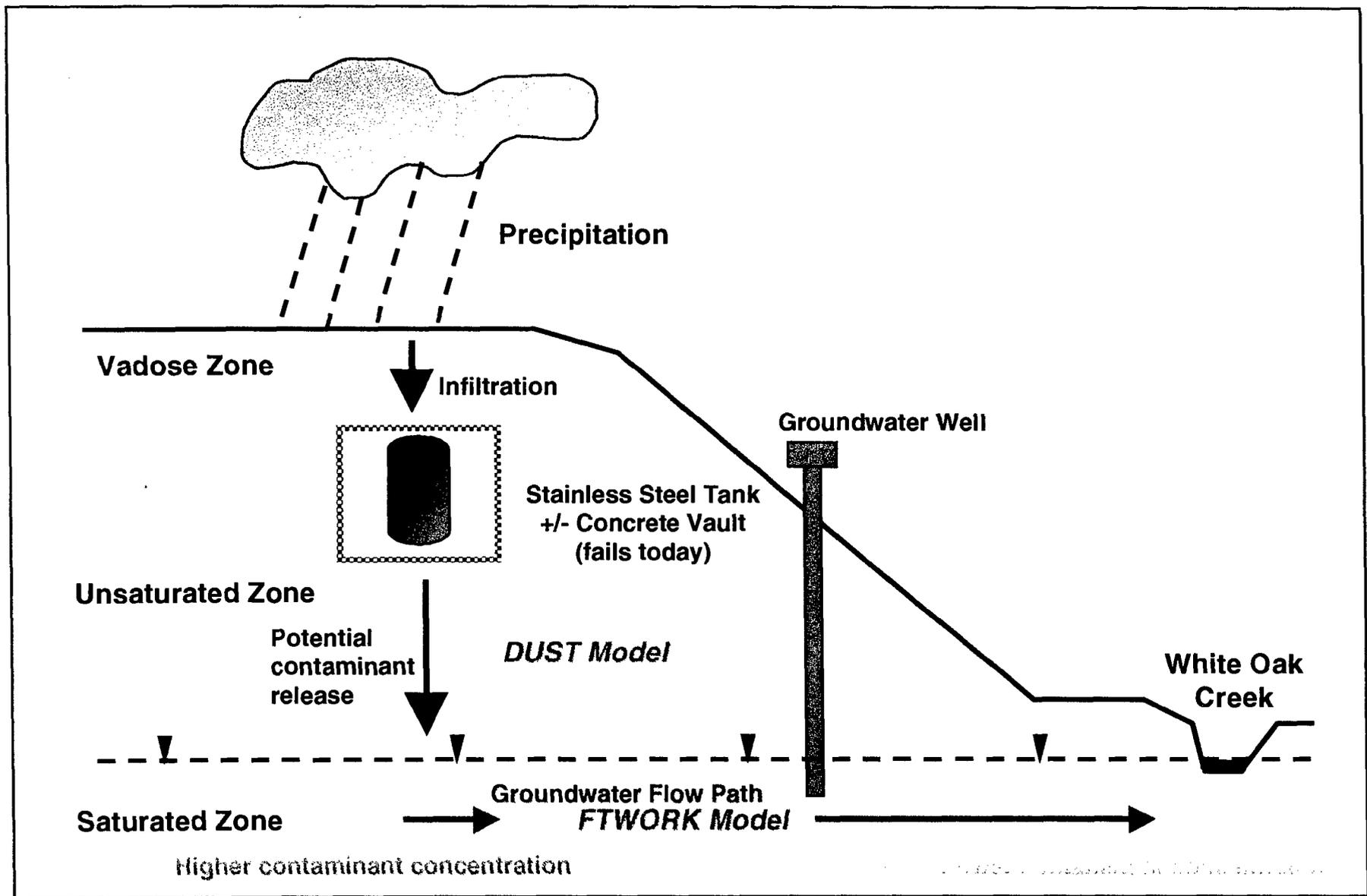


Figure 2. Site conceptual model for LLLW tank human health risk assessment.

assumptions include: (1) attenuation of the contaminants through soil as they transport via groundwater to the nearest stream and (2) reduction in source term with only 2 inches of liquid and 0.1 inches of sludge remaining in the tank.

Tanks which pose no significant risks by CERCLA definition still require remediation under the FFA because they are listed in Appendix F of the FFA. If the risk is below the EPA range of concern, the tank shell and residuals are a candidate for remediation as a maintenance action.

Remediation Decision Process

In addition to the risk assessment discussed above, other factors are also considered when making remediation decisions. These other factors include:

- tank accessibility (e.g., located in a vault, buried under a building, etc.),
- waste acceptance criteria for disposal facility to receive tank shell,
- contamination adjacent to the site (soil and groundwater),
- future land use in the area,
- future activities associated with adjacent facilities (i.e., decontamination and decommissioning),
- institutional controls, and
- other factors specific for the area.

Figure 3 illustrates conceptually how these factors are evaluated in the remediation decision process. This decision process information is provided to EPA and TDEC prior to remediation of a particular tank to gain consensus on the remediation decision (e.g., removal versus in-place remediation) prior to implementation. These factors are expanded upon in the following paragraphs.

<<<<Place **Figure 3** (Conceptual LLLW Tank Remediation Decision Process) here.>>>>

Tank accessibility includes an evaluation of the size and location of the tank in a vault or soil, as well as, the diameter and presence of an access riser(s). The size of the tank will determine if a tank filled with flowable fill/grout can be removed in the future using conventional equipment readily available at ORNL. A 40-ton crane (currently available at ORNL) can lift a 4,000-gallons capacity tank filled with flowable fill. However, if a 150-ton crane (available in the United States) was used it could lift a 15,000-gallons capacity tank filled with flowable fill. The location of the tank in a vault or soil will help determine the difficulty and cost effectiveness in accessing the tank for removal. The location of a tank in a vault, direct buried, or under a building affects the feasibility of excavating and removing it for disposal. Also, a tank may not have a riser that is large enough or accessible (without excavation) which effects sampling/characterization, content removal, and ability to place grout for stabilization in place.

If a tank is determined to be accessible, the waste acceptance criteria (WAC) of the disposal

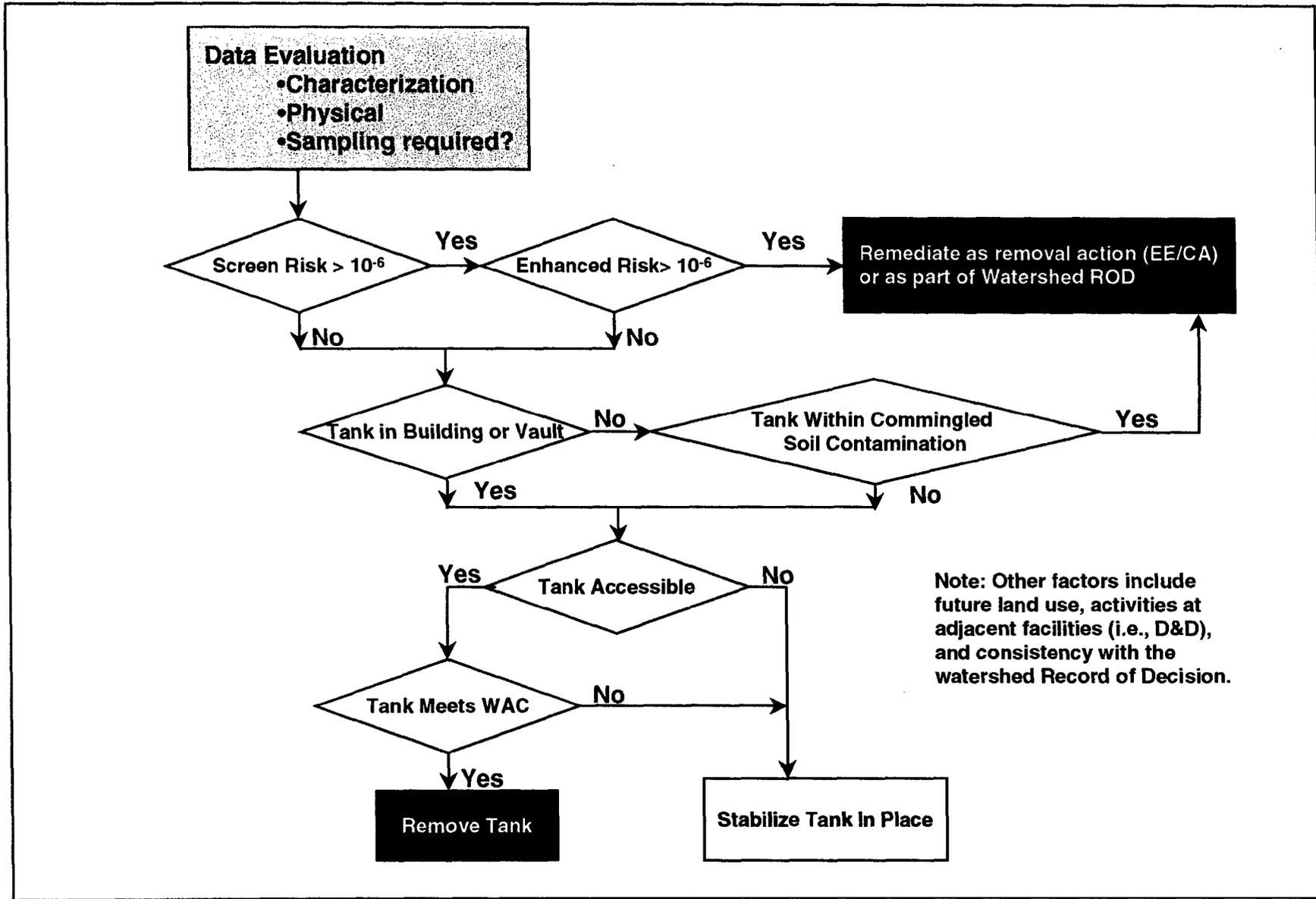


Fig 3. Conceptual LLLW tank remediation decision process.

facility must be evaluated, along with, Department of Transportation (DOT) requirements for transport of contaminated tank and residues on public highways. If analysis of the tank shell and contents indicates the WAC and DOT requirements can not be met with out expensive, aggressive pretreatment, the tank should be a prime candidate for in-place stabilization if this is compatible with future plans for the surrounding area.

If the tank is determined to be surrounded by soil or groundwater contamination due to past leaks it should be remediated as a CERCLA action (e.g., removal action). Otherwise, the tank should be considered a candidate for remediation as a maintenance action.

Consideration of the long-term remediation goals for the overall site will be addressed by the Bethel Valley Watershed ROD. The Inactive Tank Program will continue to focus on tank shell and content remedial alternatives that are consistent with the on-going watershed ROD process.

ENVIRONMENTAL RESTORATION AND WASTE MANAGEMENT INTEGRATION

In 1995, the ER program began remediating inactive tanks as maintenance actions based on this remediation decision process while at the same time WM began planning for isolating tanks taken out of service in recent years. Tank isolation activities included stopping nonprogrammatic inputs to the tank, emptying/rinsing the tank, characterizing residual waste liquids and sludge (if any), and cutting and capping critical piping connecting the tank to the active LLLW system. After the tanks were isolated they were to be administratively transferred to ER for remediation. However, it was realized that it would be more costly to perform tank isolation and remediation as separate field activities due to the duplication in field planning documentation and contractor personnel mobilization/training. In addition, cost would be incurred for surveillance and maintenance activities for the time between isolation and remediation activities.

Thus, in 1996 when WM began isolating tanks, ER technical forces worked with them to make necessary remediation decisions prior to isolation activities. The integration of EM/WM activities eliminated redundant activities and addressed remediation concerns prior to initiating isolation field activities. This integration has resulted in cost and schedule savings associated with inactive LLLW tank isolation and remediation. Some of the efficiencies achieved through this integrated effort strategy are as follows.

- The tank is sampled once to gather information needed to make both isolation and remediation decisions by following existing waste management standard operating procedures. Separate ER documents, such as a sampling analysis plan, safety and health plan, quality assurance project plan, etc., are unnecessary.
- The decision to remove or stabilize the tank in place is made on the basis of a screening-level risk assessment, cost effectiveness, future activities in the vicinity of the tank site, etc., prior to mobilizing the WM subcontractor who will carry out the isolation and remedial

activities. Thus, only one set of implementation plans (site safety and health plan, engineering specifications, etc.) is prepared to support field activities and subcontractor personnel are mobilized only once. Training cost for subcontractor personnel are also incurred once.

- For those tanks where in-place stabilization is the preferred alternative, isolation can be achieved by filling the tank with flowable fill/grout, thus the costs of excavating soil to expose pipelines, disposing of the potentially contaminated soil, as well as, the costs of actually cutting and capping lines, will not be incurred because placement of the grout serves as a tank and pipeline isolation technique. In addition, ALARA goals are achieved by minimizing personnel exposure to an excavated tank and piping and the potential for volatilizing contaminants during cutting and capping are eliminated.
- Even after isolation, tanks are susceptible to inleakage due to loss of integrity of old piping connected to the tank and further degradation of the tank walls. As a result, tank liquid levels must continued to be monitored and accumulated liquids periodically pumped and treated. These surveillance and maintenance activities are eliminated by combining WM isolation activities with ER remediation activities.

There are two primary challenges when integrating these activities: (1) WM's isolation schedule and funding is accelerated compared to the ER project funding profile and prioritization which is based primarily on risk and (2) regulator concurrences are contingent upon larger ER programmatic issues and watershed remediation objectives which directly impact the individual tank project-specific decision process. However, DOE plans to combine both ER and WM activities by FY 1999 to facilitate the integration of these two programs so that transfer of facilities/responsibilities will not be necessary and funding/scheduling issues will no longer be a hindrance.

SUMMARY

Based on past experience, the integration of ER remediation activities with WM isolation activities has resulted in an estimated 50 percent reduction in cost and also in an accelerated schedule due to the integrated isolation/remediation decision-making process resulting in a focused sampling effort; elimination of redundant ER/WM documentation; a single mobilization of trained subcontractors; reduction in the amount of soil excavation and pipeline cutting and capping; minimization of secondary waste generation; and reduction of surveillance and maintenance activities.

Since 1995 when inactive tank remediation began, the following has been accomplished.

- Five tanks have been removed and disposed of.
- Sixteen tanks have been stabilized in place by filling them with a stabilization/fixation material (i.e., grout).

- Initiated a time-critical removal action that will involve removal of TSCA, PCB, TRU-contaminated sludge from a tank in the main plant area (scheduled to be complete in FY 98).
- Completed cathodic protection upgrades on existing piping.
- Performed monthly tank and annual pipe leak detection tests.
- Submitted annual FFA Implementation Plan and Structural Integrity Assessment Plan.

Examples of ORNL's past tank remediation activities involving tank removal and stabilization in place can be seen in Figure 4.

<<<<Insert **Figure 4** (Examples of ORNL LLLW tanks being remediated by removal and stabilization.) here>>>>

Tank remediation should be viewed as a dynamic, flexible, customized process that must be adapted in response to the specific circumstances of individual tank systems and site conditions. Thus, this remediation strategy will be tailored to accommodate feedback from lessons learned from previous tank maintenance/remediation activities. The Inactive Tank Program will continue to integrate activities with WM when possible and participate in the Bethel Valley Watershed ROD to provide consistency, and strive to find new and innovative approaches to tank remediation.

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Tank LA-104 Removal



**Tank 3002A Stabilization In Place
(Grouting)**

Fig 4. Examples of ORNL LLLW tanks being remediated by removal and stabilization.

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