Evaluating Operational Irregularities at Hanford's Environmental Restoration Disposal Facility - 8132

C.H. Benson
Wisconsin Distinguished Professor
Department of Civil and Environmental Engineering
University of Wisconsin-Madison
1415 Engineering Drive
Madison, WI 53706

W.H. Albright
Associate Research Hydrogeologist
Desert Research Institute, Nevada System of Higher Education
2215 Raggio Pkwy
Reno, NV 89512

D.P. Ray
Chief, Soils and Materials Section, Geosciences Branch
U.S. Army Corps of Engineers, Omaha District
215 North 17th Street
Omaha, NE 68102

J.S. Smegal
Legin Group, Inc.
12800 Middlebrook Road, Suite 420
Germantown, MD 20874

O.C. Robertson, Jr.
Richland Operations
U.S. Department of Energy
Richland, WA 99352

D.C. Gupta
Office of Environmental Management, EM-22
U.S. Department of Energy
Washington, D.C. 20585

ABSTRACT

This paper describes the findings of an independent technical review that investigated operational irregularities at the Environmental Restoration Disposal Facility (ERDF) at Hanford. The ERDF is a large-scale disposal facility authorized by the Environmental Protection Agency and the Washington State Department of Ecology to receive waste from Hanford cleanup activities. The irregularities included (i) failure to recognize that pumps for the leachate collection system were not functioning for an extended period and (ii) falsification of

compaction data by a technician responsible for monitoring waste placement in the ERDF. Other issues related to compaction of the waste were also considered during the independent technical review. A number of important lessons were learned as part of this review. These lessons are summarized in the paper. They are relevant to the ERDF as well as other landfill operations at Department of Energy facilities.

INTRODUCTION

The ERDF is a large-scale disposal facility operated by the US Department of Energy (DOE) to receive waste from Hanford cleanup activities. Currently, six disposal cells comprise the ERDF, with four more cells being planned for construction (Fig. 1). Approximately 6.1 million Mg (6.8 million tons) of waste, with approximately 1.4 million GBq (39,000 Ci) of radioactivity, have been placed in the ERDF. The cells are each 152 m (500 ft) square at the bottom, 21 m (70 ft) deep and over 304 m (1000 ft) wide at the surface. The cells are doubled-lined with a Resource Conservation and Recovery Act (RCRA) Subtitle C-type liner and have a leachate collection system. The capacity of the initial six-cells is 7.2 million Mg (8 million tons). [1, 2, 3]

An interim cover has been placed over filled portions of the first two cells. After the ERDF is filled, a final cover will be placed over the entire facility to provide isolation from humans and other biota at the surface and to limit percolation of water into the entombed waste. The design of the final cover has not yet been completed.

Fig. 1. An aerial view of Hanford's Environmental Restoration Disposal Facility.

Source of Concern

An event occurred in May 2006 that affected the pumps that are designed to operate automatically when the level of leachate exceeds prescribed settings. The contractor did not discover the inoperable leachate pumps until December 2006, although technicians were aware of, and had recorded the lack of flow from the pumps. An extensive investigation in response to this event also revealed that some of the waste compaction test data did not correspond to the Radiological Control Technician records of entry into the contaminated area where compaction tests are performed. When the technician who was responsible for taking these tests was confronted with this discrepancy, he confessed to having not performed the compaction tests and indicated that he fabricated the test data since June 2005. [4]

DOE and the US Environmental Protection Agency (EPA) were notified of the lack of leachate pumping on 21 December 2006 and the falsification of compaction data on 12 January 2007. The DOE contractor managing the ERDF placed it in a standby mode on 15 January 2007. Shortly thereafter, EPA verbally imposed conditions for a limited restart and, with the consent of EPA, limited waste placement operations were resumed on 19 January 2007 in an area that had not yet been used.

DOE's Office of Environmental Management (EM) convened an independent technical review (ITR) team to assess the impacts of these operational irregularities. The ITR also evaluated deviations from the waste placement plan and investigated concerns about the adequacy of compaction. The ITR team conducted a site visit on 13 March 2007. During this visit, the ITR team met with representatives of the EPA involved with oversight of the ERDF, received a detailed briefing from the ERDF operations staff, and participated in a brief tour of the facility. Following the site visit, the ITR team reviewed extensive technical documentation regarding the design and operation of the ERDF. [5]

LINES OF INQUIRY

DOE requested that the ITR team consider seven lines of inquiry (LOI) pertaining to the operational irregularities at the ERDF. These LOI were often comprised of several key questions. The findings of the ITR team for each of these LOI are described in this section.

LOI No. 1. Validate Scope of Identified Problems

The ITR determined that a root cause analysis conducted by the contractor described the investigation into reasons why the falsification of compaction data went undetected for several months. Shortcomings in past procedures (e.g., lack of accountability of the subcontractor, lack of visual verification of testing) were documented. The changes proposed by the contractor, if implemented, appeared sufficient to provide confidence that the prescribed testing will be performed in the future. [6]

The ITR team also concluded that the root cause analysis did not address factors contributing to failure of the leachate pumping system or the contractor's inability to identify that pumping was not occurring for an extended period. The precise reason for the pump failure remains unknown,

although the primary hypothesis is that damage was caused by a lightning strike. Subsequent analyses did indicate that the problem would have been noticed had the pumping rate been regularly compared to historical pumping rates. The contractor has proposed making this type of comparison henceforth.

LOI No. 2. Assess Contractor Evaluation of Elevated Leachate Level on Landfill Liner

The contractor analyzed the impacts of the excessive leachate level by (i) comparing the quantity of liquid that collected in the leak detection zone (LDZ) relative to the action leakage rate (ALR) and (ii) examining the load placed on the lining system by the additional liquid in the landfill. However, neither of these analyses assessed the most significant impact associated with the elevated leachate level, i.e., did the excessive leachate level cause additional leakage from the ERDF?

An analysis of leakage would consider the amount of water that collected in the LDZ and determine the fraction of this water that leaked from the secondary liner in the ERDF. A comparison of the liquid quantity in the LDZ to the ALR (as done by the contractor) is inadequate alone, because this analysis does not consider that some of the liquid in the LDZ may have leaked from the secondary liner during the period when the pumps were not operational. Because the secondary liner employs a composite barrier system, any additional leakage due to the excessive leachate level probably was negligible (Fig. 2.). Nevertheless, the ITR team concluded that an analysis should be conducted to estimate the amount of additional leakage that occurred. The contractor conducted this analysis subsequently, and showed that the leakage was negligible.

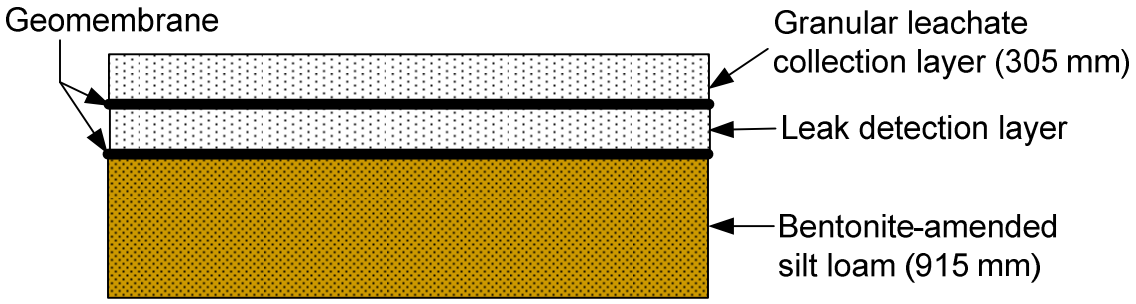

Fig. 2. Schematic of double liner at the ERDF.

The analysis regarding the additional loads imposed on the liner by the excessive leachate level was determined not relevant. The load applied by the waste being placed in the ERDF, which is largely earthen material, is far greater than would ever be applied by an excessive accumulation of leachate.

LOI No. 3. Evaluate Adequacy of Landfill Performance in View of the Discovered Falsified Compaction Data and Potential Leachate Level Problems

The most significant issue regarding waste compaction is whether the compacted waste fill in the ERDF will provide adequate support for the final cover. A schematic drawing of the conceptual landfill at ERDF is shown in Fig. 3. The final cover is a particularly important part of the ERDF, because the cover limits the amount of percolation that enters the waste and ultimately becomes leachate. Adequate waste density is crucial to ensure that the waste has sufficient stiffness to support the final cover with minimal settlement.

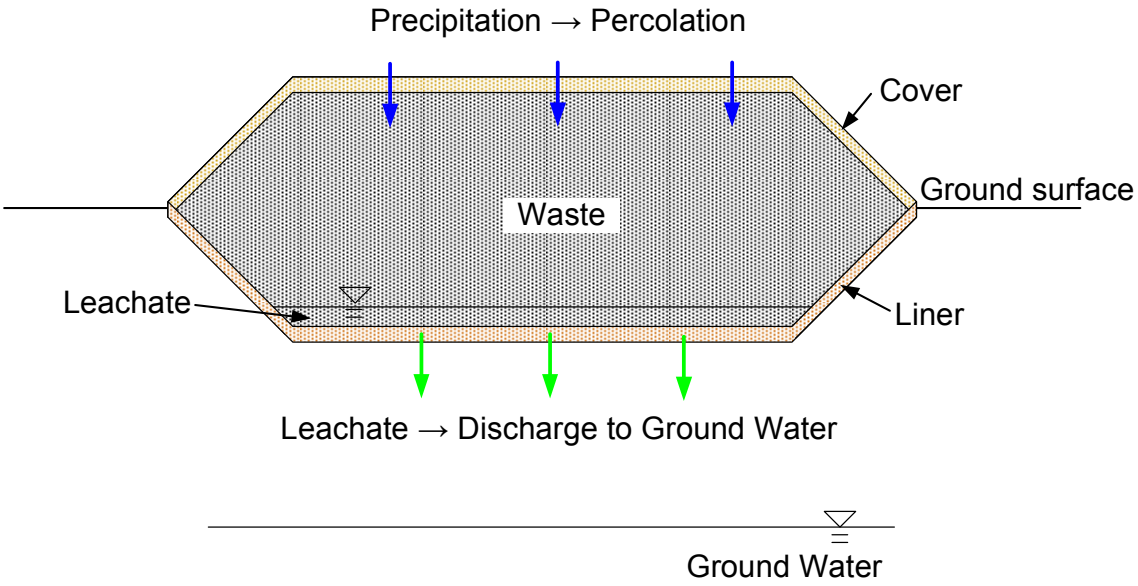

Fig.3. Conceptual design of the landfill and leachate system at the Hanford ERDF.

The ITR team evaluated whether the impacts of problems discovered regarding compaction been adequately analyzed by the contractor. The analysis conducted by the contractor indicated that results of waste compaction testing between January 2002 and January 2007 were questionable. A considerable portion of the data was falsified, and in many cases where measurements were made, the technician was re-doing tests to find an area that met the compaction criteria. Both of these actions cast considerable doubt on the reliability of the density testing during this period.

The contractor performed a large-scale in situ density test in an attempt to verify the compaction. A test pit was also excavated to inspect the compacted material visually. Large-scale in situ tests of this type are the best direct method to determine in situ density and thoroughness of compaction for material containing large particles, such as the waste being placed in the ERDF. Although the ITR team had several questions about how this test was conducted and how the data were interpreted, the test results did suggest that the waste was adequately compacted in the area that was tested. However, the test was conducted at a single location and near the surface. Thus, a conclusion regarding the adequacy of compaction in other regions of the waste could not be made based on this single test. Consequently, the ITR team concluded that other

methodologies or demonstrations are needed to confirm that the waste has been compacted adequately.

The contractor has proposed a placement optimization and settlement monitoring test (referred to as the "field settlement test" henceforth) to evaluate the stiffness of the waste and to investigate waste placement techniques that can be used in the future. The ITR team concluded that the field settlement test proposed should provide strong evidence regarding the adequacy of the compacted waste to provide support for the final cover. The ITR team also indicated that a survey grid should be established on the completed cell so that settlement of the waste mass can be measured on a monthly basis. Favorable results from the field settlement test and a long-term settlement-monitoring program would provide an indication that the methods previously used to place and compact the waste at ERDF are providing adequate compaction.

The contractor has also proposed shifting from a density test methodology to a performance-based placement specification to confirm adequate compaction of the waste. This specification will be developed as part of the field settlement test. Performance-based specifications are widely used in practice to place and compact materials in civil engineering structures, and are developed by constructing a test fill to determine the number of passes required to optimize compaction using the equipment and materials proposed for the project.

The ITR team concluded that the density methodology that has been used to evaluate compaction at the ERDF has many technical flaws and is of questionable value. The performance-based methodology proposed by the contractor is a much better approach to control compaction of the waste. This approach will ensure that the waste is compacted in a consistent and uniform manner, and will avoid many of the problems with density testing that led to data falsification.

To address the problems with leachate pumping, the contractor has proposed a manual pumping regime and a data analysis approach to ensure that leachate levels remain below the maximum permissible level. The pumping regimen is intended to ensure that the system is pumped on a regular basis. The data analysis will compare current pumped volumes to historical volumes. Significant deviations between pumped volumes and historical volumes would precipitate additional investigation. The proposed approach is simple, reasonable, and should be effective provided that historical leachate volumes are consistent with past volumes.

Even with these measures, excessive leachate levels could be realized if the rate of leachate generation increases (for some unknown reason) and the automatic pumping system fails between pumping events. Thus, the ITR team recommended that an automated system be installed to monitor leachate level directly with real-time remote output. Similar systems are commonly used in industrial settings, and can be installed at relatively low cost. Moreover, the system would provide a continuous record of the leachate level in the ERDF relative to the maximum permissible level.

LOI No. 4. Validate Adequacy of Landfill Waste Debris and Contaminated Soil Mix

Field observations made by the contractor in test pits excavated into previously placed waste that contained debris showed that the debris were surrounded by soil. However, documentation has

not been provided to confirm that the 3:1 ratio (soil to debris), or the number of containers over which this ratio can be averaged (24), is adequate to support the final cover for the ERDF. The field settlement test being proposed by the contractor for developing the performance-based compaction methodology (i.e., the ERDF Placement Optimization and Settlement Monitoring Test) will provide the information needed to address this question.

LOI No. 5. Assess the Adequacy of the Compaction Method

The ITR team evaluated whether the compaction criterion adequately prescribed and properly defined in the current specifications. The compaction criterion was determined to be clearly described as a given percentage of the maximum dry density of the reference material (SWL sand). However, the criterion was developed based on a series of laboratory tests on soil using a relatively rapid rate of loading. In contrast, the waste fill consists of a mixture of soil and debris and is loaded slowly. Moreover, simplifying assumptions regarding secondary compression were made when the criterion was developed. Consequently, the relevancy of the criterion is questionable. The ITR team concluded that additional information or demonstrations are needed to verify that the compaction criterion is adequate. Data collected from the field settlement test will be used to address this issue.

The ITR team also evaluated whether the soil pressure requirement used at the ERDF has been sufficient to achieve adequate waste compaction, and determined that the soil pressure requirement has not been directly related to the compaction criterion. The compaction requirement has always been to achieve at least 90% compaction per American Society for Testing and Materials (ASTM) D 1557 using the reference compaction curve. A test program was conducted by the contractor to evaluate the effectiveness of compaction using equipment that meets the soil pressure requirement (a John Deere 1050C bulldozer with a track pressure >110 kPa). Density tests conducted in the test area indicated that 5 to 7 passes with the John Deere 1050C over a 400-mm lift are sufficient to achieve at least 90% relative compaction per ASTM D 1557. However, this test was conducted using soil alone (i.e., daily operational cover) rather than a soil-debris mixture. Thus, the relevance of these findings to compaction of the mixture being placed in the ERDF is unknown.

A root cause analysis conducted by the contractor indicated that the technician responsible for compaction control in the ERDF frequently experienced difficulty in obtaining a satisfactory compaction test result even though the equipment being used met the soil pressure requirement. Based on this experience, a reasonable conclusion is that the soil pressure requirement may not sufficient to ensure that adequate compaction of the soil-debris mixture being placed in the ERDF. Results of the field settlement test will help identify whether the equipment and methods being used are appropriate and whether a performance-based operational procedure can be used in lieu of density testing.

Adequacy of the compactor weight was also evaluated by the ITR team. They concluded that a heavier compactor will compact the waste over a greater depth and provide more effective densification of the waste, particularly when thicker lifts are used, but will not necessarily be more effective in crushing debris in the waste. However, no definitive information was found indicating whether the waste has been compacted insufficiently (or sufficiently) to provide stable

support for the final cover. Thus, from the perspective of densification, a conclusion regarding the need for a heavier compactor was not made. .

The ITR team also concluded that the information currently available is insufficient to confirm that the existing compaction specification and compaction methods are adequate to ensure that the waste will provide a stable foundation for the final cover to be placed on the ERDF. Such a specification needs to be developed using information collected from the field settlement test.

LOI No. 6. Assess the Adequacy of the Compaction Testing and Monitoring

The ITR team evaluated whether testing with a nuclear density gauge was necessary or appropriate for evaluating waste compaction in the ERDF, whether an independent third party should be evaluating compaction of the waste, and the frequency with which compaction testing should be conducted. [7]

Insufficient information was available to determine whether density testing with a nuclear densometer, or any other device that measures density over a small volume, is appropriate for evaluating compaction of the waste placed in the ERDF. The placement of larger materials in the ERDF has the potential to create voids or areas of insufficient compaction that could go undetected using a device that measures density over a small volume, such as the nuclear densometer. This is particularly true when a densometer is used in backscatter mode. Thus, the ITR team was skeptical that adequate compaction testing could be conducted with a nuclear densometer.

The ITR team also concluded that that there is no need for an independent third party to evaluate compaction of the waste being placed in the ERDF provided that the contractor implements the changes they have proposed to their operational and management procedures (e.g., daily oversight, management surveillance, shadow program). The ITR team also recommended that a performance-based placement specification be implemented, which would reduce the need for periodic compaction testing (i.e., testing becomes continuous with a performance-based method).

LOI No. 7. Identify Adequacy of Proposed Management Actions

The contractor is implementing modifications to their management systems to ensure that the problems associated with the compaction testing and leachate levels will not occur again. Progress towards their completion is assessed through the ERDF Corrective Action Tracking system.

The contractor has revised numerous plans and operating procedures in response to the recently discovered problems with compaction testing and leachate collection. These include more specific instructions on configuration management changes, as well as notification on findings associated with internal and external assessments and audits; new requirements to identify potential environmental, safety, and health hazards generated by design changes; additional instruction on developing or revising procedures to address operational changes; and modifications to the operation, monitoring, and analysis of leachate collection system data.

The Quality Assurance Project Plan (QAPjP) includes a new section which states that all quality significant data will require a secondary verification check by the work supervisor to demonstrate conformity of data and information using the appropriate data check sheets. The provision applies to daily verification of air monitoring equipment, facility maintenance inspections, leachate collection inspections, and compaction testing. The section further states that evidence of conformity with the acceptance criteria is maintained in the records and indicates the person authorizing the release of the data as well as the primary, secondary verification, and data sheet. Lastly, the QAPjP contains new provisions for periodic review of any data generation methods to ensure that such methods address customer satisfaction, conformity to data and information requirements, and process trends – including opportunities for preventive action. [8]

The contractor has instituted additional training to ensure personnel are fully aware of any recent changes to operating procedures and to re-emphasize the importance of the proper conduct of operations (including monitoring and testing responsibilities) in assuring compliance with all applicable requirements. This training has included formal classroom sessions, as well as less structured tailgate and one-on-one instruction in the field. Training has been documented in accordance with procedures. The Training Plan has been revised to include more specific categories of personnel. The required training matrix includes minimum mandatory training and required reading, as well as the training frequency. In addition, the revised training matrix is broken down by function-specific job categories instead of the more generic -- line management, supervisors, waste disposal personnel, drivers, and office personnel categories used in the old plan. [9]

The contractor has also increased daily oversight of key activities relating to compaction testing and leachate monitoring. Moreover, by adding an Operations Manager, the Site Superintendent has assumed additional direct supervision of craft personnel. Additional staff have been identified that can conduct compaction tests and provide quality assurance and subcontractor oversight. In those instances in which personnel are temporarily acting in these positions, designation of permanent staff will be critical to ensure long-term performance of the oversight functions.

A shadow program has also been implement that provides another level of oversight to confirm that disposal, facility infrastructure, maintenance, and waste handling operations are conducted in accordance with requirements. The shadow program will be phased out once confidence develops that personnel are consistently adhering to procedures to ensure full compliance. No documentation regarding the specific criteria that the contractor will use to make this determination was found. The contractor is in the process of developing a more rigorous surveillance program as a successor to the shadow program. This program will reportedly involve frequent direct observation, formal checklists, and periodic independent focused assessments; however, documentation on the specific aspects of the program has not been finalized.

ITR FINDINGS

Based on the review, the ITR team recommended that (i) permanent staff be assigned to the tasks associated with each of the operational and management changes that have been proposed by the contractor, (ii) an automated system be installed to monitor leachate depth in the ERDF, (iii) an estimate be made of the amount of additional leakage from the ERDF that occurred due to the pumping failure, (iv) the field settlement test be conducted, (v) a performance-based method for compaction control be developed, (vi) a settlement monitoring program be implemented in filled cells to assess whether past filling practices have resulted in a waste fill that will support the final cover, and (vii) the equipment used to place the waste employ geographic position system (GPS)-based grade control and stiffness-based instruments to assess filling and compaction directly while the equipment is operating.

- The ITR team believes that the operational and management changes that have been proposed (e.g., daily oversight, management surveillance, shadow program) significantly reduce the possibility for data falsification in the future. These activities should be continued. Moreover, to ensure that these changes are institutionalized, the ITR team recommended that permanent staff be assigned to the tasks associated with each of the operational and management changes.

- The ITR team believes that the proposed program to pump the leachate collection system regularly will greatly reduce the possibility that excessive leachate depths will occur in the ERDF in the future. However, the ITR team recommended that an automated system be installed to monitoring leachate depth in the ERDF. The ITR team also recommended that computations be made to determine the amount of additional leakage from the ERDF that occurred due to the pumping failure.

- The ITR team believes that field settlement test being conducted at the ERDF will provide important insights needed to address many of the unresolved issues related to the waste placement method (e.g., suitability of equipment, suitability of soil-debris ratio, need for density testing, etc.). The test will also provide the data needed to (i) evaluate whether the placement methods used heretofore have resulted in a waste mass that will support the final cover for the ERDF and (ii) to develop a performance-based waste placement method.

- The ITR team recommended that the performance-based method for waste placement be developed. This methodology is consistent with modern approaches being used for other earthen fills and will result in a more effectively compacted waste mass. Use of a performance-based method will also eliminate the need for density testing and will preclude many of the issues that led to data falsification in the past.

- The ITR team recommended that a settlement monitoring program be implemented in filled cells and that data collected from this monitoring program be used to assess whether past filling practices have resulted in a waste fill that will support the final cover.

- The ITR team recommended that compaction equipment with GPS-based grade control and stiffness-based instruments be used to assess compaction directly while the equipment is operating. These features would provide a continuous record of filling and continuous assessment of the degree of waste compaction.

CONCLUSIONS

The lessons learned from this review can be used to enhance operations at ERDF, as well as other DOE landfills. These include:

- Performance-based specifications permit better control of waste compaction operations and monitoring;

- Automation (e.g., compaction monitoring, leachate monitoring) reduces reliance on human factors, and can result in more effective operations;

- Installation of a flexible cap provides better protection from unforeseen and uneven landfill settlements and instills greater confidence in compliance with 500-year design life;

- Automation of waste monitoring at the landfill entry can avoid unintentional land filling of non-compliant waste;

- Review of DOE's policy governing landfills, which have been designed very conservatively and do not account for effectiveness of modern barrier systems. Reconsidering performance assessments may permit more cost-effective operations;

- Collection of additional data regarding performance of barrier systems over various time-scales will enhance long term stewardship; and

- Periodic review and updating of methods and specifications will improve management of projects that can take decades to complete.

The ERDF contractor has accepted all of the ITR team's recommendations and has begun implementation. In addition, the contractor has taken a number of immediate steps to improve the ERDF landfill operations, including the acquisition of two waste compactors equipped with GPS that allow operators to directly monitor compaction of the waste. During the initial phases of operations, the compactors are being used on a test pad to develop protocols and to compact the waste effectively in early 2008.

REFERENCES

1. M.A. CASBON, "Design Analysis Construction of W-296 Environmental Restoration Disposal Facility, Volumes 1 and 2", BHI-00355, Bechtel Hanford Incorporated (1995).

2. “Environmental Restoration Disposal Facility (ERDF) Cells 3 and 4 Trench Liner System and Support Facilities Construction Quality Assurance Plan”, 0600X-QA-G0002 Rev. 1, Bechtel Hanford Incorporated (2000).

3. “Construction Quality Assurance Plan for Environmental Restoration Disposal Facility (ERDF) Cells 5 and 6”, 0600X-QA-G0003 Rev.1, Bechtel Hanford Incorporated (2005).

4. Memorandum from T.F. Kisenwether, ERDF Operations Manager, “Falsification of Environmental Restoration Disposal Facility Compaction Logs” 373-3310/T2-03, Washington Closure Hanford, January 18, 2007.

5. C.H. BENSON, W.H. ALBRIGHT, D.P. RAY, “Evaluating Operational Issues at the Environmental Restoration Disposal Facility at Hanford” U.S. Department of Energy, Office of Environmental Management, Hanford Operations (2007).

6. “Falsification of ERDF Compaction Test, Root Cause Analysis”, RCA-2007-0001, Washington Closure Hanford (2007).

7. “Compaction Testing Procedure”, Standard Operating Procedure 5-57, Rev. 1, S.M. Stoller Corporation (2007).

8. “Quality Assurance Project Plan (QAPjP) for the Hanford Environmental Restoration Disposal Facility” Standard Operating Procedure 6-00, Rev. 3, S.M. Stoller Corporation (2007).

9. “Training Plan for the Environmental Restoration and Disposal Facility Disposal Operations”, Standard Operating Procedure 5-11, Rev. 2, S.M. Stoller Corporation (2007).