

### **EXECUTIVE SUMMARY (February 2025):**

City of Shawnee, Oklahoma (City) retained Freese and Nichols, Inc. (FNI) in June 2024 to assist the City in response to certain actions required by a November 2023 consent order issued by Oklahoma Water Resources Board (OWRB). The scope of the work included the following major tasks:

1. Visual site assessment,
2. Limited topographic survey to assist in geotechnical and hydrologic/hydraulic (H&H) evaluations,
3. Historical document review,
4. H&H studies to determine spillway capacity with respect to OWRB requirements,
5. Independent seepage and slope stability analysis of the embankment using existing data from a 2024 report prepared by Terracon Consultants,
6. Preparation of this Preliminary Engineering Report (PER) which includes results of above tasks, recommendations for further analysis, monitoring, and/or repairs as applicable, and peer review of the 2024 Terracon report.

FNI performed a visual assessment on July 3, 2024 and found the spillway and embankment to be in Fair condition based on the OWRB condition rating terminology.

The Terracon investigations and the Consent Order were promulgated by the 2022 annual dam inspection that indicated a slope failure was occurring along the downstream slope near the spillway. FNI examined this area visually and did not conclude that a slope failure had occurred. FNI concluded that the repaired area reflects a localized pavement surface course and subgrade failure. The pavement had been repaired before FNI's site visit.

In the opinion of FNI, the geotechnical strength parameters used in the 2024 Terracon report for slope stability analysis are conservative and are not consistent with values of similar soils on other dams in the state. The Terracon results are also inconsistent with a dam that has performed satisfactorily without a slope stability incident since it was constructed in 1936. Seepage, slope stability, and H&H analyses were conducted by FNI, and the results indicate that the dam is in compliance with the Title 785, Chapter 25 requirements for spillways and embankment dams.

Through the visual assessment and the engineering evaluations, FNI did not identify any dam safety issues that need to be addressed immediately. There were no adverse seepage observations, nor any visual indication of past or current slope instability other than historically noted riprap sloughs in the upper portion of the upstream slope.

FNI recommends an updated breach analysis with modern 2D modeling techniques to better document hazard rating and quantify downstream impacts. To assess the post seismic performance of the dam, a liquefaction and loss of strength analyses/study may be performed. If existing soils are determined to

liquefy or lose strength through seismic loading, a post-seismic slope stability and deformation analysis is recommended.

To improve the physical condition of the dam and limit further deterioration, FNI recommends riprap repair/replacement to the upstream slope, clearing and grubbing of the lower downstream embankment slope, along with some other minor items listed in Section 7. The full scope of recommended repairs are estimated to cost on the order of \$3 to \$3.5 million, based on 2024 construction costs for similar work in the region. The cost estimate range includes replacing upstream slope riprap along nearly the full length of dam, clearing and grubbing of the lower downstream slope, installing seepage monitoring devices, and adding riprap scour protection upstream of the spillway drop structure. Engineering design and permitting services are not included in these costs.

*Seth Barkhimer Slides following from March 17, 2025 City Commission Meeting...*

# CITY OF SHAWNEE

February 18, 2025

## Twin Lake #1 Dam Update

### WORK SCOPE

#### Assist City in Response to OWRB Consent Order

- Independent Visual Assessment
- Topographic Surveys
- Independent Geotechnical Analyses
- Re-Evaluate Spillway Capacity
- Peer Review of Previous Reports by Others
- Recommendations for Further Dam Safety Studies or Construction Projects

# VISUAL ASSESSMENT

July 3, 2025

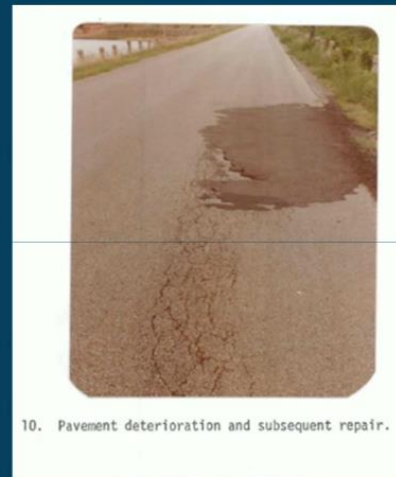


F R E E S E   A N D   N I C H O L S

# VISUAL ASSESSMENT

## CREST

- "Satisfactory" Condition
- No dam safety issues
- Past and on-going pavement/subgrade distress
- Leaning power poles



10. Pavement deterioration and subsequent repair.

*Page 6, USACE Phase I Report, 1978*

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# VISUAL ASSESSMENT

## UPSTREAM SLOPE

- "Fair" Condition
- Over-steepened sections
- Localized sloughing
- Mis-matched riprap
- No immediate dam safety concerns



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# VISUAL ASSESSMENT

## DOWNSTREAM SLOPE

- "Fair" Condition
- Vegetation, Trees
- Seepage in groins
- Seasonal ponded water at toe
- No immediate dam safety concerns



FRESE AND NICHOLS

# VISUAL ASSESSMENT

## SPILLWAY

- "Fair" Condition
- Concrete weathering
- Scour
- No immediate dam safety concerns



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# GEOTECHNICAL ANALYSIS

## INDEPENDENT ANALYSIS FOR SLOPE STABILITY AND SEEPAGE

- Used raw data from Terracon reports
- All OWRB slope stability criteria were met
- Industry standard seepage stability conditions were met
- Additional stability analysis for earthquake loading could be warranted in further studies (USACE criteria)

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# GEOTECHNICAL ANALYSIS

Table 8. Existing Condition Slope Stability Analysis Results

Cross Section	Hydraulic Condition	Analysis Condition	Slope	Minimum Required FS	Calculated FS
Left Section STA 5+50	Normal Pool	Steady-State	D/S	1.5	1.67
	Normal Pool	Steady-State	U/S	1.5	1.64
	Normal Pool	RDD	U/S	1.2	1.70
Central Section STA 17+00	Normal Pool	Steady-State	D/S	1.5	1.53
	Normal Pool	Steady-State	U/S	1.5	2.07
	Normal Pool	RDD	U/S	1.2	1.30

Table 9. Existing Condition Pseudostatic Stability Analysis Results\*

Cross Section	Strength Parameters	Hydraulic Condition	Analysis Condition	Slope	K <sub>u</sub>	Minimum Required FS	Calculated FS
Left Section STA 5+50	Effective	Normal Pool	Pseudostatic	D/S	0.151	1.0	1.26
		Normal Pool	Pseudostatic	U/S	0.131	1.0	1.26
	Undrained	Normal Pool	Pseudostatic	D/S	0.151	1.0	1.26
		Normal Pool	Pseudostatic	U/S	0.131	1.0	1.26
Central Section STA 17+00	Effective	Normal Pool	Pseudostatic	D/S	0.114	1.0	1.13
		Normal Pool	Pseudostatic	U/S	0.134	1.0	1.59
	Undrained	Normal Pool	Pseudostatic	D/S	0.114	1.0	1.10
		Normal Pool	Pseudostatic	U/S	0.134	1.0	1.59

\*All pseudostatic analyses were performed considering Site Class D and return periods of 2,500-yr, 5,000-yr and 10,000-yr. Results using the 10,000-yr return period are shown in the table. Factors of safety from the 2,500-yr and 5,000-yr return period exceed these values.

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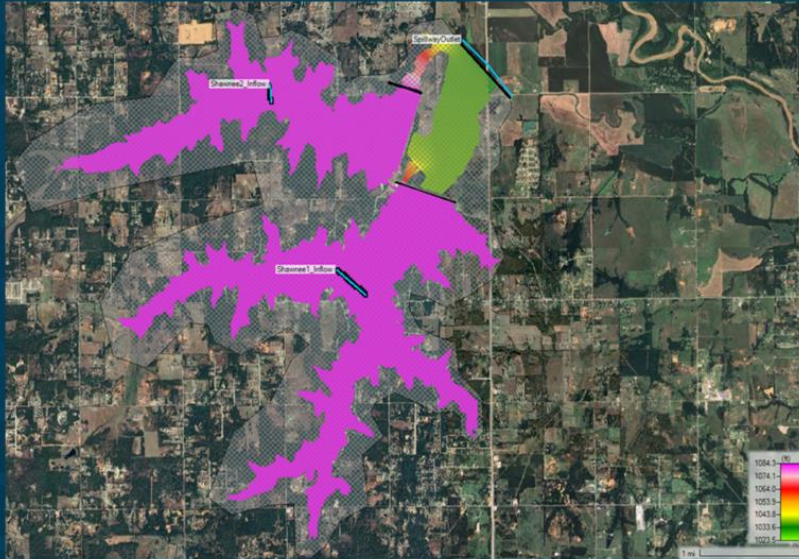
## SPILLWAY CAPACITY

- Required to pass 50% of Probable Maximum Flood (PMF) without dam overtopping in existing conditions.
- 1978 USACE Phase I reported ability to pass 81% PMF
- New FNI study revealed dam can pass 65% PMF (22,700 cfs)
- If spillway were to be replaced, would require the dam to pass 75% PMF with 3 feet of freeboard
  - Dam raise or larger spillway, or both

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# SPILLWAY CAPACITY



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## PEER REVIEW

- USACE reviewed and provided feedback on report
- FNI review main points
  - Conclusions consistent with USACE
  - Initiator for studies was a pavement failure interpreted to be a slope failure.
  - Methods of drilling not consistent with standard of practice for dams
  - Reliance on other methods of investigation that did not correlate well with conventional borings and recovered samples.
  - Very low material strength properties used in modeling.
  - Reported FOS less than 1 for slope stability under current conditions.
  - Modeling results, conclusion questionable compared to historical performance.

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# RECOMMENDATIONS

## Additional Studies:

- Updated Breach Model/Inundation Maps

## Dam Repair Projects:

- Riprap Repair/Replacement
- Clear Trees/Vegetation
- Scour Protection in Spillway

Table 19. Estimated Construction Costs – Recommended Dam Improvements

Work Item	Base OPCC	Estimate Range		
		-15	to	+50
Mobilization/Demobilization	\$185,800	\$157,930	-	\$278,700
Erosion and Sediment Controls	\$53,000	\$45,050	-	\$79,500
Care of Water During Construction	\$235,000	\$199,750	-	\$352,500
Upstream Riprap Replacement	\$2,363,000	\$2,008,550	-	\$3,544,500
Downstream Slope/Toe Clear & Grub	\$216,000	\$183,600	-	\$324,000
Spillway Repairs	\$74,800	\$63,580	-	\$112,200
<b>TOTAL</b>	<b>\$3,127,600</b>	<b>\$2,658,460</b>	<b>-</b>	<b>\$4,691,400</b>