Technical Memo

To: Blake Johnson and Anthony Quintrall, HDR

From: Zia Zafir - Sacramento

Date: April 2, 2007

Project No.: 66388/8

Subject: **Technical Memorandum**
TRLIA Certification
Statistical Analyses on QA Moisture Content Data

This technical memorandum transmits the results of statistical analysis on the QA moisture content test data performed by Kleinfelder on Phases 1, 2 and 4 of the TRLIA project. The QA tests were performed between 2004 and 2007.

Discussion

USACE has expressed three primary concerns regarding the moisture during the field testing program; a) lack of moisture control during the field operations, b) compaction on the wet side of optimum, and c) compaction on the dry side of optimum.

The concerns regarding apparent lack of moisture control during construction is addressed in this memo. Moisture quality control was performed on a daily basis to meet the relative compaction requirements.

Kleinfelder has addressed the density test results which were wet of the specification moisture limit in our letter dated 30 March 2007, subject: Response to USACE Comment Letter, Levee Reconstruction Project, TRLIA Phases 1, 2, and 4, Yuba County, California. Based on our field oversight of the testing program we believe the soils were stable and met the relative compaction requirements.

We have also addressed the density test results which were dry of the specification moisture limit in our letter dated 30 March 2007 and in this technical memorandum. Based on our review of the data, samples that were below the specified range were only slightly outside of the lower limit. In Phase 1, out of the 6 tests having laboratory-measured moisture content on the dry side of the specified limit, 5 were within 1% of the specified range. In Phase 2, out of the 70 tests that were outside the specified range, only 2 were on the dry side of the specified limit. In Phase 4, out of 15 tests that were

outside the specified range, 5 were on the dry side of the specified limit. However, 4 of those samples were within 1% of the specified limit on the dry side.

Compaction (Density and Moisture) Testing

Quality control was performed by the contractor and Kleinfelder performed quality assurance testing at a frequency of approximately 20 percent. Tests were conducted in accordance with ASTM D1556 (sand cone test method). Moisture content determination was completed in general accordance with ASTM D2216. Additionally, representative bulk samples of the compacted materials were returned to our Sacramento Laboratory for maximum dry density and moisture content evaluations (compaction curves) in accordance with ASTM D1557.

Moisture Quality Control

Moisture quality control was performed by the contractor on a daily basis during construction. Due to the turn around time for moisture content test results from the laboratory of at least 24 hours, the contractor used a nuclear test gauge to estimate preliminary moisture contents for the compacted engineered fill. In addition, daily visual field observations were made by a representative of Kleinfelder during the placement and moisture conditioning of the soils. Based on the preliminary nuclear gauge results by the contractor and our visual observations, the moisture content of the soils at the time of compaction was acceptable.

Phase 1 Impervious Fill

Impervious fill statistical data is summarized for the difference between the field moisture content and optimum moisture content (difference = field – optimum) in the form of minimum, maximum, mean, and standard deviation in Table 1 below. Distribution of the data is presented in Figure 1. The moisture content specification for this phase was –1% to +3% of the optimum moisture content. Out of 7 tests having laboratory-measured moisture content on the dry side of the specified limit, 6 tests had moisture contents less than the –1% of the optimum and one had higher than +3% of the optimum.

Table 1 – Difference in Moisture Content QA Data Summary for Phase 1 Impervious Fill

Moisture Difference – PHASE 1 IMPERVIOUS FILL	
Value	**QA**
Number of Samples	12
Minimum	-4.7
Maximum	3.5
Mean	-0.7
Standard Deviation	2.0
Tests Outside Specified Range	7

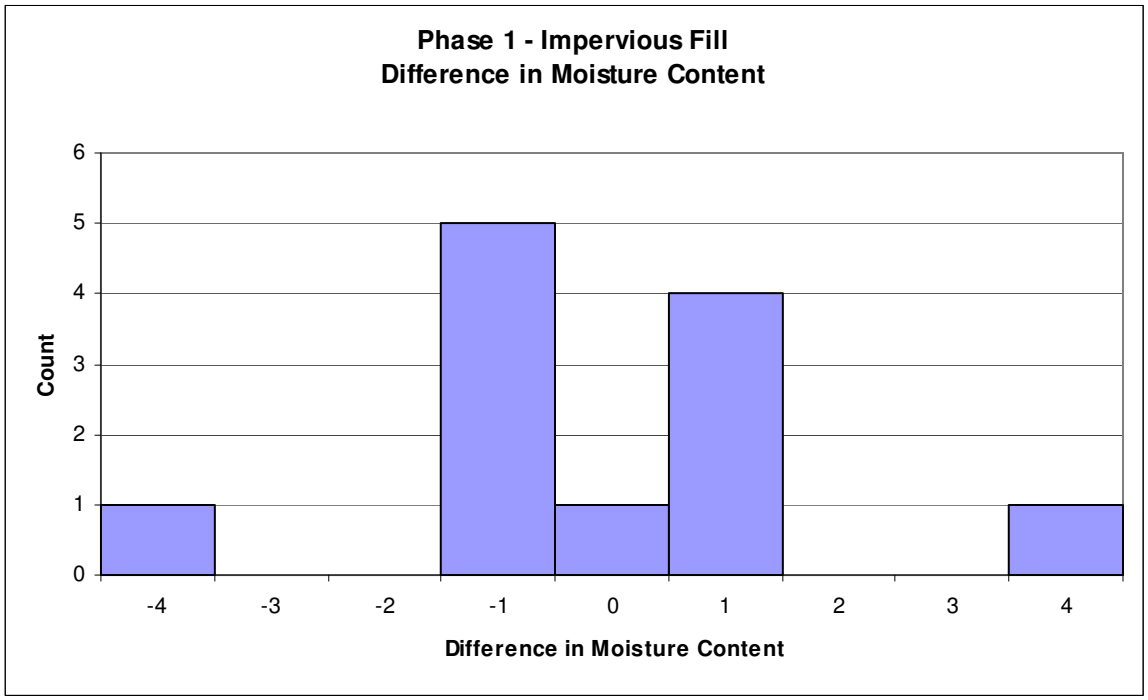

Figure 1: Histogram for Phase 1 Impervious Fill – Difference in Moisture Content

Phase 2 Impervious Fill

Phase 2 included data from the WPIC, Bear River, Olivehurst Detention Basin, Pump Station, and Ring Levee Embankment Fill. The statistical data is summarized for the difference between the field moisture content and optimum moisture content (difference = field – optimum) in the form of minimum, maximum, mean, and standard deviation in

the Table 2 below. Distribution of the data is presented in Figure 2. The moisture content specification for this phase was –2% to +2% of the optimum moisture content. Out of 70 tests having laboratory-measured moisture content outside the specified range, only 2 had moisture contents less than –2% of the optimum and rest of the tests had higher than +2% of the optimum.

Table 2 – Difference in Moisture Content QA Data Summary for Phase 2 Impervious Fill

% Fines – PHASE 2 EMBANKMENT FILL	
Value	**QA**
Number of Samples	106
Minimum	-4.9
Maximum	7.5
Mean	2.4
Standard Deviation	2.1
Tests Outside Specified Range	70

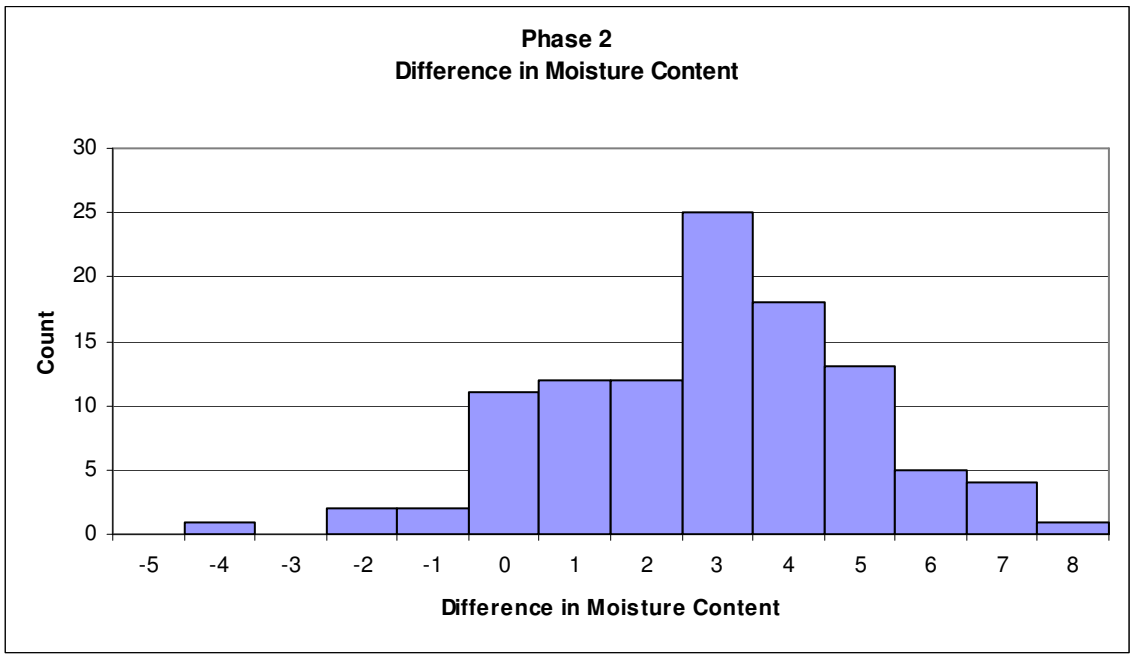

Figure 2: Histogram for Phase 2 Impervious Fill – Difference in Moisture Content

Phase 4 Impervious Fill

Phase 4 Impervious Fill statistical data is summarized for the difference between the field moisture content and optimum moisture content (difference = field – optimum) in

the form of minimum, maximum, mean, and standard deviation in the Table 3 below. Distribution of the data is presented in Figure 3. The moisture content specification for this phase was –2% to +2% of the optimum moisture content. Out of 15 tests having laboratory-measured moisture content outside the specified range, 5 had moisture contents less than –2% of the optimum and rest of the tests had higher than +2% of the optimum and 4 of those samples were within 1% of the specified limit on the dry side.

Table 3 – Difference in Moisture Content QA Data Summary for Phase 4 Impervious Fill

% Fines – PHASE 4 EMBANKMENT FILL	
Value	**QA**
Number of Samples	34
Minimum	-3.2
Maximum	6.3
Mean	1.1
Standard Deviation	2.5
Tests Outside Specified Range	15

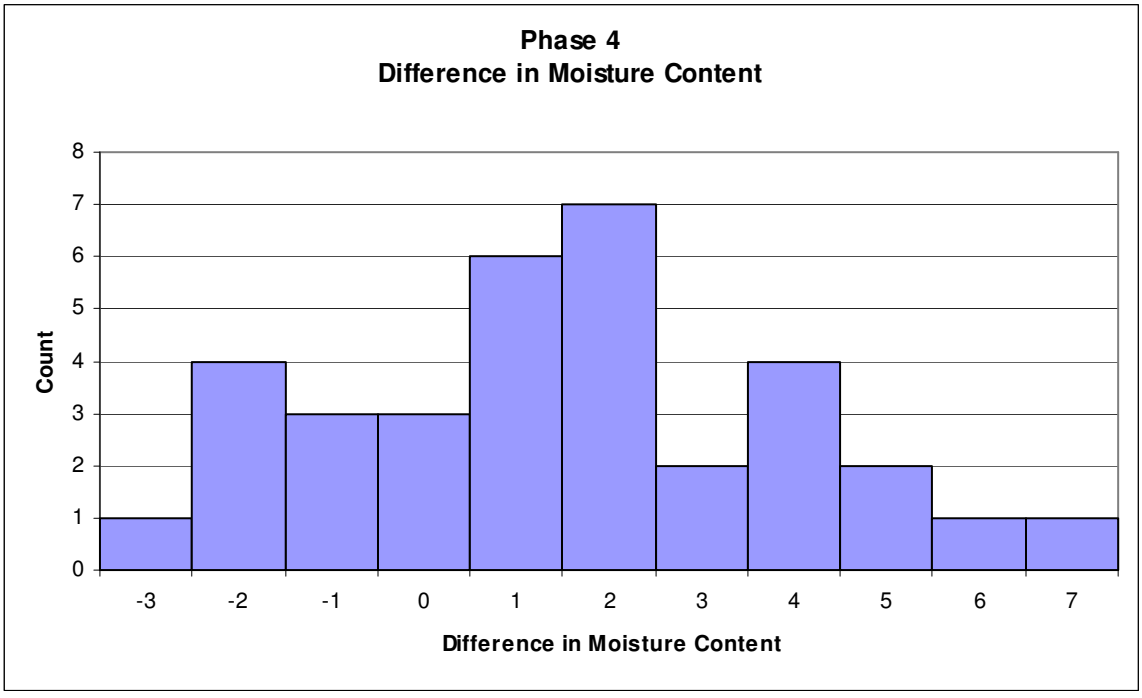

Figure 3: Histogram for Phase 4 Impervious Fill – Difference in Moisture Content

Conclusion

Based on our analysis of the statistical data and field observations, it is our opinion that the material as placed meets the overall intent of the design and the project goals and objectives. The majority of the samples located below the specified range demonstrated moisture contents less than 1% out of specification. All material placed as embankment fill, including the material that did not meet specifications for moisture content, met the compaction requirements, thereby achieving the objectives for strength and permeability.