ATTACHMENT A

PIEZOMETER DATA
AND
GROUNDWATER ELEVATION CONTOUR MAP
FINAL OBSERVATION WELLS REPORT I!
For Reaches North and South of Powerline Road

AMERICAN RIVER WATERSHED PROJECT
(COMMON FEATURES), CALIFORNIA
SACRAMENTO RIVER LEVEE AND BERM
STRENGTHENING

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AUTHORITY: WATER RESOURCES DEVELOPMENT ACT OF 1996
Discussion and Evaluation of Results

General Observations

No major storm events causing high river stages occurred during the entire monitoring period. During both winters, the river stage rose between 15 and 20 feet. The river stages and piezometer levels were generally highest in December through the end of January and gradually decreased after January.

The results of the monitoring program are discussed and evaluated herein in three parts: a general review of the monitoring results, a comparison of river stages and piezometer levels, and a qualitative correlation between analysis results and monitoring results. Conclusions and recommendations are presented subsequently.

General Review of Monitoring Results

A continuous record of monitoring results of river stages and landslide piezometer levels was obtained during this monitoring program. Only the relatively deep USACE piezometers gave meaningful results. The RD-1000 piezometers were installed too high to yield meaningful data during this period of relatively low river stages.

As noted, no significant high-river-stage events occurred during the monitoring period. Nevertheless, the piezometer data showed significant rises in the groundwater levels in response to higher river stages. The piezometer levels were always well below the ground surface on the landslide of the levee, consequently no evidences of upward seepage were expected, and none were observed.

Comparisons of Piezometer Levels to River Stages

The first comparison is between piezometer levels at the landslide levee toe and river stages, made for two locations. The Verona (VON) gage is located near 2F-01-15 (North of Powerline Road) as shown in Figure 2-1. The correlation between river stage recorded at VON and ground water level recorded at piezometer 2F-01-15 is depicted in Figure 5-1. Also shown in this figure is the comparison of piezometer 2F-01-19 with two gages, Bryte (BRY) and RD1000, which are located south of Powerline (see Figure 2-1). The findings from these comparisons are shown in Figure 5-1 and they indicate the following:

2F-01-15 N:

Two distinct trends are evident.

- The river stages were approximately 1 to 3 feet below the ground water levels in the piezometer during low river stage.
- The river stages were approximately 9 to 10 feet above the ground water levels in the piezometer during high river stage.
- Note that Piezometer 2F-01-15 N is installed in an area of reported incidences of seepage and boils.

2F-01-19 S:

Two distinct trends are evident.
Discussion and Evaluation of Results

- The river stages were approximately 1 to 1.5 feet below the ground water levels in the piezometer during low river stage.
- The river stages were approximately 4 to 5 feet above the ground water levels in the piezometer during high river stage.
- Note that no incidence of seepage and boils were reported at the location of this piezometer.

The subsurface conditions at these two piezometer locations are shown in Figures 5-1b and 5-1c. The sand aquifer in 2F-01-15N and 2F-01-19S starts at depths of 73.5 feet and 32.5 feet, respectively. The soil above the sand aquifer is fine grained soil consisting of clay, silt, and silty sand. The difference between the river stage and water level at the piezometer during the peak river stage is higher for piezometer 2F-01-15N than piezometer 2F-01-19S. The reason for the more pronounced time lag in Piezometer 2F-01-15N is probably caused by the thicker and less pervious blanket which slows the percolation time.

Comparison of Water Levels between Near-field and Far-field Piezometers

The second comparison is between piezometer levels at different distances from the landside levee toe and river stages, at two locations. This comparison was made for piezometers relatively aligned in a transverse direction to the river.

1. Piezometers 2F-01-26 and 2F-01-28 (both north of Powerline Road) are located on the landside toe and about 250 feet from the landside levee toe, respectively. The comparison of the two readings is shown in Figure 5-2.

The ground water level at the near-toe piezometer is generally about 1.25 ft higher than the far-field piezometer during high river stage, while the ground water levels are similar during low river stage.

2. Piezometers 2F-01-68 and 2F-01-69 (both north of Powerline Road) are located about 50 feet and 200 feet, respectively, from the levee toe. The comparisons of these readings are shown in Figure 5-3.

The ground water level at the near-toe piezometer is generally about 3.0 feet higher than the far-field piezometer during high river stage, while the water levels are generally similar during low river stage.

Qualitative Correlation between Monitoring Results and Analysis Results

This correlation was made qualitatively only, using results of previous underseepage analyses (URS 2002d and 2002e). The scope of the monitoring program did not include additional underseepage analyses.

First, there was an apparent slight time lag of not more than several days between river stage peaks and piezometer level peaks, as seen in Figure 5-1. This amount of time lag was expected based on transient seepage analyses. Considering that a high river stage typically lasts several days, use of steady-state underseepage analyses is justified and is not expected to lead to any significant conservatism in analysis results.
Second, as expected, the measured piezometer levels resemble the river stages but show lower amplitude. This is expected as a result of seepage head losses in the aquifer between the seepage entrance point and the landside measuring location. For the same reason, the piezometer levels farther from the levee toe are lower than those near the levee.

Conclusions
The monitoring results demonstrate the rapid response of landside seepage conditions to changes in river stages. The groundwater response to higher river stage has a short time lag and relatively smaller attenuation of the peaking amplitudes. The results did not allow any correlation between measured flood stage and surface seepage effects, because of the lack of high river stages during the monitoring period.

![Figure 5-4- Schematic of Locations of Near-field and Far-field Piezometers](image)

Nevertheless, the river stage, near-field and far-field piezometer readings are providing a window into a better assessment of the far-field boundary conditions and overall calibration of the model. As far as numerical seepage modeling is concerned, the observed water levels at points A, B, and C can be used for the calibration. This calibration will serve to minimize the uncertainty in selecting the appropriate boundary conditions, especially the far-field boundary condition and to provide insight into the estimate of the in-situ permeability of the soil. This calibrated model can then be used to predict the seepage response of the levee system for higher design water level.

Recommendations
Two recommendations are drawn from this monitoring program:

- We recommend the continuation of the piezometer and river stage monitoring program. However, the frequency of the monitoring program could be revisited. We also recommend that only Sacramento River and 1-Street gages be monitored.
Figure 5.1: Comparison of River Stage and Piezometer Readings
SACRAMENTO COUNTY, CALIFORNIA

GROUNDWATER ELEVATIONS
FALL 2003
MEAN SEA LEVEL

COUNTY OF SACRAMENTO  PUBLIC WORKS AGENCY  DEPARTMENT OF WATER RESOURCES

DRAWN: MARCH 2004
BY: T. Crick

NOTE: THIS GROUNDWATER CONTOUR MAP IS FOR COMPARISON PURPOSES ONLY. SPECIFIC INFORMATION SHOULD BE OBTAINED BY INDEPENDENT INVESTIGATION.
ATTACHMENT B

SUBSURFACE PROFILE
SACRAMENTO RIVER EAST LEVEE