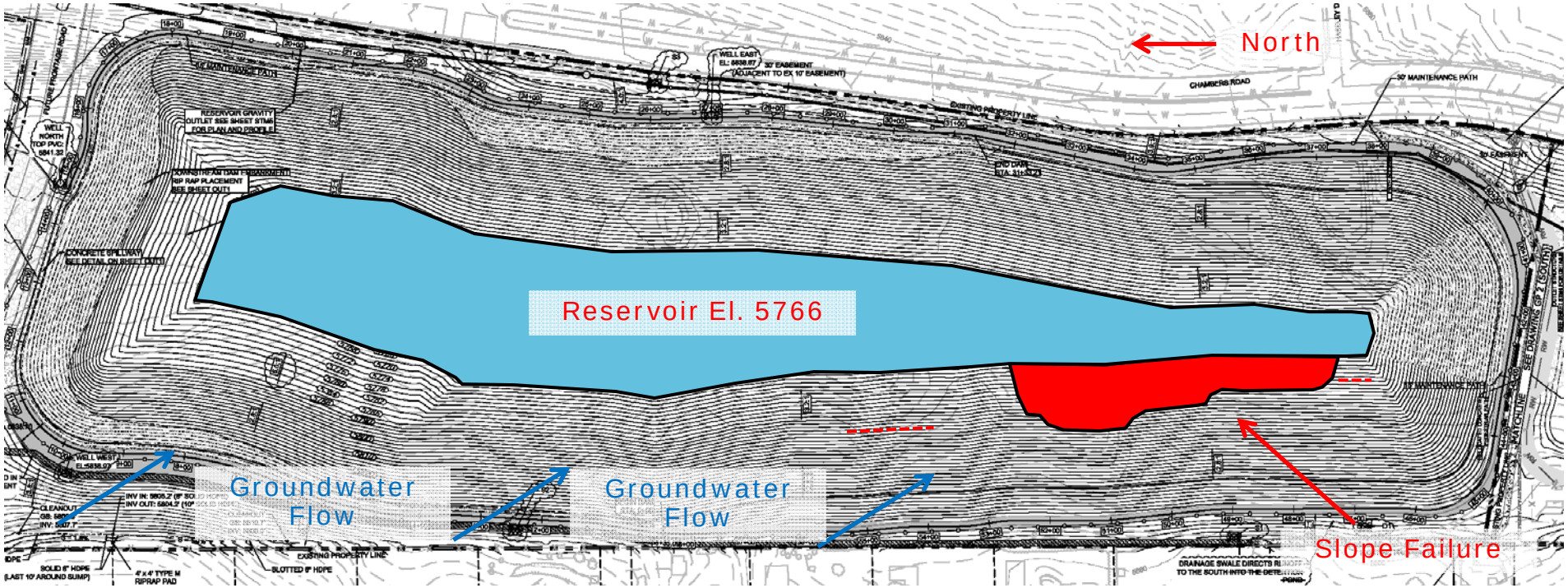
Chambers Reservoir Slope Failure on the South-West reservoir slope

Location: South-West edge of the reservoir

Location: South-West edge of the reservoir

Field Inspection 4-25-17

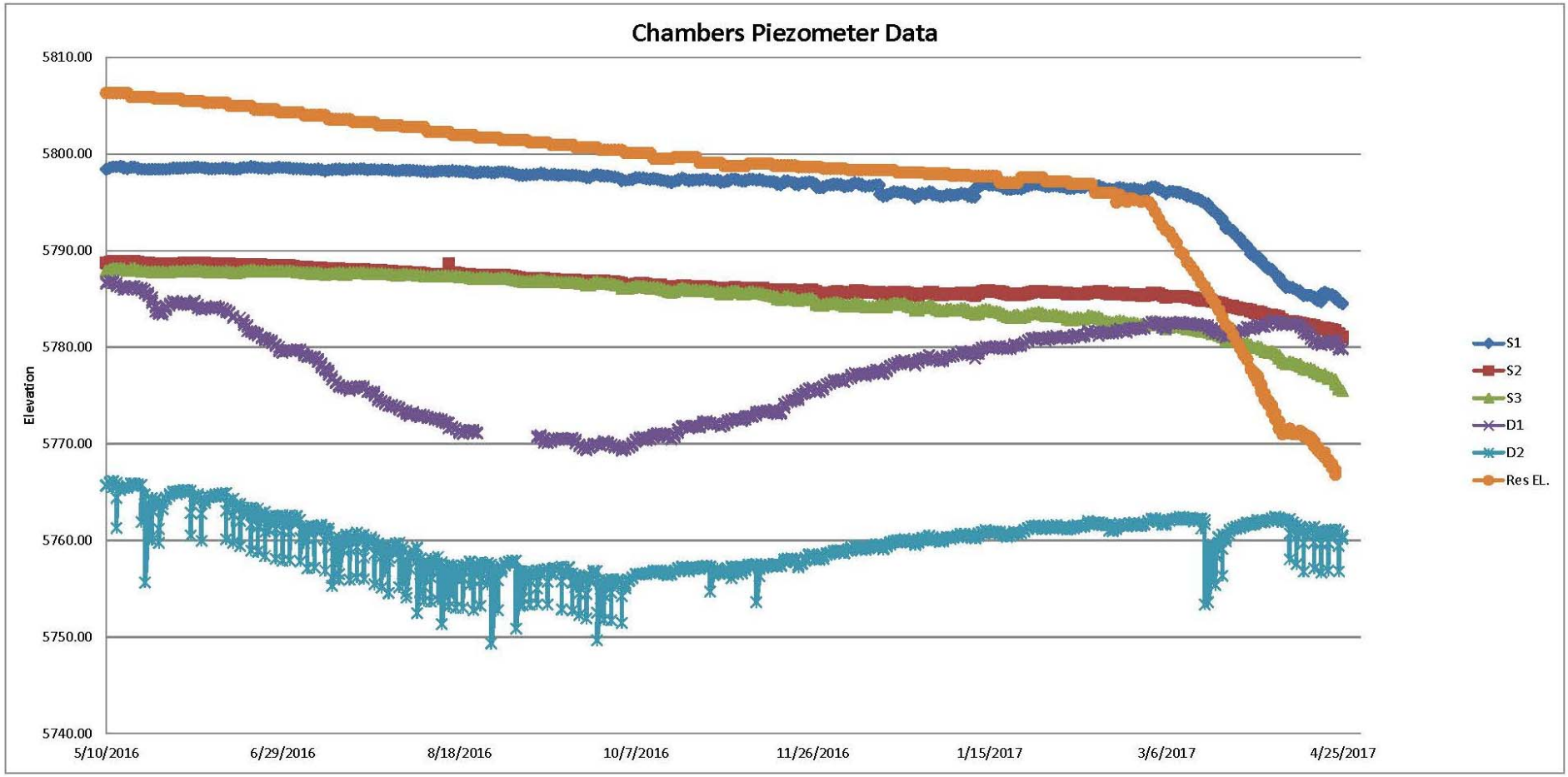


Direction of Regional Groundwater Flow: North-west to South-east

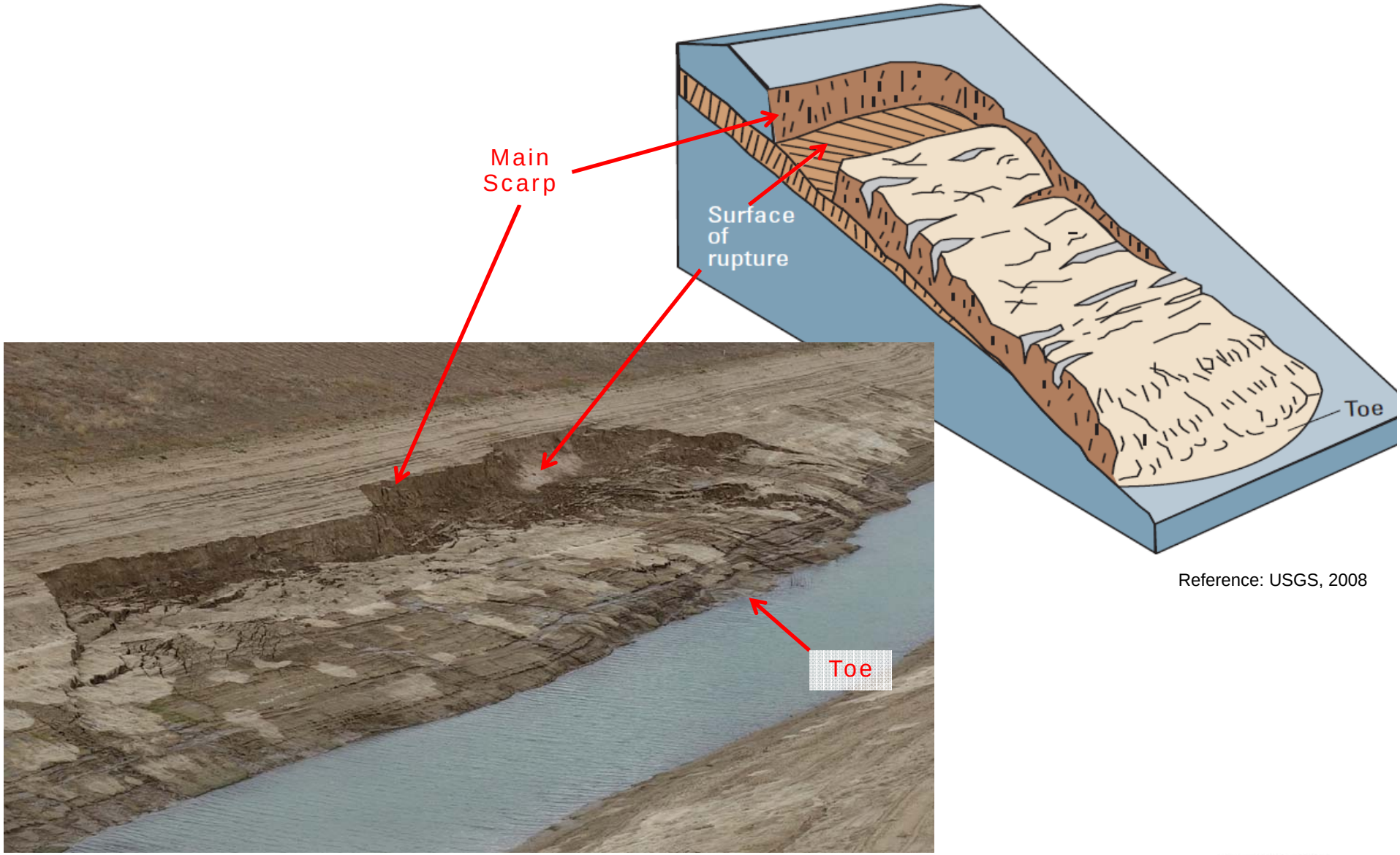
Overview

- Occurred ~March 25th or 26th, 2017
- Water observed flowing out from head scarp
  - High groundwater behind CCL
- Reservoir drawdown in March 2017
  - Rate of drawdown = 9 inches per day (El. 5796 – 5774)
  - Most rapid drawdown cycle (history of reservoir)
- March 25th, 2017
  - Groundwater El. = 5792 (piezometer S1)
  - Reservoir El. = 5781 (11 feet lower than S1)

Instrumentation



Transitional Slide



Reference: USGS, 2008

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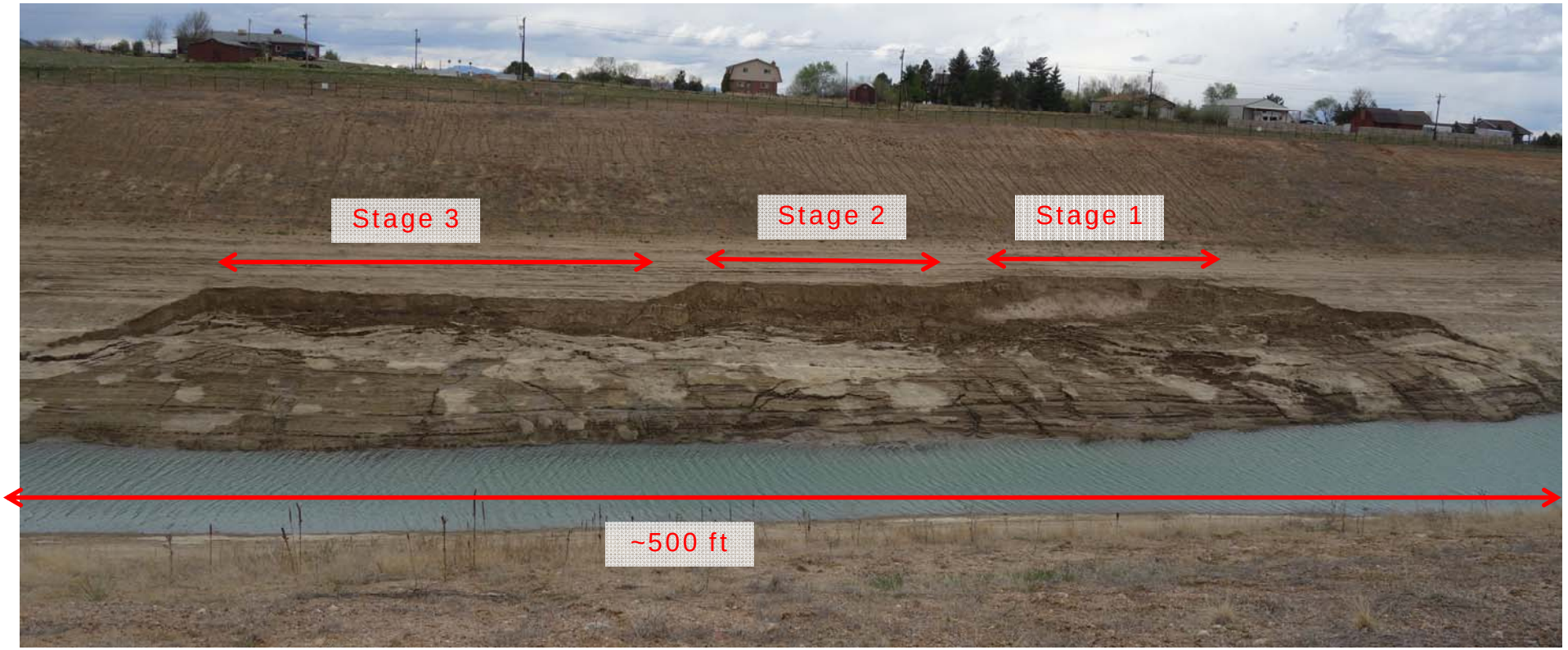
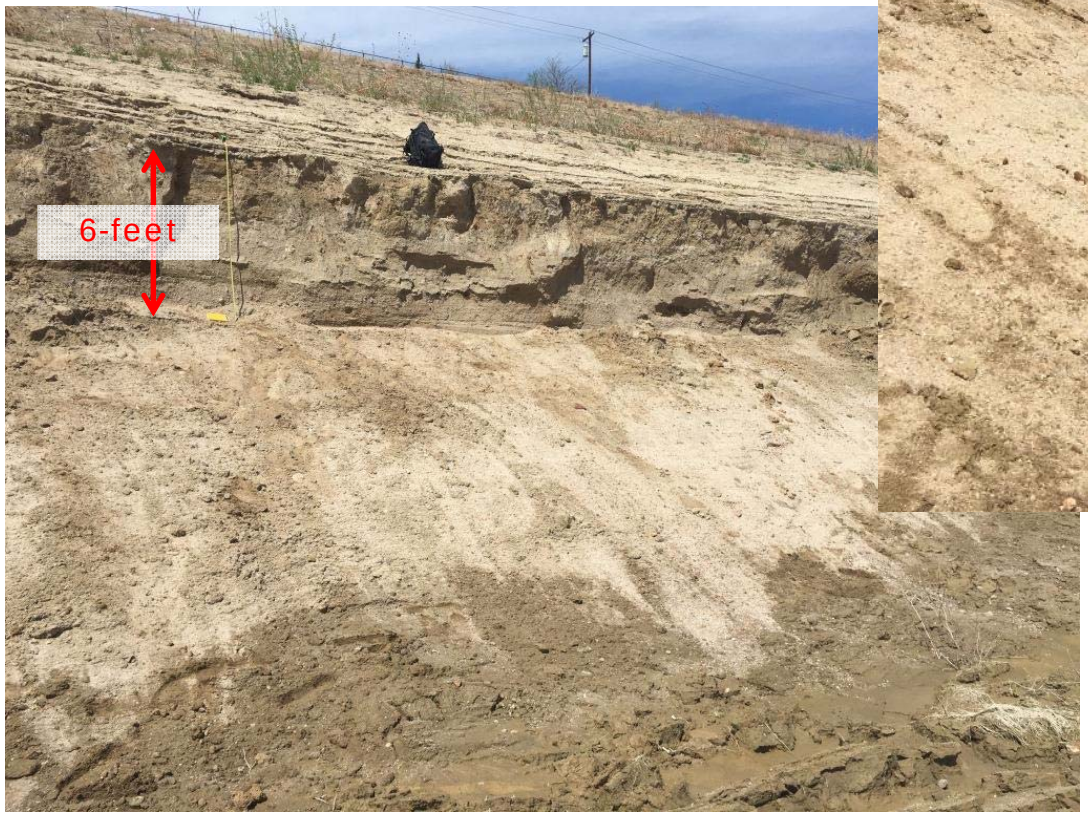
Progressive Failure

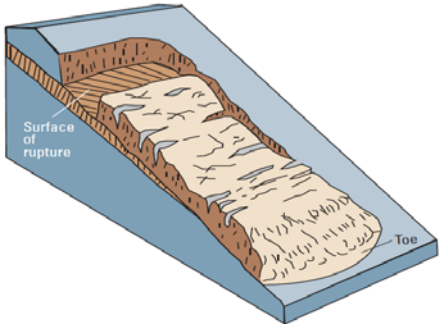


Main Scarp (stage 1)

Surface of Rupture:

- Planar surface
- Sand & fine gravel
- Dry





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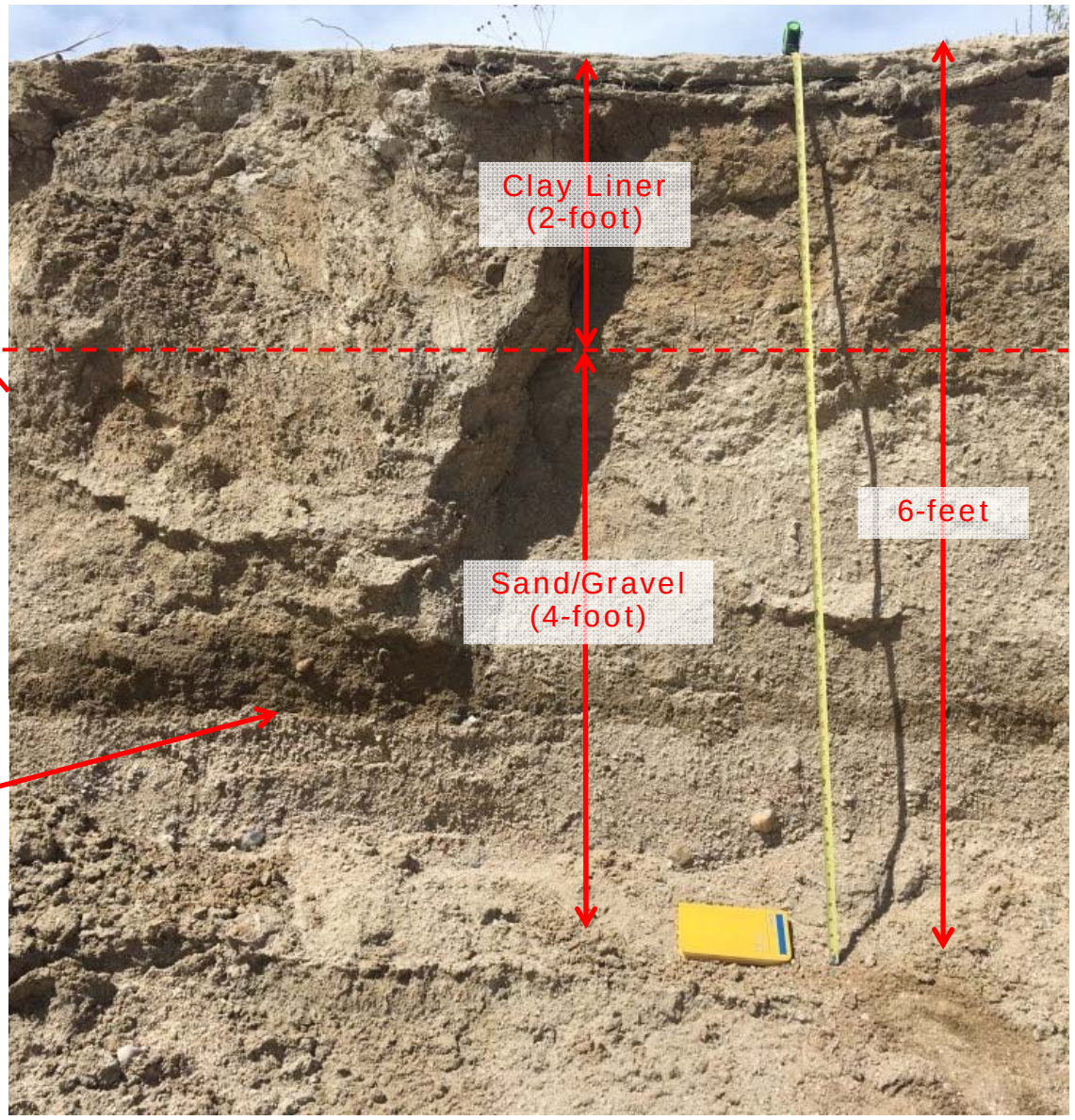
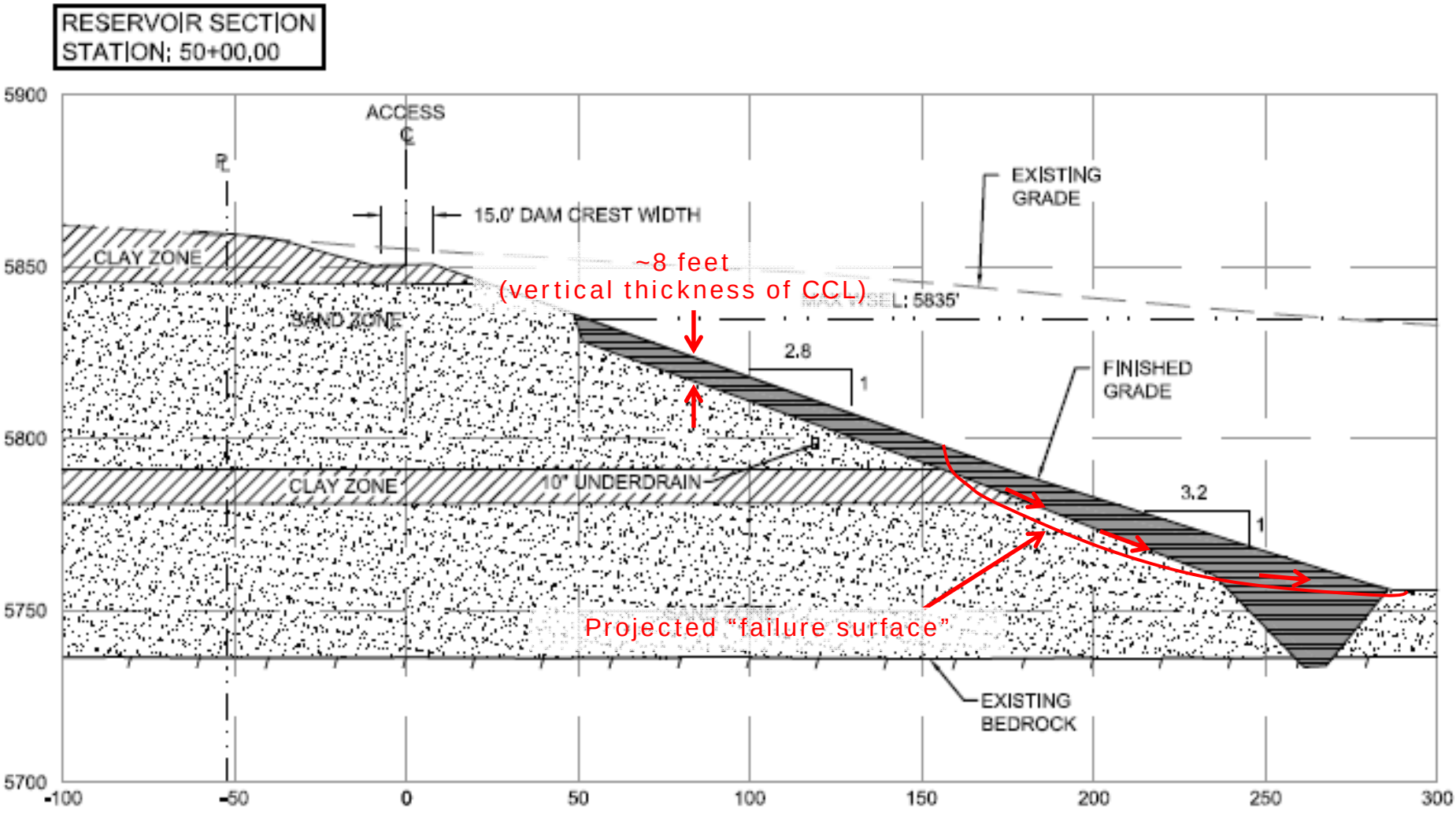
Main Scarp (stage 1)

Seepage along gravelly sandy layers



Photos taken 4-25-17

Record Drawings - Cross-section (Sta 50+00)



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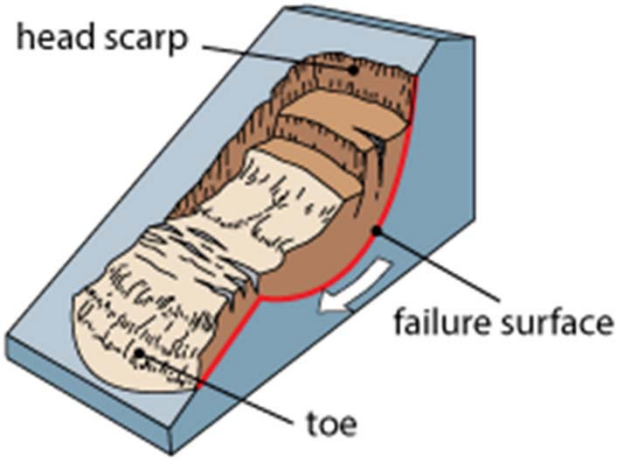
Lower Slide (stage 3)



- Failure appears to be rotational slide
- Surface of Rupture (failure surface) along wet clay layer

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Lower Scarp (stage 3)

- Scarp is wet

- Water flowing from base of scarp

    - Significant volume of water stored behind CCL

Other Un-stabilities

- - - - Tension crack/slope movement observed on both edges of the slope failure

Other Un-stabilities

- Tension crack/slope movement (~145’ long)
- 200’ north of larger instability
- Similar height to other head scarp
- 6-inches vertical movement

Other Un-stabilities

- Tension crack/slope movement
- South edge of larger instability
- 6 to 10-inches vertical movement

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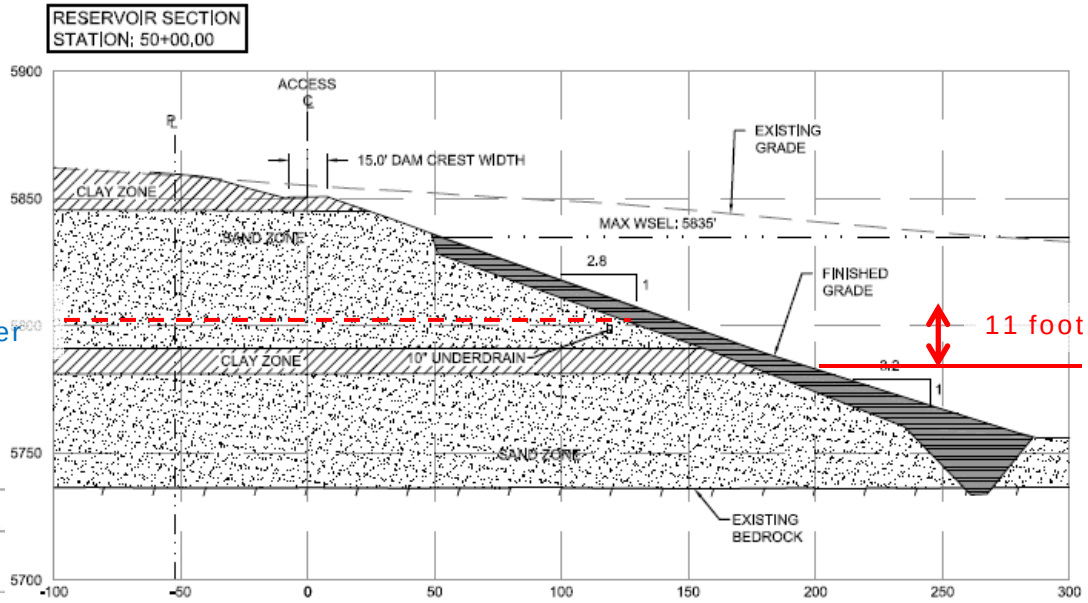
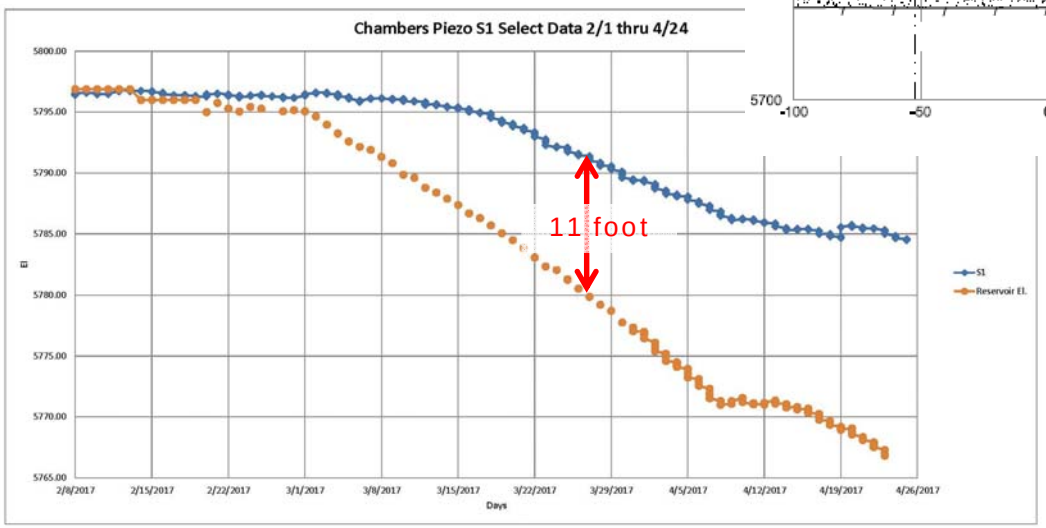
Possible causes of slope instabilities

Elevated groundwater behind CCL with low reservoir pool

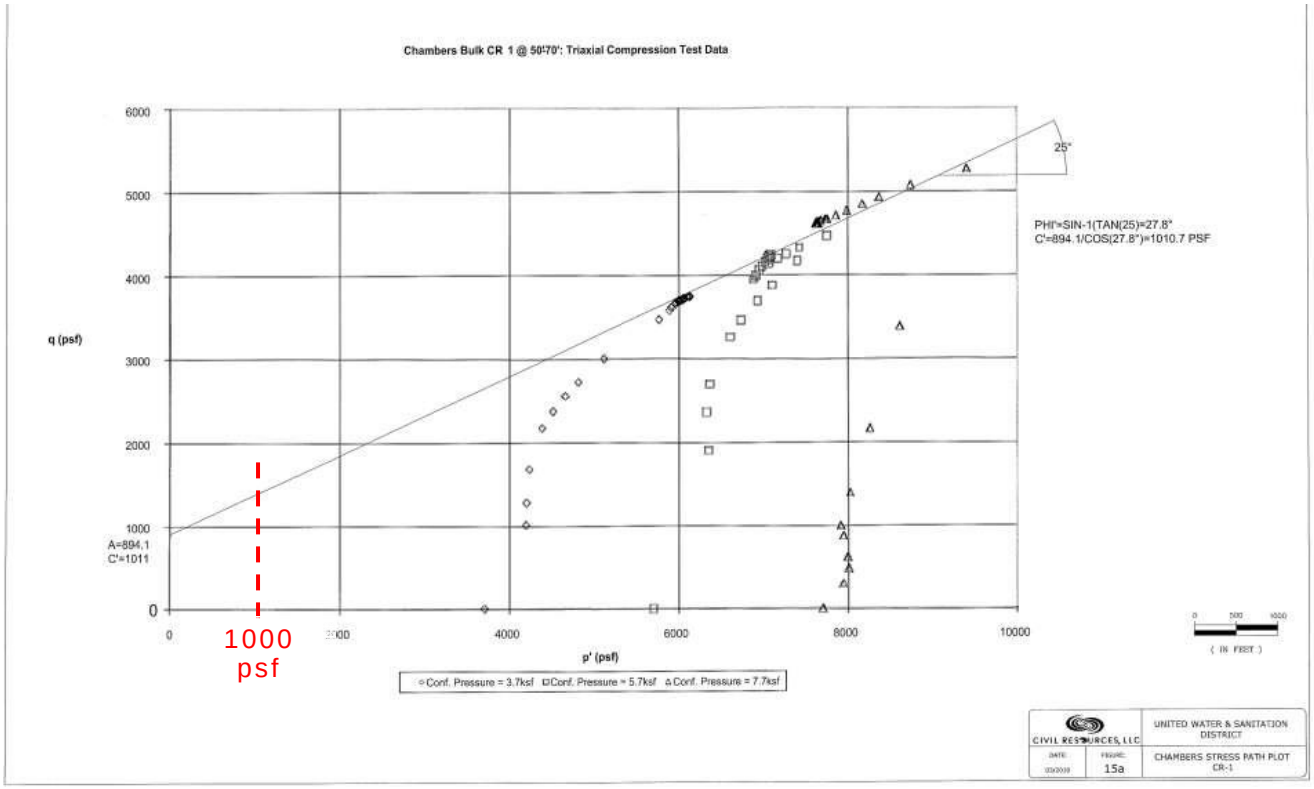
- Artesian pressure below CCL
- Uplift destabilized slope





2010 Design

- Shear Strength Parameters
  - Triaxial testing performed at stresses exceeding the stress of the CCL (3,700psf to 7,700psf)
  - Triaxial test results may over-estimate strength of CCL (both drained and undrained).



2010 Design

1. Stability Analysis identified design does NOT meet SEO criteria under “rapid drawdown”.

	Section A (phi=23°/26°)		Section D								Section G (insitu)		*SEO Criteria*
			insitu		no sand		full liner		full liner, no sand				
	shallow	global	shallow	global	shallow	global	shallow	global	shallow	global	shallow	global	
Full Res.	1.3/1.5	1.6/1.9	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	1.9	1.8	*1.5*
Drawdown	0.8/0.9	0.9/1.0	1.1	1.2	1.1	1.1	1.1	1.7	1.1	1.7	1.0	1.0	*1.2*
Earthquake	1.2/1.4	1.4/1.6	1.9	1.8	1.9	1.8	1.9	1.8	1.9	1.8	1.7	1.4	*1.0*

SEO criteria: Factor of Safety >1.2 (rapid drawdown)

Civil Resources response:

> Rapid drawdown conditions are not physically producible on this project due to the limited withdrawal rate from the facility (15.5 cfs per Mr. Leak) and the limited gravity discharge capacity (approximately 15 cfs) of the proposed outlet to the storm system. The maximum discharge rate of fifteen (15) cubic feet per second (cfs) corresponds to a rate of drawdown of approximately one (1) foot per day which is widely accepted as "safe" from creating rapid drawdown conditions.

2010 Design

1. Elevated Groundwater with low reservoir pool

   - Variable groundwater may not have been considered during design
   - GEI recommended (July, 2010)
     - stability analysis should evaluate the stability of CCL assuming high groundwater levels in permeable zones behind CCL

Observation - Rock Riprap

- Improper bedding material
- Wave erosion undermining riprap

Thank You

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