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## 1.0 INTRODUCTION

### 1.1 Purpose

The purpose of this report is twofold. First, this report documents the technical evaluation supporting the Project Hanford Management Contract (PHMC) contractor recommendation to close the Unreviewed Safety Question (USQ) as originally evaluated in TF-94-0260, "Soil Compaction Test Data Indicates Soil Density in Excess of Density Used in Tank Qualification Analysis for AP Tank Farm." (Dougherty and Rifaey 1994) Second, this report describes the status of existing structural analyses for the Tank Waste Remediation System (TWRS) waste storage structures and outlines the associated technical upgrades being considered by the contractor. This second feature of the report serves to communicate the distinction between the soil density issue which is the topic of the open USQ and other technical issues which are important to the contractor from a programmatic standpoint. Contractor actions to address the latter technical issues would support improvements in day-to-day operations (e.g., provide possible relaxations in soil load restrictions) but are not necessary to close the soil density USQ.

### 1.2 Scope

Section 2.0 of this report documents the rationale for the PHMC contractor recommendation to the Department of Energy (DOE) to close the soil density USQ. Section 3.0 documents the recommended structural analyses improvements for the double-shell tanks (DSTs) which are the structures associated with the soil density USQ. Sections 4.0 and 5.0 provide, for completeness, the same information for single-shell tanks (SSTs), double-contained receiver tanks (DCRTs), catch tanks and inactive miscellaneous underground storage tanks (IMUSTs). Section 6.0 provides the conclusions of this report.

### 1.3 Existing Analyses

Several analyses were performed to update the structural analyses of record for the double-shell tank farms (Julyk 1994a, b, c, d) and to address accident scenarios and other issues associated with the Authorization Basis for the TWRS facilities (Han 1996a and 1996b, Julyk 1996, Marusich 1996, Wagenblast 1996). These analyses answer the safety concerns associated with the USQ, but do not address all the issues associated with the technical bases for the underground storage facilities. While TWRS facilities continue to operate safely, the technical limitations of the existing calculations have already curtailed some aspects of operations. Recent (Julyk 1998b) scoping calculations indicate that some of the accident scenario calculations were overly simplified, making them conservative, but at the same time limiting operations unnecessarily. In particular, the analyses for direct-buried horizontal steel catch tanks given in Wagenblast (1996) warrant a more rigorous analysis to develop a broader operating range with respect to in situ soil loading and surface loads for day-to-day operations. Listings of the existing structural analyses relevant to the TWRS waste storage structures are provided in Tables 1, 2, and 3.

Table 1 lists the structural analyses of record for dome loading calculations from Section 5.16, "Dome Loading Controls," of *Tank Farms Operations Administrative Controls*, HNF-IP-1266 (LMHC 1998a). The structural analyses of record are those analyses relied upon in

the dome loading program (HNF-IP-1266, Section 5.16) to define the tank load limits for normal operation. Table 2 lists analyses referenced in the *Tank Waste Remediation System Basis for Interim Operation*, HNF-SD-WM-BIO-001 (BIO; LMHC 1998b), and *Tank Waste Remediation System Technical Safety Requirements*, HNF-SD-WM-TSR-006 (TSRs; LMHC 1998c). The analyses referenced in the Authorization Basis are associated with accident scenarios. Table 3 lists additional structural analyses recently released but not used as references in the Authorization Basis. The inclusion in this report of these analyses is by the recommendation of TWRS structural analysts; they are verified (peer-reviewed) technical basis documents necessary for day-to-day operations of the underground storage facilities.

## 2.0 USQ CLOSURE RATIONALE

The USQ regarding soil density as declared by the Department of Energy (Wagoner 1994) is being recommended for closure. This USQ addresses the discovery of actual soil density in excess of that used in tank qualification analyses. As shown below, the actual soil density is now accounted for in the analyses which support the accident scenarios found in the BIO (LMHC 1998b) and the administrative procedure (LMHC 1998a) used to establish the dome loading program called for in the TSR AC 5.16 (LMHC 1998c). The analyses which support the current Authorization Basis use appropriate and conservative values for soil density.

### 2.1 Background

During a 1994 review of tank farm construction records at the Hanford Site, the contractor determined that the 241-AP Tank Farm's soil was compacted to a density greater than originally assumed in the 1982 structural qualification analysis. In part, the Interim Operational Safety Requirements (WHC 1996) were based on this original structural analysis. The analysis in KEH-R-82-21, *Stress Analysis and Structural Analysis of 241-AP Tank Farm* (KEH 1982), assumed a soil density of 1,762 kg/m<sup>3</sup> (110 lb/ft<sup>3</sup>); however, a preliminary assessment of soil compaction test data indicated that the actual soil density is approximately 1,938 kg/m<sup>3</sup> (121 lb/ft<sup>3</sup>). Consequently, the total load on a tank dome appeared to exceed the total qualified load provided by the existing structural analysis. Per DOE Order requirements, DOE was informed of an unusual occurrence on June 17, 1994, by way of RL-WHC-TANKFARM-1994-0035, *Review of Records Results in Discovery of Potential Violation of 241-AP Tank Farm Dome Loading Requirements*. The contractor confirmed this determination on June 23, 1994, and recommended that DOE-RL declare this discovery a USQ (Raymond 1994). A USQ was subsequently declared by DOE-RL (Wagoner 1994). This USQ applies to double-shell tanks, including aging waste tanks.

The Interim Operational Safety Requirements authorized a maximum combined tank load that includes the summation of (1) soil load, (2) concentrated load, and (3) uniform load. An increase in the soil density increased the soil load. If the actual soil density were higher than the density assumed by the analysis of record for a given soil depth, the combined total load could be higher than the authorized total load. Revised qualified total dome loads were calculated for all tanks in the DST farms for a bounding soil density of 125 lb/ft<sup>3</sup> (Julyk 1994a, b, c, d).

As a result of the USQ on soil density, a Justification for Continued Operation (JCO) was prepared (Lee 1994) and approved by DOE (Wagoner 1995). The dome load estimates for all double-shell tanks were determined to be acceptable when the higher soil density value was used (Wagoner 1995). This technical basis was incorporated into the BIO, Section 1.4 (LMHC 1998b). However, as noted in this same section of the BIO the USQ is not closed. The Safety Evaluation Report (SER; Wagoner 1997) documenting the DOE approval of the BIO specifically states, in reference to the soil density USQ: "The technical basis for closure of this USQ is not clearly supported in the BIO. Action Statement 2 in the BIO SER attached to RL letter 96-MSD-390 directed the Contractor to submit a specific evaluation of the basis for closing this USQ. The required evaluation was not received by RL for action." This report was prepared to satisfy the requirement to deliver an evaluation of the basis to close the USQ.

## 2.2 Evaluation of Authorization Basis and Associated Analyses

The Authorization Basis analyses and controls for the DSTs are found in the BIO (LMHC 1998b) and the TSRs (LMHC 1998c). The DOE approval of these documents is contained in Wagoner (1997). The following evaluation is organized according to sections of the BIO and TSRs for which soil density is technically relevant. Associated technical basis documents are referenced throughout the evaluation.

### 2.2.1 Basis for Interim Operations (LMHC 1998b)

**2.2.1.1 Section 5.3.2.13, Tank Failure Due to Excessive Loads.** The postulated tank failure mechanisms that produce the worst consequences are excessive pressurization of the dome and seismic forces. Dome collapse caused by internal pressurization (e.g., H<sub>2</sub> deflagration, organic-salt nitrate reaction, organic solvent or gasoline fire) is discussed in other sections of the BIO. The accidents second in potential severity are a load drop event and hazards that result in excessive uniform or concentrated load. The soil density is considered when determining uniform load on the tanks; therefore, section 5.3.2.13 is applicable to this evaluation.

The following quote is taken from Section 5.3.2.13: "No credible scenario was identified that would result in dome collapse resulting from excessive uniform load because the loads required for failure are not attainable with current equipment or tank farm configurations. At present, the largest uniform load is 4,900 to 9,800 kg/m<sup>2</sup> (1,000 to 2,000 lb/ft<sup>2</sup>) given a soil density of 2,080 kg/m<sup>3</sup> (130 lb/ft<sup>3</sup>) and depth of 2.1 to 4.6 m (7 to 15 ft). (Note that 4.6 m [15 ft] is the dome soil cover near the wall of tanks with 2.4 m [8 ft] of soil cover over the central dome region.)" The report WHC-SD-TWR-RPT-002, *Structural Integrity and Potential Failure Modes of the Hanford High-Level Waste Tanks*, (Han 1996b) estimates soil load that would cause dome failure for SSTs. Han (1996b) states that these results may be conservatively applied to the DSTs and failure would require an additional 5.2 m (17 ft) of soil cover based on the 2002 kg/m<sup>3</sup> (125 lb/ft<sup>3</sup>) soil density. Note that a listing of actual soil densities given in Han (1996b) shows that all are below 125 lb/ft<sup>3</sup>. Dome collapse from excessive load was therefore considered to be incredible.

Other sections of the BIO were reviewed for accidents in which a specific dome loading value was assumed as a contributor to DST failure. These sections were reviewed to determine if the value used in the supporting analysis was conservative with respect to the soil density issue.

The soil density values, their use in the structural analyses and the link to the BIO are provided in Table 4.

**2.2.1.2 Section 5.3.2.14, Flammable Gas Deflagrations.** This accident analysis assumes a 310 kPa (45 psig) overpressure in the tanks and uses a 1,922 kg/m<sup>3</sup> (120 lb/ft<sup>3</sup>) soil density from LA-UR-3196 (LANL 1995) (rather than the higher 2,002 kg/m<sup>3</sup> [125 lb/ft<sup>3</sup>] of HNF-IP-1266 [LMHC 1998a]) to show that the tanks will not fail under this pressure. This accident scenario is an estimate since flammable gas generation is not quantified in the BIO. The assumption of soil density for this accident is within the operating range of DSTs and is not intended to establish a limit. As is shown in Appendix D of Han (1996b), the effects of an internal overpressure in the tank would be less if the soil load were greater. Controls associated with this accident are preventive in nature and are not derived from quantitative analysis.

**2.2.1.3 Section 5.3.2.15, Organic Solvent Fire.** This accident analysis assumes an overpressure event for of 207 kPa (30 psig) and does not result in tank failure. This accident is bounded by the LANL (1995) analysis for overpressure. Again, as is shown in Appendix D of Han (1996b) the effects of an internal overpressure in the tank would be less if the soil load were greater. Controls associated with this accident are preventive in nature and not associated with the dome loading controls.

**2.2.1.4 Section 5.3.2.16, In-Tank Fuel Fire/Deflagration.** This accident is bounded by the analysis of Sections 5.3.2.14 and Sections 5.3.2.15. Controls associated with this accident are preventive in nature and not associated with the dome loading controls.

**2.2.1.5 Section 5.3.2.17, Organic Salt-Nitrate Reaction.** The organic salt-nitrate reaction accident analysis supposes a failure of the dome during an overpressure event based on Wagenblast (1996). Wagenblast (1996) uses 125 lb/ft<sup>3</sup> for the soil density. The controls associated with this event are to prevent the conditions leading to ignition of the waste (i.e., a safety limit on waste temperature, ventilation requirements, etc). There are no controls associated with dome loading for this accident scenario.

**2.2.1.6 Section 5.3.2.23, Natural Phenomena.** According to this section, which references Han (1996b), tank failures or collapse of major structures would not be expected for the evaluation basis earthquake.

## 2.2.2 Technical Safety Requirements (LMHC 1998c)

**AC 5.16, Dome Loading.** The dome loading control states that a program shall be maintained to limit loads so waste is not released from structures in the tank farms from accidental equipment drops or excessive loads leading to upper tank structural failure. There is no limit given in the TSR for soil density.

The dome loading program is established in the contractor procedure, *Tank Farms Operations Administrative Controls*, HNF-IP-1266, Section 5.16, "Dome Loading Controls" (LMHC 1998a). This contractor procedure contains the limits established for the soil density (see Attachment C of LMHC 1998a). The limits are part of a suite of values (e.g., soil depth at apex, qualified distributed load, qualified uniform load) associated with establishing dome load. These values, along with the protocol for analysis of the loads on the tanks, and other controls on activities in the tank farms, comprise the dome loading program. The dome load limits are based on the qualified loads as defined in the dome loading program.

### 2.3 Conclusion of the Evaluation

The issues associated with the structural analysis of record for the soil density USQ were of concern with the previous Authorization Basis (WHC 1996). These issues have been appropriately addressed in the technical bases supporting the current TWRS Authorization Basis (LMHC 1998b and 1998c) and therefore the contractor recommends closure of this USQ. This report satisfies the requirement in the BIO SER (Wagoner 1997) to deliver an evaluation of the basis to close the USQ.

## 3.0 RECOMMENDED DST STRUCTURAL ANALYSES IMPROVEMENTS

The recommended analyses improvements will provide a comprehensive evaluation of normal and seismic loads for the DSTs. The analyses improvements will consider sufficient variations in loads and material conditions to demonstrate the margin of safety for other projected load cases such as waste retrieval activities. Additionally, the analytical tools developed to perform the recommended analyses can be used to support the future performance of a TWRS comprehensive seismic vulnerability study. Such a study has been discussed (DOE 1997) in the context of reducing calculated risk in the TWRS Final Safety Analysis Report (FSAR).

### 3.1 DST Description

Construction of DSTs started in the late 1960s; these tanks had double steel shells and improved leak detection. Between 1968 and 1986, 28 DSTs were built and situated in 6 tank farms each with 2 to 8 tanks. Five of the tank farms are located in the 200 East Area, and one tank farm is located in the 200 West Area. All DSTs are similar in design and each has a capacity of approximately 3.8 million L (1 million gal). Slight differences in tank construction and ancillary equipment, however, have occurred over the years from design improvements and because of the need to accommodate variations in waste composition. The DSTs were constructed to provide intermediate storage for high-level radioactive waste, including waste capable of boiling due to radioactive decay (aging waste) and waste not capable of boiling (non-aging waste). Waste requiring intermediate storage has come from Hanford site processing facilities. Currently, some of the DSTs receive liquid waste from processing activities (e.g., saltwell pumping), and all DSTs are considered in service.

Designed to minimize the potential for leakage of radioactive liquids to the environment, each DST consists of a carbon steel primary tank and a carbon steel secondary tank within a protective reinforced concrete shell (see Figure 1). The protective concrete shell is designed to

sustain soil loads and to tolerate the temperature gradients caused by the heat generated by the contained radioactive waste. The cylindrical concrete wall (18-inches thick) was constructed monolithically with a keyed construction joint below the upper haunch of the concrete dome. The concrete wall rests on a reinforced concrete foundation base mat through steel bearing plates separated by a thin layer of dry graphite. The foundation base mat includes a shear key to restrict relative lateral motion between the wall and base mat which allows limited free radial differential thermal expansion.

The primary tank contains waste, is freestanding on an insulated concrete pad and the tank roof is attached to the concrete dome by uniformly spaced J-bolts. During construction, the insulated pad protected the structural concrete foundation from excessive temperatures during post-weld stress relief heat treatment of the primary tank. The post-weld heat treatment reduces high-stress points at metal joints to reduce joint susceptibility to corrosion and cracking. The insulating pad is also cast with air distribution and drain grids to provide for leak detection, maintain a uniform tank bottom temperature, facilitate heat removal, and eliminate pockets of water condensation.

The insulating pad rests on the secondary tank, which is 1.5 m (5 ft) larger in diameter than the primary tank, creating an air space (or annulus) separating the two steel tank walls. The secondary tank is attached to the cylindrical wall and upper haunch of the concrete shell, up to a point of tangency with the primary tank, by uniformly spaced J-bolts. The secondary tank was not post-weld stress relieved. The secondary tank serves as a confinement barrier in case of primary tank leakage. The annular space of each DST is monitored for leaks. To date, none of the Hanford Site DSTs have leaked.

### 3.2 Assessment of Existing DST Structural Analyses

The original structural analyses of record for the DSTs are 15 to 30 years old and do not account for the extended time these tanks will be used for containing the waste, the different loads that will be imposed by retrieval, and the aged condition of the tanks. Interim analyses (Julyk 1994a, b, c, d) were performed to address the normal loading associated with the direct gravity soil overburden in support of the JCO (Lee 1994). The interim analyses were completed using static and elastic models duplicating the original analyses of record to assess the effects of the increased soil density with the in-situ soil elevations to support the JCO.

A qualitative review of the seismic evaluation from the original analyses of record was also completed as part of the interim analyses. As stated in the Delphi report (Han 1996a) and the structural integrity assessment document (Han 1996b) compiled for TWRS BIO and FSAR, it is accepted that the tanks will not provide a release to the onsite worker or offsite public from dome failure because of a design basis earthquake. However, other non-catastrophic failures (not resulting in airborne release), such as some damage to the tank, are not well defined in the reviews mentioned above. The combination of appropriate gravity loads with the original seismic loads was stated in the interim analyses as having a good probability of being acceptable if a new seismic analysis were conducted. However, other analyses in support of the Multi-function Waste Tank Facility (MWTF; Wagenblast 1995) and the C-106 sluicing project (WHC 1995a) indicate that the assumptions in the original seismic analyses of record for DSTs may be

nonconservative with respect to non-catastrophic failures of the tanks due to a design basis earthquake.

The issues that need resolution, while accounting for the additional mass due to the soil density increase, are the non-rigid (low-frequency) response of the tank roof, the asymmetric seismic-induced soil loading, and the structural discontinuity between the tank wall and the footing. The original analyses assumed that the tank dome responds as a rigid body under vertical seismic induced excitation. The increased soil density and the increased soil cover height qualified in the interim gravity load analyses will tend to further amplify the tank dome response under seismic loading. Asymmetric loading due to seismic motion moves the tank laterally due to the soil strain and has the potential to laterally displace (slide) the upper concrete tank structure, the attached primary tank roof, and the secondary tank relative to the footing. This sliding could fail the secondary liner and potentially fail the primary tank as well as causing non-catastrophic failure of the tank, but could not cause offsite public or onsite worker consequences. Thus a direct leak path to the soil could occur from the seismic event. Additionally, this sliding could cause failure by buckling the lower concrete tank wall which is the direct support for the tank dome. Failure of the tank side wall could lead to damage to the dome (non-catastrophic failure). The seismic soil-structure interaction analysis necessary to demonstrate structural adequacy for a design basis earthquake can be simplified using techniques developed during the design phase of MWTF.

In fiscal year (FY) 1994 and 1995, the first of two phases of double-shell tank structural load limit calculations were performed (Hyde 1994 and Scott 1995) and demonstrated the sensitivity and stability of the DST dome and side walls for application of normal loads: e.g., snow load, crane loads, and soil loads. The third phase calculation included the normal load analysis with the effects of material degradation and additional thermal profiles applied to the full structure including the soil-structure response with the footings. The computer analysis and draft report were completed but the review and final comments were not finalized and issued. The final documentation of this report is necessary to update the normal load evaluation and would provide an improved technical basis to deal with day-to-day dome loading considerations and retrieval activities in the DST farms.

In FY-96, the final phase of the DST structural load limit calculations were to be performed to establish the seismic capacity of the DSTs. This analysis was not initiated but would be necessary to complete an updated seismic evaluation. An assessment of the opinion provided by the Delphi panel (Han 1996a) concerning the Hanford Site high-level waste tank seismic capacity and failure modes was provided in *Evaluation of Hanford High Level Waste Tank Failure Modes for Seismic Loading* (RLCA 1996). Although this assessment agreed with the Delphi panel conclusions on the ultimate seismic capacity of the DSTs (and SSTs), the assessment differed in the descriptions of the failure modes and, in the opinion of the analysts consulted for this report, did not appear to adequately treat the sliding concern discussed above.

### 3.3 Recommended Analyses for DSTs

#### 3.3.1 Scope of Work

Complete the third phase of the Normal Load Analysis Report.

Complete the seismic analysis and document the seismic capacity of all DSTs using acceptance criteria consistent with national standards (ASME 1992 and ACI 1990) and DOE guidance (BNL 1993), and calculate the structural margins for the evaluation basis seismic loading in accordance with HNF-PRO-97, *Engineering Design and Evaluation* (PHMC 1997) for an existing Performance Category 3 structure.

#### 3.3.2 Deliverables

Double-Shell Tank Normal Load Analysis Report

Double-Shell Tank Seismic Analysis

Assemble and test the seismic finite element model

Select seismic loads applicable to Hanford waste tanks

Complete DST analysis of record with seismic load evaluation

Revision to Han (1996b) report to include above DST results

### 3.4 Cost and Schedule Estimate

<u>Estimated Cost:</u>	<u>(\$K)</u>
Complete the DST Normal Load Report	40
DST analysis for seismic loads	240
Revise Han 1996b report	15
Total	295

<u>Budget Distribution Forecast</u>	<u>(\$K)</u>
First Quarter	45
Second Quarter	100
Third Quarter	100
Fourth Quarter	50

These cost and schedule estimates are being considered for inclusion into the MYWP for FY 1999.

## 4.0 RECOMMENDED SST STRUCTURAL ANALYSES IMPROVEMENTS

This section provides an overview of recommended structural analyses for SSTs. The primary benefits of performing these analyses would be to provide an improved technical basis for the structural aspects of the SSTs for day-to-day operations and retrieval activities. Additionally, the analytical tools developed to perform the recommended analyses can be used to

support the future performance of a TWRS comprehensive seismic vulnerability study. Such a study has been discussed (DOE 1997) in the context of reducing calculated risk in the TWRS Final Safety Analysis Report (FSAR).

#### 4.1 SST Description

Twelve SST farms containing 149 tanks (133 100-Series 75-ft diameter and 16 200-Series 20-ft diameter tanks) were constructed between 1943 and 1964 and grouped into farms consisting of 4 to 18 tanks. The farms were divided equally between the 200 East and the 200 West Areas and assigned letter identifiers consistent with the area designations. The original SST design was an integral reinforced concrete shell, foundation base mat, and dome with a mild carbon steel lining the bottom and walls (see Figure 2; 100-Series tanks). Over time, while the basic design remained essentially the same, the depth of the tanks in new farms was increased with corresponding increases in storage capacity (see Figure 3). Although some minor design improvements were made in the tank bottoms, the steel liners are not structurally connected to the concrete and were not post-weld stress relieved.

The first tanks, built concurrently with the bismuth-phosphate processing plants (B Plant and T Plant), were designed with 5.5 m (18 ft) liner heights and operating volumes of 2 million L (530,000 gal). The next tanks were built first with 7.3 m (24 ft) liner heights and operating volumes of 2.9 million L (758,000 gal) and finally with liner heights of 9.8 m (32 ft) and operating capacities of 3.8 million L (1 million gal).

The SSTs are out of service, that is, no process wastes have been added to the 149 SSTs since November 1980. Even though the SSTs at TWRS are not currently receiving waste, waste storage in the tanks and waste transfer out of the tanks will continue until final waste disposal is complete.

#### 4.2 Assessment of the Existing SST Structural Analyses

There is a collection of documents that summarize the structural analyses that have been performed for the SSTs. These documents form the analyses of record for SSTs (see Han 1996b for summary review). The technical basis for the dome load controls for SSTs (LMHC 1998a and 1998c) is the interim sensitivity analysis report (Ramble 1983) as supplemented by the more recent results from the Delphi panel accident load assessment (Han 1996a) prepared for the TWRS BIO and FSAR. A review (Raco 1996) of the Ramble supporting document identified areas of improvement for the analysis, especially in thermal modeling and soil conditions. As an interim effort to address in-place soil conditions, the analysis results from Ramble (1983) were recently reassessed (Julyk 1998a) on a tank-farm-by-tank-farm basis. This interim reassessment provided some relief to the non-TSR dome load requirements (LMHC 1998a) but does not remove the TSR restriction prohibiting soil additions. Supplemental analyses proposed in this report would provide an improved technical basis to deal with day-to-day dome loading considerations, retrieval activities and possibly provide a relaxation of TSR controls on addition of soil. In general, except for the C-106 analyses (WHC 1993 and 1995a), the existing SST structural analyses are 15 to 20 years old and do not account for the extended time these tanks will be used for containing the waste, the different loads that will be imposed by retrieval, and the aged condition of the tanks (i.e., material degradation). The analyses for the 200-Series SSTs

are considered adequate and hence the recommended analyses below are specific to the 100-Series SSTs.

#### **4.3 Recommended Analyses for SSTs**

Proposed analyses improvements include: more realistic, representative temperature profiles in the concrete; more realistic modeling of the footing and thorough consideration of all loads on the footings; improved modeling of soil-structure interaction; characterization of the thermal stresses for large differences in the steel and concrete thermal expansion; reasonably-bounding concrete physical properties; and a more realistic assessment of the soil loading including a bounding soil density consistent with available site data.

##### **4.3.1 Scope of Work**

The scope of work includes the following work activities.

###### **4.3.1.1 Load Definition**

The thermal history and current loads for each tank group will be defined. The following list includes the expected loads.

- Dead loads; soil, concrete, steel, permanent equipment and attached components to the tank. Although not part of the scope of this estimate, additional soil density measurements of the SSTs would greatly enhance the analyses activities.
- Live loads; natural loads (snow, rain, ashfall), and temporary and moving equipment.
- Internal loads; hydrostatic and vapor pressure.
- Seismic loading (soil-structure and fluid-structure seismic induced interaction loads).

###### **4.3.1.2 Material Data Characterization**

Document the properties of the materials associated with the tanks as they exist today: soil (at different locations), concrete (creep and cracking, etc.), and steel components (liners, studs and rebars).

###### **4.3.1.3 Environmental Effects**

Characterize the material aging mechanisms and temperature effects on concrete based on available data.

###### **4.3.1.4 Structural Acceptance Criteria**

Review and modify the DST structural acceptance criteria developed in FY-95 (WHC 1995b) for use with the single-shell tanks.

#### **4.3.1.5 Analyses**

The analyses should include, but not be limited to the following analysis types:

- Sort tanks into groups of similar configurations.
- Determine loads on each tank from the operating history, tank load control documents, and planned use.
- Select the worst tank from each group to envelope the tanks in this group.
- Develop finite-element model for the worst tank in each group.
- Perform thermal analysis (temperature history input to stress analysis).
- Perform static analysis (dead and live loads).
- Perform evaluation for seismic loads by reference to existing analyses, such as the MWTF seismic analysis, and determine potential benefit of a more detailed seismic evaluation.
- Report resulting stresses and margins for appropriate combinations of normal loads.
- Report resulting stresses and margins for appropriate combinations of seismic and normal loads.

#### **4.3.1.6 Evaluation**

Assess the structural integrity of the tanks in accordance with the developed acceptance criteria.

- Apply material aging mechanisms and temperature effects on concrete to the analyses results
- Compare results with allowable criteria
- Qualify the tanks, e.g., determine margins, load capacities (if possible), and structural integrity of each group of tanks

#### **4.3.2 Deliverables**

Provide structural analysis as a supporting document and load limits that improve the technical basis for assurance of SST structural integrity.

Revision to Han (1996b) report to include above SST results.

#### 4.4 Cost and Schedule Estimate

<u>Estimated Cost:</u>	<u>(\$K)</u>
Acceptance Criteria for SSTs	50
Load Definition	10
C, B, U, T and BX Farm Structural Analysis/Load Limits	150
BY, S, TX, and TY Farm Structural Analysis/Load Limits	150
SX Farm Structural Analysis/Load Limits	150
A and AX Tank Farm Analysis/Load Limits	80
Revise Han (1996b) report	<u>25</u>
Total	615

<u>Budget Distribution Forecast</u>	<u>(\$K)</u>
First Quarter	100
Second Quarter	200
Third Quarter	200
Fourth Quarter	115

These cost and schedule estimates are being considered for inclusion into the MYWP for FY 1999.

### 5.0 OTHER WASTE STORAGE TANKS

The following sections address the catch tanks, DCRTs, and IMUSTs. "Inactive" means that the tank is either physically or administratively isolated. "Miscellaneous" means that the tank is not within a major facility and not a primary waste storage tank (i.e., 100- or 200-Series SSTs and DSTs). A major facility is usually (but not always) housed in a building.

#### 5.1 Catch Tanks

Catch tanks are underground storage tanks that collect small amounts of waste drained from diversion boxes, valve pits, diverter stations, and other equipment. Although older catch tanks are buried directly in the soil, replacement catch tanks are housed in subsurface concrete vaults that provide secondary confinement for the waste. The four basic catch tank designs (see Figures 4 and 5) are (1) direct buried, concrete; (2) direct buried, steel; (3) steel tanks contained in a vault or pit; and (4) concrete vaults with steel liner. The first three designs are shown in Figures 4 and 5. The catch tanks are ventilated by a passive ventilation system.

#### 5.2 Double-Contained Receiver Tanks (DCRTs)

A DCRT, sometimes referred to as a catch station or lift station, is a short-term waste storage facility that is used for waste transfer operations. The DCRT consists of an underground concrete structure that contains a filter pit, pump pit, and a vault in which a catch tank is installed. The active DCRTs are depicted in Figures 6 and 7.

### 5.3 Inactive Miscellaneous Underground Storage Tanks (IMUSTs)

The miscellaneous inactive storage facilities (MISFs) may contain low- or high-level radioactive wastes or nonradioactive materials and may be located below or aboveground. These tanks contain both radioactively contaminated and nonradioactively contaminated waste. The IMUSTs are typically tanks buried directly in the ground or contained within vaults. The inactive miscellaneous aboveground storage facilities are typically tanks located on the surface or contained within inactive TWRS facilities. These tanks may contain radioactively contaminated or nonradioactively contaminated waste and are not discussed in this report.

**Radioactively Contaminated IMUSTs.** A group of 70 small (<189,270 L [<50,000 gal]) radioactively contaminated, inactive, and abandoned underground storage tanks are collectively termed the IMUSTs. These tanks are located throughout the 200 East and 200 West Areas (Stickney and Lipke 1998).

Many of these abandoned tanks are buried directly in the ground; others are installed in underground vaults. Many of the tanks contain sludge and process materials. These IMUSTs were not designed, nor are they used, for high-level waste storage. The tanks have been administratively divided between TWRS (43 tanks), the U.S. Department of Energy Environmental Restoration Project (22 tanks), the B&W Hanford Company (3 tanks), and Waste Management Hanford (2 tanks). Most of the tanks assigned to TWRS are considered ancillary components of the tank farm system.

### 5.4 Assessment of Existing Structural Analyses on Other Tanks

A structural assessment in support of the TWRS BIO and FSAR for specific accident loads for specific catch, receiver, and storage tanks was reported in *Structural Assessment of Accident Loads* (Wagenblast 1996). The assessment was based on failure limit analyses (beyond design code requirements) to establish failure load capacities of the selected structures. The results of this assessment indicated that certain of the structures considered in the assessment were not satisfactory under normal loading. Although these findings were based on simplified analyses, they led to technical safety requirements (TSRs) that prohibit equipment lifts over MISFs; prohibit additional concentrated loads on catch tanks, DCRTs, and MISFs; and prohibit any increase in the soil cover depth over catch tanks and MISFs.

These restrictions have complicated normal operational activities for these tanks. Additional analyses are required in order to justify a relaxation of these restrictions. Preliminary calculations have indicated that the concentrated load and soil load restrictions could likely be relaxed for catch tanks and IMUSTs that are direct-buried horizontal steel tanks by considering the beneficial effects of soil-structure interaction.

### 5.5 Recommended Analyses for Other Tanks

It is recommended that drawings of catch tanks and IMUSTs be reviewed to determine basic size, wall thickness, material, and depth of soil cover of those tanks that can be considered as direct-buried horizontal steel tanks. This set of tanks would then be evaluated for soil loading

and concentrated loading applied at surface grade to determine appropriate operational restrictions by considering beneficial effects of soil-structure interaction.

### 5.6 Cost and Schedule Estimate

<u>Estimated Cost:</u>	<u>(\$K)</u>
Complete Review of Drawings	20
Complete Analysis of Selected Tank	<u>25</u>
Total	45

<u>Budget Distribution Forecast</u>	<u>(\$K)</u>
First Quarter	45

These cost and schedule estimates are being considered for inclusion into the MYWP for FY 1999.

### 6.0 CONCLUSIONS

The issues associated with the structural analyses of record for the soil density USQ were of concern with the previous Authorization Basis (WHC 1996). These issues have been appropriately addressed in the technical bases supporting the current TWRS Authorization Basis (LMHC 1998b and 1998c) and therefore the contractor recommends closure of this USQ. This report satisfies the requirement in the BIO SER (Wagoner 1997) to deliver an evaluation of the basis to close the USQ.

The recommendation to close the USQ can be made independent of the circumstance that there are significant improvements being considered for the analyses of the waste storage structures. Tank qualification calculations incorporating appropriate assumptions for soil density are approximate yet conservative. Improvements in these and other structural performance calculations will provide a better basis for understanding structural margins, will provide the tools to utilize these margins under new loading scenarios for retrieval, and will provide the bases for certain relaxations and refinements of operational controls.

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Table 1. Structural Analyses of Record

Facility	Document
SSTs	<i>Single-Shell Waste Tank Load Sensitivity Study</i> , SD-RE-TI-012, Revision A-0 (Ramble 1983)
AP Tank Farm (DSTs)	<i>241-AP Waste Storage Tanks – Supplemental Gravity Load Analysis</i> , WHC-SD-WM-ANAL-033, Revision 0 (Julyk 1994a)
AW-AN Tank Farms (DSTs)	<i>241-AW/AN Waste Storage Tanks – Supplemental Gravity Load Analysis</i> , WHC-SD-WM-ANAL-035, Revision 0 (Julyk 1994b)
AY/AZ Tank Farms (DSTs)	<i>241-AY/AZ Waste Storage Tanks – Supplemental Gravity Load Analysis</i> , WHC-SD-WM-ANAL-034, Revision 0 (Julyk 1994c)
SY Tank Farm (DSTs)	<i>Analysis of Underground Waste Storage Tanks 241-SY at Hanford Washington</i> , ARH-R-172, Revision 0B (ECN 193600) (Julyk 1994d)

Table 2. Structural Analyses References for the BIO (LMHC 1998b)

Facility	Document
DSTs / SSTs	<i>DELPHI Expert Panel Evaluation of Hanford High Level Waste Tank Failure Modes and Release Quantities</i> , WHC-SD-TWR-RPT-003, Revision 0 (Han 1996a)
DSTs/SSTs	<i>Structural Integrity and Potential Failure Modes of the Hanford High-Level Waste Tanks</i> , WHC-SD-TWR-RPT-002, Revision 0A (Han 1996b)
DSTs, SSTs, DCRTs	<i>Tank Farm Drop Load Evaluation</i> , WHC-SD-WM-TI-782, Revision 0 (Julyk 1996)
DSTs/SSTs	<i>The Effects of Load Drop, Uniform Load, and Concentrated Loads on Waste Tanks</i> , WHC-SD-WM-CN-051, Revision 0 (Marusich 1996)
DSTs	<i>Soil Weight at Hanford Waste Storage Tank Locations</i> , WHC-SD-WM-SOIL-001, Revision 0B (Pianka 1994)
DSTs	<i>Soil Load above Hanford Waste Storage Tanks</i> , WHC-SD-WM-TI-665, Revision 0B (Pianka 1995)
DSTs, SSTs, DCRTs, Catch Tanks	<i>Structural Assessment of Accident Loads</i> , WHC-SD-WM-TI-775, Revision 0 (Wagenblast 1996)

Table 3. Supplemental References for Dome Loading Calculations.

Facility / Subject	Document
SSTs / Lightning Rod Installation Dome Load Evaluation	Julyk, L. J., 1997, <i>Generic Dome Load Evaluation for Lightning Ground Rod Installation within Single-Shell Tank Farms</i> (internal memo 74731-97-LJJ-091 to D. W. Crass and J. L. Homan), December 11, 1997, Lockheed Martin Hanford Company, Richland, Washington.
100-Series SSTs / Soil Density / Soil Depth Analysis	Julyk, L. J., 1998, <i>100-Series Single-Shell Tank Dome Load Assessment for Effect of Potential Increase in In-Situ Soil Density Versus Analysis-of-Record Assumption and Assessment of Tanks with In-Situ Soil Cover Height in Excess of Analysis-of-Record Recommended Generic Limit</i> (internal memo 74731-98-LJJ-001 to R. E. Raymond), January 12, 1998, Lockheed Martin Hanford Company, Richland, Washington.

Table 4. Soil Density Values Used in Supporting Analyses

	Value (lb/ft <sup>3</sup> )	Origin	Use in Analysis	Additional Comments
1	130	BIO, Section 5.3.2.13 and Julyk 1994d and Julyk 1994c.	BIO only (Section 5.3.2.13) as an example. Not used in TSRs nor in LMHC 1998a implementing document.	Used as an example; not claimed as a limit.
2	125	Wagenblast 1996 and Han 1996b	Allowed load.	Referenced in BIO.
3	137	Marusich 1996	Failure load. Not used as TSR limit.	Used as a conservatively high load to demonstrate tank failure.
4	125 125 125 & 130 120 - 130	Julyk 1994a Julyk 1994b Julyk 1994c Julyk 1994d	AP Tank Farm AW/AN Tank Farms AY/AZ Tank Farms SY Tank Farm	Used as structural analysis of record (referenced in LMHC 1998a) Seismic loads addressed in each document.
5	120	LANL 1995	Used in BIO, Section 5.3.2.14, "Flammable Gas Deflagration Accident." 45 psig over-pressure.	--
6	120	LMHC 1998b (from LANL 1995)	Section 5.3.2.15, "Solvent Fire." 30 psig over-pressure.	--
7	125	Wagenblast 1996	BIO Section 5.3.2.16, "Gas Pool Fire." Assumed load for internal vacuum calcs.	See Appendix 9 of Wagenblast (1996), which leads to Appendix 5, "Internal Vacuum."
8	125	Wagenblast 1996	BIO, Section 5.3.2.17, "Organic Salt Nitrate Reaction"	See Appendix 13 of Wagenblast (1996) for soil density values used in calculations.
9	None given	Han 1996b	BIO, Section 5.3.2.23, "Natural Phenomena"	Seismic loads are not credited with failing the tanks (Han 1996b; Section 5.6.5); also see Item 4.
10	116 (App. C) or 110 to 125 (App. D)	Han 1996b (Appendices C & D)	Internal Overpressure Loads	This is an accident load analysis performed for the BIO; Overpressure is 141 psig and fails the tank at 110 to 125 lb/ft <sup>3</sup> .
TF-94-0260, Revision 0, Issues (Dougherty & Rifaey 1994)	a. Structural b. Seismic c. Flam. Gas	a. See above Item 2 and Item 4. b. Addressed in structural analyses of record for DSTs (Item 4) and Item 9. c. See above Item 5.		

Conversion: 1 lb/ft<sup>3</sup> = 16.02 kg/m<sup>3</sup>

1 psig = 6.89 kPa

Figure 1. Graphic Representation of a Double-Shell Tank.

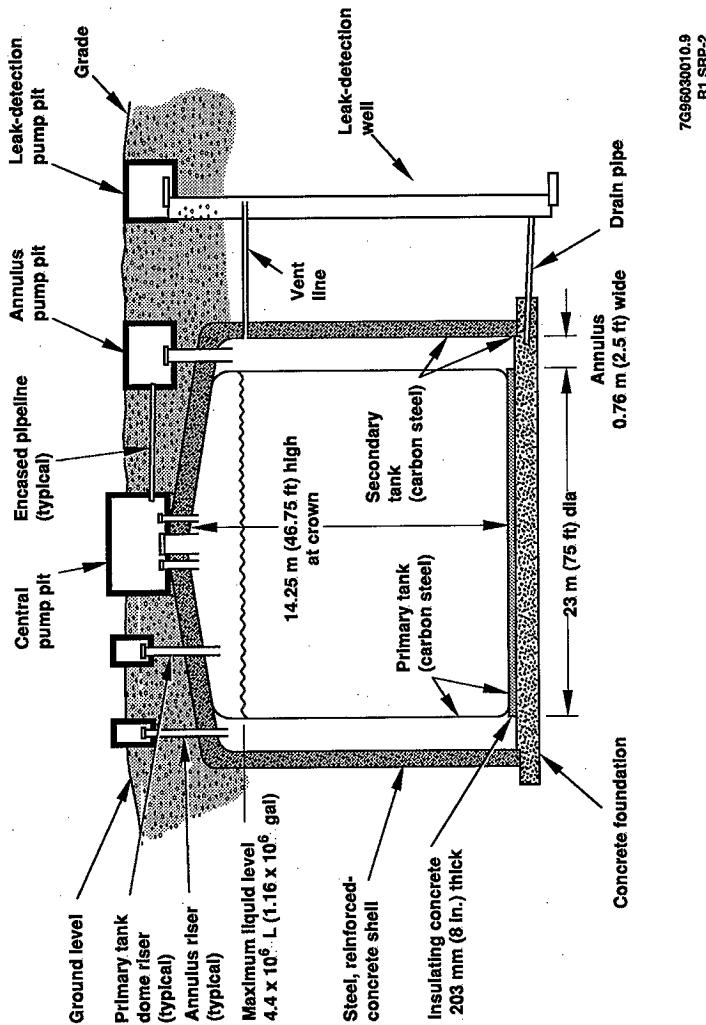


Figure 2. Graphic Representation of a 100-Series (75-Foot Diameter) Single-Shell Tank.

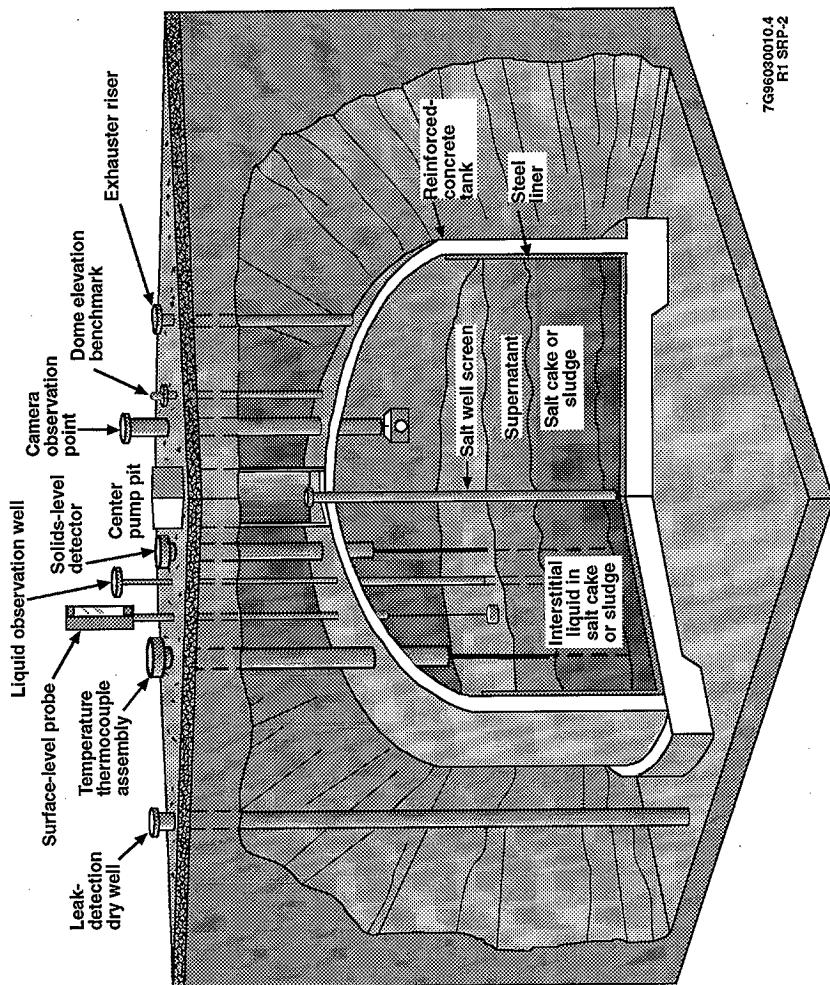
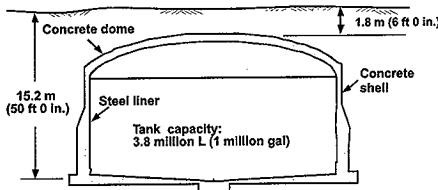
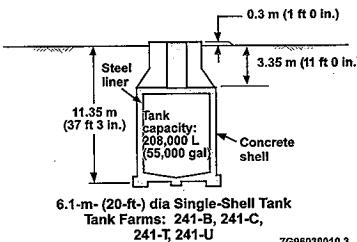
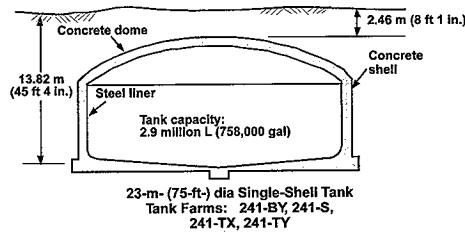
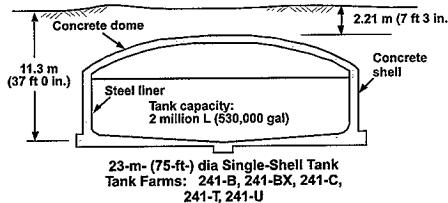


Figure 3. Configurations of 100-Series (75-Foot Diameter) and 200-Series (20-Foot Diameter) Single-Shell Tanks.



\*A and AX have flat bottoms



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R3 SRF-2

Figure 4. Designs for Direct-Buried Horizontal and Vertical Type Catch Tanks.

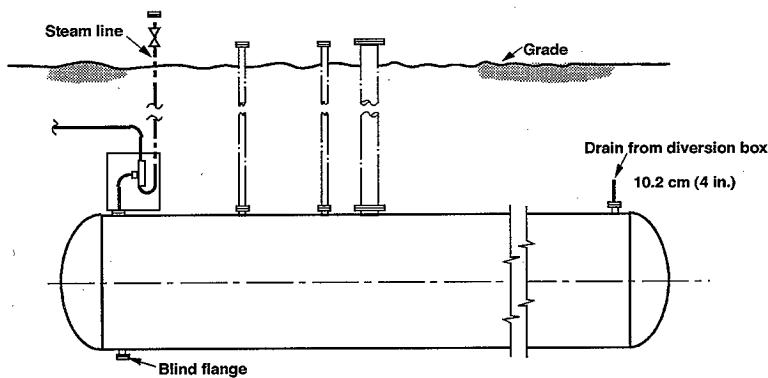
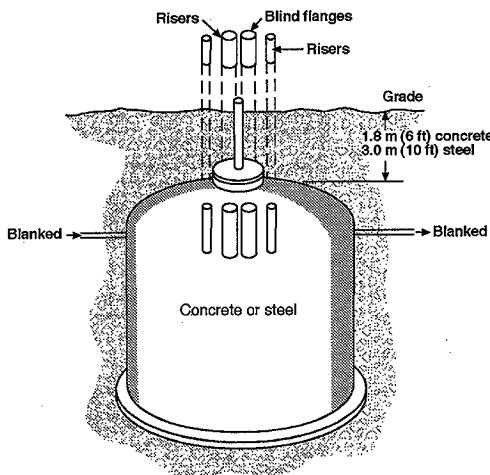
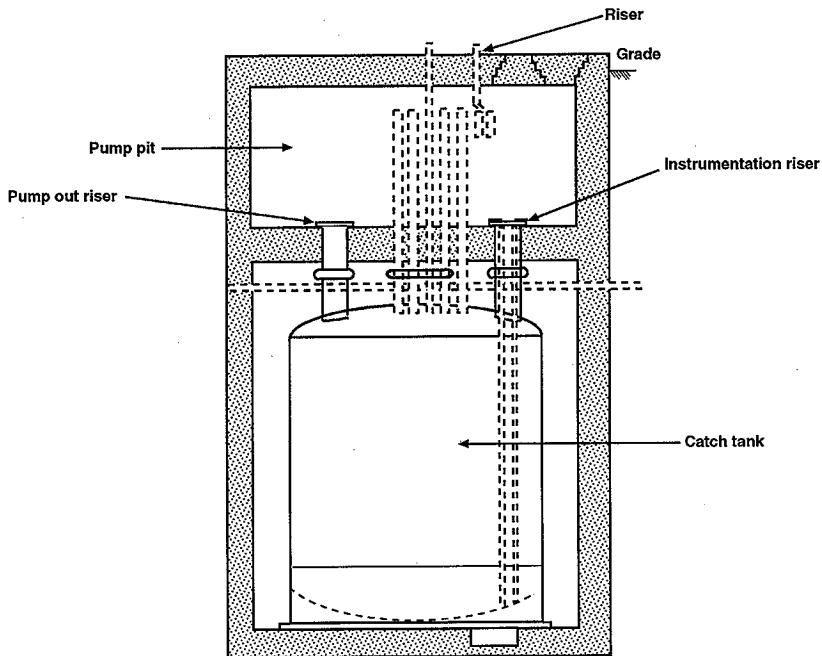
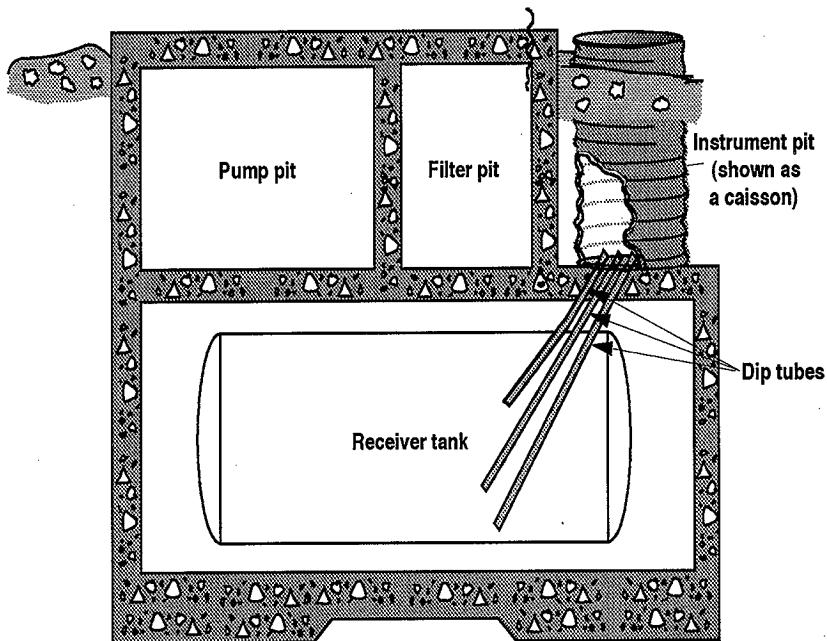


Figure 5. A Design for Concrete-Encased Type Catch Tanks.



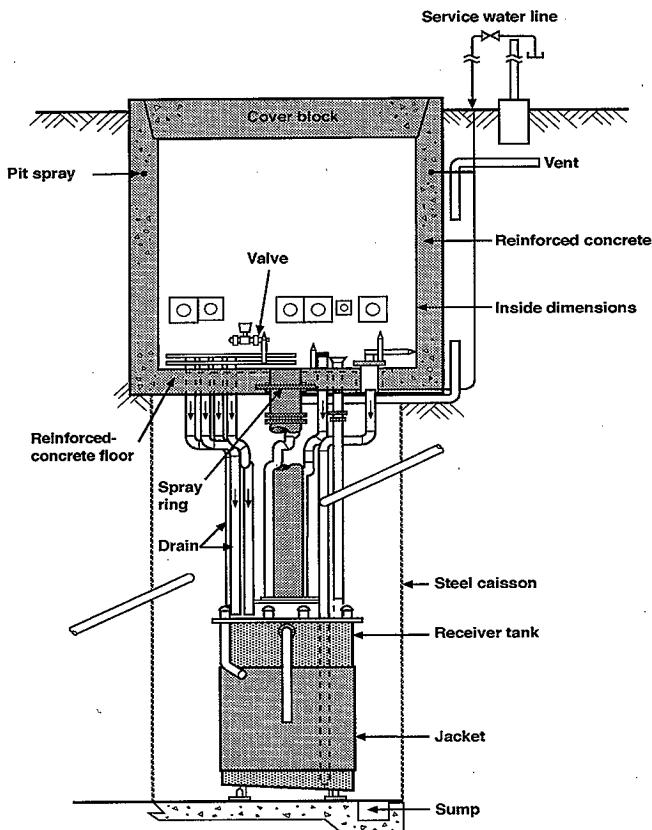
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Figure 6. A Horizontal Double-Contained Receiver Tank Configuration.



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Figure 7. A Vertical Double-Contained Receiver Tank Configuration.



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R2 SRP-2