

**[DNFSB LETTERHEAD]**

May 2, 1997

The Honorable Alvin L. Alm  
Assistant Secretary for Environmental Management  
Department of Energy  
1000 Independence Avenue, SW  
Washington, D.C. 20585-1000

Dear Mr. Alm:

Members of the staff of the Defense Nuclear Facilities Safety Board (Board) recently visited the Hanford Site to review safety issues related to the Tank Waste Remediation System (TWRS). Among the issues reviewed was the institutionalization of systems engineering at Hanford in response to Board Recommendation 92-4. The [enclosed report](#) identifies areas where effort is needed for that goal to be achieved. This report is provided for your use in developing a revised Implementation Plan for Recommendation 92-4. The Board staff will continue to work closely with Department of Energy (DOE) personnel involved with this activity.

During the staff's review, personnel from the DOE Richland Operations Office expressed the desire that the Board staff work only through the DOE Regulatory Unit when reviewing the portions of the TWRS that have been privatized. Although our staff has agreed, in this instance, to continue to work through DOE officials, that in no way alters the Board's responsibilities and authorities under the Atomic Energy Act, as amended. In particular, the Board reserves the right to obtain information, by subpoena if necessary, from any individual, including contractor employees at defense nuclear facilities, who are to fully cooperate with the Board. If you have any questions on this matter, please do not hesitate to contact me.

Sincerely,

***John T. Conway***  
Chairman

c: The Honorable Tara O'Toole  
Mr. Mark B. Whitaker, Jr.  
Mr. John Wagoner

Enclosure

# DEFENSE NUCLEAR FACILITIES SAFETY BOARD

April 10, 1997

**MEMORANDUM**  
**FOR:** G. W. Cunningham, Technical Director  
**COPIES:** Board Members  
**FROM:** R. Arcaro  
**SUBJECT:** Review of the Tank Waste Remediation System at the Hanford Site, March 30–April 3, 1997

## 1. Purpose

This report documents a review by staff of the Defense Nuclear Facilities Safety Board (Board) of safety issues at the Hanford Site's Tank Waste Remediation System (TWRS). The review covered systems engineering, disposal system design, a possible leak in Tank BY-112, and characterization of the vadose zone. The review was conducted March 31 through April 3, 1997, by R. Arcaro, R. Barton, R. Daniels, L. Jellett, and S. Stokes.

## 2. Summary

**Systems Engineering.** The management of the Department of Energy Richland Operations Office (DOE-RL) has demonstrated some progress in systems engineering in its efforts to implement Board Recommendation 92-4. However, the systems engineering process at Hanford is not yet institutionalized to the point where it is clearly directed, proceduralized, implemented, and repeatable. The DOE-RL and Board staffs are developing a set of proposed deliverables that will demonstrate the institutionalization of systems engineering for the TWRS.

**Disposal System Design.** DOE-RL has directed characterization of the Hanford tank wastes for purposes of disposal system design in accordance with Board Recommendation 93-5. The staff's initial review of progress in this area revealed that some design modifications may be necessary to accommodate increased levels of chromium in the waste. The staff will continue its review in this area to ensure that additional potential impacts are systematically investigated.

The Board staff held discussions with DOE-RL management regarding the staff's interface with the private contractors responsible for processing the tank waste during the first phase of privatization. DOE-RL managers requested that the staff interact solely with the DOE-RL contracting officers and the DOE-RL Privatization Regulatory Unit. The Board staff agreed to this arrangement, contingent upon receiving unencumbered access to information regarding the design, construction, operation, and decommissioning of these defense nuclear facilities. The acting director of the Regulatory Unit expressed confidence that the DOE-RL employees would be capable of providing this information.

**Tank BY-112.** DOE-RL reported that tank BY-112, which had a slowly dropping interstitial liquid level (ILL), was not leaking. While the staff agrees that there is no evidence to suggest the tank is leaking, the technical assessment performed by the Hanford contractor has technical deficiencies indicating that the liquid distribution in the waste is not well understood.

**Characterization of the Vadose Zone.** DOE-RL's characterization of the vadose zone under SX tank farm and interpretation of the data by an expert panel indicate that radioactive cesium is migrating through the vadose zone more quickly and at greater depths than was previously estimated.

### 3. Background

The Implementation Plan for Recommendation 92-4 committed DOE to implementing a systems engineering process for the development of the TWRS, the system intended to retrieve the waste from the Hanford tanks and treat it for ultimate disposal. The plan was approved by the Board in December 1994. Since that time, significant changes have taken place in the TWRS program. DOE now intends to contract a majority of the work to private vendors, who will be paid a fixed price for the service. The Project Hanford Management Contractor (PHMC) will retain responsibility for operating the tank farms and providing the feed to the private vendors. Several projects have been canceled. As a result of these changes, DOE is revising the Implementation Plan for Recommendation 92-4.

As DOE attempts to develop the TWRS, there are several ongoing activities that will affect the eventual performance of the system. Tanks continue to be vulnerable to leakage. Tank BY-112 was suspected of leaking when, in February 1997, several liquid level readings fell below baseline values. Additionally, the understanding of the migration of radionuclides through the vadose zone toward the groundwater has been called into question following discovery of radioactive cesium as deep as 135 feet below the surface—significantly deeper than was previously estimated.

### 4. Discussion

**Tank Waste Remediation System (TWRS) Systems Engineering.** Although some progress has been made in implementing systems engineering for one project within the TWRS, the process as defined by the TWRS Systems Engineering Management Plan and implementing procedures has not been fully institutionalized. DOE-RL management presented the Double-Shell Tank Retrieval Project (W-211) as a demonstration of the progress made in implementing the systems engineering process. Development of functions and requirements and generation and analysis of alternatives are being performed to develop a technical requirements specification for the double-shell tank system. Requirements from this specification will be allocated to various projects, including project W-211. Following this exercise, the design criteria used for the already completed design will be verified against the specification to ensure that the project is consistent with the technical baseline of the overall TWRS. DOE-RL management has suggested that this verification be provided as a Recommendation 92-4 deliverable to demonstrate the institutionalization of systems engineering for *existing*

projects at the TWRS. While such a process represents a reasonable approach to the systematic verification of existing project designs, the Board staff saw little evidence that other projects are following or are scheduled to follow this approach.

Additional efforts are necessary to demonstrate the institutionalization of systems engineering for the TWRS and to satisfy the objectives of Recommendation 92-4. The Board staff identified the following deficiencies:

- The set of systems engineering procedures currently used at the TWRS lacks definitive direction on how the systems analysis should be translated into design specifications. Additionally, there is no procedure directing the use of design reviews.
- There is no schedule indicating how and when design criteria for existing projects other than project W-211 will be verified against technical requirements specifications.
- Technology needs are not integrated into an easily managed system, but are currently satisfied by several activities and sources. Limited information on prioritization, schedule, and contingency planning is available.
- Contingency planning for failure of the privatized projects does not include a system to ensure that expertise is maintained by the PHMC to resume development of the TWRS should they be required to assume responsibility for the now privatized projects. While DOE-RL has identified the capabilities that are required to be maintained, there is no method to ensure that necessary projects remain funded or that essential individuals (or their equivalent) remain with the PHMC.

**Use of Tank Waste Characterization in Disposal System Design.** The Board staff initiated discussions with DOE-RL on how waste characterization information obtained in accordance with the implementation of Recommendation 93-5 is being used for design of the retrieval, pretreatment, and immobilization systems under the TWRS. The basic technologies for these systems are known. Similarly, the basic constituents of the waste are known and are defined in four waste "envelopes" to be processed during the first phase of privatization. If waste constituents are found to be outside of the intended envelopes, the most desirable action is to blend different wastes to acceptable concentrations. In this way, characterization is used primarily to verify that the waste is inside the envelopes. However, in some cases, characterization data are being used to refine designs, particularly for the greater amount of waste that is to be processed during the second phase of privatization. For example, DOE-RL has found that there is twice as much chromium 3+ ion ( $\text{Cr}^{3+}$ ) as originally estimated. Additionally, testing of pretreatment processes has determined that the baseline removal process for  $\text{Cr}^{3+}$  is not as efficient as was assumed because of the insolubility of  $\text{Cr}^{3+}$ . DOE-RL is considering the addition of an oxidation step in the pretreatment process to convert the insoluble  $\text{Cr}^{3+}$  to the more soluble  $\text{Cr}^{6+}$  ion. The Board staff is currently developing a more detailed review to ensure that DOE-RL is systematically investigating the possibility that other waste characteristics may be outside of current

range estimates.

**Tank BY-112.** In February 1997, DOE-RL reported abnormally low interstitial liquid level (ILL) readings in Tank BY-112. The readings were more than three standard deviations below the historical baseline liquid level determined in 1995. DOE-RL initiated a technical assessment to determine whether BY-112 was leaking. The investigation concluded that the feature historically identified as the ILL was probably an interface between dry waste material and slowly draining sludge at approximately 44 inches above the tank bottom. The true ILL is actually at approximately 20 inches. At this low level the older equipment used to determine ILL was incapable of detecting the interface with any certainty. DOE has committed to continuing its investigation of BY-112's liquid level using new equipment with improved range and precision.

Given that there is limited reliable data from which to analyze the trend of the newly discovered ILL, no conclusion can be drawn as to whether the tank is leaking. However, the Board staff identified the following deficiencies in DOE's technical assessment:

- Core samples indicate that the ILL identified by the new readings is not a global feature of the tank waste. Two samples taken in different areas of the tank did not identify an ILL. In fact, one sample indicated a wet layer of waste over a dry layer. Because it is clear that a liquid interface is present in the waste near the liquid observation well where the ILL readings are taken, DOE described the comparison of sample results with the ILL readings as "inconclusive." Although the data from the samples are puzzling, they do not support DOE's description of a slowly drying sludge layer over completely saturated sludge. Additional investigation of the sample results is necessary to reconcile this contradiction.
- The assessment concludes that the low readings obtained in February were actually the result of increased data scatter. The report asserts that the readings are within three standard deviations when all level data since 1995 are taken into account. The variance in the data had increased recently as a result of "continued degradation of the old equipment." This technique of compiling data over long time periods can hide small trends in liquid level that would result from a tank leak. Therefore, its use is inappropriate.
- In attempting to identify the cause of the recent increased "scatter" in the data, DOE investigated the possibility that the low readings were the result of a particular measuring technique in which the level is determined more remotely. Their *qualitative* analysis of the data concluded that although the technique resulted in data that were generally lower than those resulting from the "normal" technique, the difference was not significant. DOE did not perform a statistical test—the "Student t-test"—used to determine quantitatively the significance of an effect on a population of random variables. Upon performing this test, the Board staff found that the measuring technique did in fact result in statistically significantly lower readings. It is likely that this alternative measurement technique contributed to the original low readings.

**Characterization of the Vadose Zone.** DOE-RL recently finished measuring contaminant concentrations in various boreholes into the vadose zone under SX tank farm. The expert panel formed to review the data from these measurements concluded that radioactive cesium ( $^{137}\text{Cs}$ ) has transported to much greater depths than was previously believed possible. The following conclusions of the panel were presented to the Board staff:

- Neither the early gamma spectral logging data nor gross-gamma logs indicated that the  $^{137}\text{Cs}$  has moved as a broad plume deep into the vadose zone.
- The likely mode of contaminant transport is along preferential, vertical, possible tortuous pathways caused by a variety of potential mechanisms. These mechanisms may include boreholes, clastic dikes, or pathways created by the waste itself as a result of high specific gravity, temperature, pressure, ionic concentration, and pH.
- Migration of the  $^{137}\text{Cs}$  through the formation does not necessarily indicate an immediate health risk to the surrounding population.
- Implications for site remediation and tank closure could be immense.

Recommendations cited by the expert panel, with one potential exception, appear to be appropriate to support a better understanding of the vadose zone contamination and its potential to contaminate groundwater. These recommendations are grouped into three major areas:

- Borehole drilling into the groundwater horizon
- Borehole logging improvements
- Study of the contaminant transport/migration phenomenon.

Of these, borehole drilling into the groundwater is most problematic. DOE's drilling into the formation might provide valuable information on the vertical extent of the contamination; however, it could also provide a direct path for the contaminants into the groundwater, thus making a serious problem worse. This is particularly true if a primary mechanism for transport is via the borehole itself. Additionally, this information could be of limited value in the absence of other data that would be used to fully characterize the vadose zone/waste system. DOE's path forward clearly identifies the need to fully understand the vadose zone transport phenomenon, rather than simply determining the extent of contamination. This "systems" approach would allow DOE to predict accurately the efficacy of tank closure designs and the extent of retrieval operations.

## 5. Future Staff Actions

The Board staff will continue to work with DOE to identify a set of acceptable

products that will fully demonstrate the implementation of systems engineering for the TWRS. Additional discussions are necessary to translate the deficiencies noted in this report to hard deliverables that will meet this objective. The staff will also continue to evaluate other safety issues related to the tank farms, including their impact on the TWRS program. In particular, the staff will review the final report of the expert panel studying vadose zone characterization, and continue monitoring the vadose zone characterization efforts and their impact on tank waste retrieval and tank closure.