U.S. Department of Energy
Office of Environmental Management

Independent Technical Review Report: Hanford Operations

Evaluating Operational Issues at the Environmental Restoration Disposal Facility at Hanford

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Sponsored by:

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EXECUTIVE SUMMARY

This report describes the findings of an independent technical review (ITR) team that investigated operational irregularities at the Environmental Restoration Disposal Facility (ERDF) at Hanford. These 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 technicians responsible for monitoring waste placement in the ERDF. Other issues related to compaction of the waste were also considered by the ITR team.

The ITR team concluded that Washington Closure Hanford (WCH) and Stoller Corporation (Stoller) identified key issues that led to falsification of the compaction data and have proposed a management plan that will greatly reduce the probability of data falsification henceforth. The level of oversight included in the management plan is sufficient to preclude independent third-party compaction testing. The ITR team also concluded that the plan proposed by WCH and Stoller to manage leachate pumping will minimize the likelihood of unrecognized pumping system failures and excessive leachate depth in the ERDF. However, the ITR team also believes that the long-term effectiveness of these changes hinges on permanent staff being assigned direct oversight of these issues.

Because the compaction data were falsified for an extended period, the ITR team concluded that significant uncertainty exists regarding the ability of the waste to provide effective support for the final cover ultimately to be placed on the ERDF. WCH has proposed a field test that will address this issue (*ERDF Placement Optimization and Settlement Monitoring Test*). The ITR team believes that the outcomes of this test, along with a settlement-monitoring program on the existing filled cells, will provide insight into the ability of the existing waste to support the final cover. This field test can also be used to assess the suitability of the 3:1 soil-debris ratio and will provide the information needed to develop a performance-based method for waste placement. Development of a performance-based approach is strongly supported by the ITR team, as this methodology will result in more effective waste placement and will eliminate many of the issues that led to data falsification. The performance-based method will also eliminate the need for density measurements with a nuclear densometer, which have little value for assessing compaction of the heterogeneous mixture containing large particles that is being placed in the ERDF.

The ITR team also considered the soil pressure requirement and the weight of the compactor in the context of effective compaction of the waste. Soil pressure is the key factor influencing crushing of materials during compaction; compactor weight controls the depth to which compaction occurs. Conclusions regarding the suitability of the current equipment requirements could not be made with the existing information. However, the ITR team believes that the outcome of the field test proposed by WCH will provide the insight needed to determine if the current requirements for compaction equipment are satisfactory.

Based on the review, the ITR team recommends that:

- permanent staff be assigned to the tasks associated with each of the operational and management changes that have been proposed by the contractor,

- an automated system be installed to monitor leachate depth in the ERDF,

- an estimate be made of the amount of additional leakage from the ERDF that occurred due to the pumping failure,

- the proposed *ERDF Placement Optimization and Settlement Monitoring Test* be conducted in the near future and that the ITR team review the data and outcomes of the test,

- a performance-based method for compaction control be developed that will eliminate the need for density testing,

- 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, and

- the equipment used to place the waste employ GPS-based grade control and stiffness-based instruments to assess filling and compaction directly while the equipment is operating.

ACKNOWLEDGEMENTS

This technical review was supported by Mark Gilbertson (DOE-HQ), Dinesh Gupta (DOE-HQ), and Owen Robertson (DOE-RL). Their support and feedback during the review is gratefully acknowledged. John Smegal of the Legin Group Inc. assisted with preparation of this report and with the review of management issues. Discussions held with personnel from the US Environmental Protection Agency (EPA), Washington Closure Hanford (WCH), and Stoller Corporation were critical to the mission of the ITR team. The ITR thanks those individuals with EPA, WCH, and Stoller who provided information and input during the review.

INTRODUCTION

The Office of Environmental Management (EM) of the US Department of Energy (DOE) convened an Independent Technical Review (ITR) to assess the impacts of operational irregularities that were recently discovered at the Environmental Restoration Disposal Facility (ERDF) at Hanford. These irregularities included:

- deviations from the waste placement plan;
- falsification of compaction test data;
- questions about the adequacy of compaction testing; and
- failure of the leachate collection system to operate as designed, and the inability of operating personnel to recognize that the system was not functioning.

The ITR team conducted a site visit on 13 March 2007. During this visit, the ITR team met with representatives of the US Environmental Protection Agency (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.

The ITR team was composed of three experts in waste containment, civil engineering, and geotechnical engineering: Craig H. Benson, PhD, PE (University of Wisconsin; Madison, WI), William H. Albright, PhD (Desert Research Institute; Reno, NV), and David P. Ray, PE (US Army Corps of Engineers; Omaha, NE). Brief curriculum vitae for the members of the ITR team are contained in Appendix A.

BACKGROUND

Environmental Restoration Disposal Facility

The ERDF is a large-scale disposal facility authorized by the EPA and the Washington State Department of Ecology to receive waste from Hanford cleanup activities. ERDF is operated by Stoller Corporation (Stoller) under subcontract to Washington Closure Hanford (WCH). Currently, six disposal cells comprise the ERDF, with four more cells being planned for construction by WCH. 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 RCRA Subtitle C-type liner and have a leachate collection system. An interim cover has been placed over filled portions of the first two cells. The capacity of the initial six-cells is 7.2 million Mg (8 million tons).

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.

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. Stoller management 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.

Subsequently, Stoller conducted an extensive management assessment in response to this event, during which they discovered that some of the 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 data. On 20 December 2006, Stoller transmitted an assessment to WCH indicating that compaction testing was not completed for two weeks in October and all of November 2006.

DOE and EPA were notified of the lack of leachate pumping on 21 December 2006 and the falsification of compaction data on 12 January 2007. WCH placed the ERDF in a standby mode on 15 January 2007. In response, EPA verbally imposed conditions for a limited restart. On 19 January 2007, with the consent of EPA, Stoller resumed limited waste placement at an area in the trench that had not yet been used.

LINES OF INQUIRY

DOE requested that the ITR team consider seven lines of inquiry (LOI) pertaining to the operational irregularities at the ERDF. Findings of the ITR team for each of these LOI are described in this section. These findings were presented at briefings held at Hanford (7 June 2007) and in Washington, DC (13 June 2007). The presentation made at these briefings is in Appendix B.

LOI No. 1. Validate Scope of Identified Problems

Do the results of the root cause analysis, conducted by the contractor in January 2007, represent a complete set of reasons for current concerns related to compaction documentation and monitoring of the leachate level in the ERDF?

Compaction:

The root cause analysis conducted by the contractor describes 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) are documented. The changes proposed by the contractor, if implemented, appear sufficient to provide confidence that the prescribed testing will be performed in the future.

Leachate Levels:

The January 2007 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 the Elevated Leachate Level on the Landfill Liner

Are the contractor evaluations adequate for assessing the impact of exceeding the operating limits above the landfill liner as a result of leachate pump failure from May through December 2006?

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. Neither of these analyses assesses 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. Nevertheless, an analysis should be conducted to estimate the amount of additional leakage that occurred.

The analysis regarding the additional loads imposed on the liner by the excessive leachate level is not particularly 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. The trivial magnitude of this additional load is illustrated in the analysis and the conclusions that have been proffered by the contractor.

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

Compaction:

Have the impacts of problems discovered regarding compaction been adequately analyzed by the contractor?

The analysis conducted by the contractor indicates that the compaction testing results for much of the waste placement between January 2002 and January 2007 are questionable, at best. 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 has 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 do 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 fill cannot be made based on this single test. Other testing methodologies or demonstrations are needed to confirm that the waste has been compacted adequately. The *ERDF Placement Optimization and Settlement Monitoring Test* proposed by the contractor should provide important insights into the potential impacts (if any) associated with the lack of compaction monitoring.

Remedial actions may be required if the *ERDF Placement Optimization and Settlement Monitoring Test* indicates that the waste is inadequately compacted. A summary of potential remedies is included in Appendix C.

Are the investigative and remedial measures proposed by the contractor adequate to mitigate concerns about whether the compacted fill will provide adequate support for the final cover in the context of the expected performance of the ERDF?

The only investigative measure regarding the adequacy of the compacted fill appears to be the *in situ* density test described previously. No other approach to determine whether the existing waste will provide adequate support for the cover was discovered by the ITR team. The ITR team does believe, however, that the *ERDF Placement Optimization and Settlement Monitoring Test* proposed by the contractor should provide strong evidence regarding the adequacy of the compacted waste to provide support for the final cover. The ITR team also believes 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 *ERDF Placement Optimization and Settlement Monitoring 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 proposed *ERDF Placement Optimization and Settlement Monitoring Test*. The performance-based specification method is widely used in practice to place and compact materials in civil engineering structures, and is 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 optimization process must focus on the goal of the test fill (in this case, to preclude unacceptable differential settlement within the final landfill cover system).

The ITR team believes 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. However, the performance-based methodology must be developed in the context of acceptable requirements for the final cover actually to be placed on ERDF.

Leachate Levels:

Have the impacts of problems discovered regarding leachate level been adequately analyzed by the contractor?

This issue is covered by the response to LOI No. 2.

Are the investigative and remedial measures proposed by the contractor adequate to mitigate concerns about the adequacy of leachate levels, and how these levels may affect the expected performance of the ERDF?

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, however, 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. A better approach is to install a system to monitor the 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

Will the continued use of a 3:1 ratio of contaminated soil to debris provide adequate support for the final cover in the context of the expected performance of the ERDF?

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 test fill being proposed by the contractor for developing the performance-based compaction methodology (i.e., the *ERDF Placement Optimization and Settlement Monitoring Test*) can be used to address this question.

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

Is the compaction criterion adequately prescribed and properly defined in the current specifications?

The compaction criterion is 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. Additional information or demonstrations are needed to verify that the compaction criterion is adequate. Data collected from the proposed *ERDF Placement Optimization and Settlement Monitoring Test* will be useful for addressing this question.

Has the use of a soil pressure requirement been sufficient to achieve adequate compaction at ERDF in the past?

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 ASTM D 1557 using the SWL Medium Sand compaction curve referenced in the *ERDF Waste Placement/Disposal Specification*. A test program was conducted by the contractor (see *ERDF Interim Operations Test*) to evaluate the effectiveness of compaction using equipment that meets the soil pressure requirement (a John Deere 1050C bulldozer with a track pressure >16 psi). Density tests conducted in the test area indicated that 5 to 7 passes with the John Deere 1050C over a 16-inch 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.

The root cause analysis indicates that the technician responsible for compaction control in the ERDF frequently experienced difficulty 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 test proposed by the contractor for performance-based placement of the waste (*ERDF Placement Optimization and Settlement Monitoring 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.

Does the contractor need to modify the compaction specifications?

The information currently available is insufficient to confirm that the existing compaction specification is 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. Results of the test proposed by the contractor for performance-based placement of the waste (*ERDF Placement Optimization and Settlement Monitoring Test*) will help identify a specification or methodology that is appropriate.

Are there valid reasons (e.g., debris crushing) to require a heavier compactor than the compactor required to achieve sufficient soil pressure for compaction?

A heavier compactor will compact the waste over a greater depth. Thus, a heavier compactor can provide more effective densification of the waste, particularly when thicker lifts are used. However, no definitive information is available indicating that 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 cannot be made at this time. This question may be answered more definitively once data are collected from the proposed *ERDF Placement Optimization and Settlement Monitoring Test*.

Crushing of material in the waste is primarily a function of the track pressure. Therefore, from the perspective of crushing, there is no advantage to using a heavier compactor relative to a lighter compactor if the track pressure is the same.

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

Is testing with a nuclear density gauge necessary or appropriate for evaluating compaction of the fill placed in the ERDF?

The present information that is available is insufficient 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. Results of the test proposed by the contractor for performance-based placement of the waste (*ERDF Placement Optimization and Settlement Monitoring Test*) will assist in making this

determination. A likely outcome is that a performance-based operational specification is more appropriate than point measurements made with a nuclear densometer or similar device.

Should an independent third party be evaluating compaction of the fill placed in the ERDF?

If the contractor implements the proposed changes to their operational and management procedures (e.g., daily oversight, management surveillance, shadow program), there is no need for an independent third party to evaluate compaction of the waste being placed in the ERDF.

How often should compaction testing be performed?

The frequency of compaction testing that is necessary depends on the method that is used and the importance of adequate compaction to satisfactory performance of the facility. When small-scale measurement methods (such as a nuclear densometer) are used for compaction control, and compaction of the material is critical to ensure adequate performance, compaction testing is typically conducted on each lift at a rate of one test per 10,000 ft^2 of material placed. Methods that test larger volumes of material can be conducted less frequently. However, regardless of the method being used, at least one test should be conducted per shift or whenever the characteristics of the waste or the placement method change significantly.

When a performance-based placement specification is used for compaction control, the testing frequency essentially becomes continuous provided a technician or inspector continuously observes the placement operation. This type of approach is a likely outcome of *ERDF Placement Optimization and Settlement Monitoring Test* proposed by the contractor. Adoption of the performance-based approach would eliminate the need for density testing with a nuclear densometer or similar device, and thereby make the issue of testing frequency moot.

LOI No. 7. Identify Adequacy of Proposed Management Actions

Are the programmatic changes proposed by the contractor adequate to ensure the problems associated with compaction and leachate levels will not occur again?

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.

Revised Procedures:

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 – 3.5.6 Data Collection and Reporting – 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.

Employee Training:

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.

Operational Oversight:

Stoller has 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. Stoller also has identified more staff that will conduct compaction tests and provide quality assurance and subcontractor oversight. In those instances in which Stoller personnel are temporarily acting in these positions, designation of permanent staff will be critical to ensure long-term performance of the oversight functions.

WCH also has instituted a shadow program – providing yet another level of oversight in addition to Stoller personnel – 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 WCH determines that Stoller personnel are consistently adhering to procedures to ensure full compliance. There does not appear to be any documentation regarding the specific criteria that WCH will use to make this determination. WCH 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.

LESSONS LEARNED

A number of important lessons have been learned as part of this review. These lessons, which are summarized in this section, are relevant to the ERDF as well as other landfill operations at DOE facilities.

- Performance-based specifications can 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.

- Flexible caps may provide better protection from unforeseen and uneven landfill settlements, and therefore have a greater likelihood for remaining effective throughout their design life.

- Although not specifically reviewed, automation of waste monitoring at landfill entry may avoid unintentional landfilling of non-compliant waste.

- Review of landfill operations at other DOE facilities is recommended to increase their reliability and cost-effectiveness. These reviews should include an assessment of compaction operations, the design and operation of leachate collection systems, the design and construction of liners and caps, and waste acceptance monitoring. Site-specific issues should also be considered. Applied studies should be conducted to support changes in operations based on these reviews.

- Personnel involved in landfill operations at DOE facilities need to be cognizant of the rationale and importance associated with the various activities for which they are responsible, and how these activities are related to the long-term performance of the landfill. This perspective will focus personnel on accomplishing their activities properly and thoughtfully.

- Many DOE landfills have been designed very conservatively and do not account for the effectiveness of modern barrier systems. Reviewing this policy and reconsidering performance assessments may permit more cost-effective operations.

- Long-term performance of landfills is an important issue in the context of long-term stewardship. There is an urgent need for more information regarding the performance of barrier systems used in DOE landfills over various time-scales.

- DOE-EM manages large and long-term projects that can take decades to complete. Methods and specifications developed early on may not be relevant or efficient in later years. Periodic review and updating of methods and specifications is recommended.

CONCLUSIONS AND RECOMMENDATIONS

Based on the review conducted, the ITR team makes the following conclusions and recommendations:

1. 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 recommends that permanent staff be assigned to the tasks associated with each of the operational and management changes.

2. 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 recommends that an automated system be installed to monitoring leachate depth in the ERDF. The ITR team also recommends that WCH estimate the amount of additional leakage from the ERDF that occurred due to the pumping failure.

3. The ITR team believes that the proposed *ERDF Placement Optimization and Settlement Monitoring Test* 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 recommends that this field test be conducted in the near future and that the team review the data and outcomes of the test.

4. The ITR team recommends 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.

5. The ITR team recommends that WCH implement a settlement monitoring program in the 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 recommends that this monitoring program be instituted in the near future and that the team periodically review the data and outcomes of the program.

6. The ITR team recommends that WCH and Stoller use compaction equipment that employs GPS-based grade control and stiffness-based instruments 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.

Appendix A: Resumes of the ITR Team

Craig H. Benson, PhD, PE

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EDUCATION

B.S., Lehigh University – 1985
M.S., University of Texas at Austin – 1987 (Civil Engineering, Geotechnical/Geoenvironmental)
Ph.D., University of Texas at Austin – 1989 (Civil Engineering, Geotechnical/Geoenvironmental)

POSITIONS

University of Wisconsin-Madison

- Chairman, Geological Engineering, July 2007 to Present.
- Associate Chairman for Environmental Science and Engineering, Dept. of Civil and Environmental Engineering – July 2004 to July 2007.
- Professor of Civil and Environmental Engineering, Professor of Geological Engineering – February 2000 to Present
- Associate Professor of Civil and Environmental Engineering, Associate Professor of Geological Engineering – May 1995 to January 2000
- Assistant Professor of Civil and Environmental Engineering, Assistant Professor of Geological Engineering – January 1990 to May 1995

CONSULTING ENGINEERING EXPERIENCE

Dr Benson has served as a consultant on more than eighty projects for government and industry in the United States and abroad. His consulting work includes specialty design and analysis, peer review, prototype and field testing of new technologies, forensic engineering, and litigation support. In addition, he holds two patents for equipment and methods used in testing of hydraulic conductivity and pressure plate extraction.

RECENT RELEVANT PUBLICATIONS (AS FIRST AUTHOR ONLY)

Refereed Journal Articles

Benson, C., Thorstad, P., Jo, H., and Rock, S. (2007), Hydraulic Performance of Geosynthetic Clay Liners in a Landfill Final Cover, *J. Geotech. and Geoenvironmental Eng.*, in press.

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RELEVANT PUBLICATIONS – CONTRIBUTING AUTHOR

Dr. Benson has made significant contributions to more than 100 additional relevant publications including conference papers, journal articles, reports, standards, and reviews.

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EDUCATION

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POSITIONS

Desert Research Institute

- Associate Research Hydrogeologist, Division of Hydrologic Sciences (DHS), Nevada System of Higher Education – 2002 to Present
- Served as Faculty Senate chair – 2001 & 2007
- Assistant Research Hydrogeologist, DHS – 1997 to 2002
- Staff Hydrogeologist, DHS – 1990 to 1997
- Staff Chemist, Division of Earth and Ecosystem Sciences – 1987 to 1990
- Staff Chemist, Division of Atmospheric Sciences – 1980 to 1987

CONSULTING EXPERIENCE

Dr. Albright has reviewed articles on behalf of the *Water Resources Research, Journal of Geotechnical and Geoenvironmental Engineering, Waste Management, Canadian Geotechnical Journal, and the Vadose Zone Journal*. He served as co-Principal Investigator with Alan McKay on the development of a wastewater irrigation program for Alpine County, Nevada to assess the field effects of the South Tahoe Public Utilities Division's wastewater disposal program. He also developed guidance for the state of Nevada on design and numerical modeling of landfill covers. He helped develop the concept of alternative cover design assessment for an EPA-funded program to provide field-scale data for the development of design guidance, improved numerical modeling, and regulatory revision for the design and evaluation of solid waste landfill covers. In addition, Dr. Albright directed an evaluation of evapotranspiration discharge in the Smoke Creek Basin – a closed basin in northern Nevada.

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RELEVANT PUBLICATIONS – CONTRIBUTING AUTHOR

Dr. Albright has made significant contributions to dozens of additional relevant publications including conference papers, journal articles, reports, standards, and reviews.

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POSITIONS

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- Chief, Geotechnical Engineering and Sciences Branch, Omaha District – June 2006 to Present
- Chief, Soils Section A, Omaha District – March 1991 to June 2006
- Project Manager, Rapid Response Section, Omaha District – September 1989 to October 1990
- Senior Geotechnical Engineer, Foundations and Materials Section, Omaha District – December 1984 to September 1989

CONSULTING ENGINEERING EXPERIENCE

Mr. Ray currently leads a team of 83 engineers, geologists, and scientists that provides geotechnical data and design for military and civil works customers, and provides support to military and EPA customers on hazardous, toxic, and radioactive waste (HTRW) remediation. He has overseen preparations for design documents, analyses, and report deliverables for construction of HTRW containment structures for Army, Navy, EPA, and other federal customers. The most notable projects include the Hazardous Waste Landfill at Rocky Mountain Arsenal, the Old Landfill Cap Repair at Bainbridge NTS, and the Jamaica Island Landfill Cover at Portsmouth Naval Shipyard. He also directed technical support in the construction of over 30 HTRW containment facilities, including major evapotranspiration covers for Box Canyon at Camp Pendleton and covers at Holloman AFB.

Mr. Ray prepared and taught cap/cover design and construction classes for Army and Navy, and authored guide specifications for slurry wall and clay cover construction. He also reviewed and helped prepare the Corps' QA manual for construction of HTRW containment facilities.

He served as a Project Manager for the Rapid Response Section, which included the design of the Red Water Cover at the West Virginia Ordnance Works. In addition, Mr. Ray performed design and technical support for the construction of the cover for the Delaware Sand and Gravel Superfund Site in Delaware and the clay cover for Schmalz Dump Superfund Site in Wisconsin. He also provided technical support for the design and construction of the Basin F Site at Rocky Mountain Arsenal in Colorado, the Bruin Lagoon Superfund Site in Pennsylvania, and the Moyer Superfund Site in Pennsylvania.

Appendix B: Presentation for Briefings

Appendix C: Memorandum of Potential Remedies