Technical Memorandum 01

To:	Friends of the Eel River, c/o Kamman Hydrology & Engineering Inc.	Project:	Scott Dam
From:	Scott Stephens, GE	cc:	
Date:	September 6, 2018	Job No.:	1323.100
Subject:	Scott Dam Slope Stability Analyses		

Introduction

This technical memorandum summarizes Miller Pacific Engineering Group's slope stability analyses for the existing landslide adjacent to the left (southern) abutment of Scott Dam located in Upper Lake, California. Scott Dam impounds the upper mainstream Eel River, forming Lake Pillsbury. We understand the existing landslide is approximately 500-feet long and 160-feet wide. The landslide initiated at least in the early 1920's and has been subsequently studied by PG&E through 2016. PG&E's studies included performing topographic and geologic mapping, multiple subsurface explorations, inclinometer readings, survey and groundwater monitoring. Based on available data, inclinometers installed in the landslide mass sheared in the mid 1970's. Movement has occurred at various levels within the landslide up to depths of 110 feet below ground surface. The total mass of the landslide complex is over 8 million cubic feet, weighing over 520,000 tons. It is unclear if any of these sheared inclinometers have been replaced or if inclinometer monitoring of the landslide is occurring. PG&E conclusions regarding landslides on the slope overlying the left abutment, outlined in the 2016 FERC Part 12 Safety Review, state the "susceptibility of these slopes to seismic events is not known and has not been studied." The purpose of this study is to perform preliminary evaluation of potential effects of the landslide mass on the dam

Slope Stability Analyses

Because the project area is an active landslide, we are able to back-calculate the strength along known landslide planes. To determine the residual strength of the landslide materials along the slide plane, we input Cross Section D-D' developed by PG&E into a 2-D slope stability program, (SLIDE) developed by Rocscience. Multiple slide plane soil layers were modeled within the cross section based on PG&E inclinometer data. The slide plane soil strength parameters were adjusted until the resulting slope stability factor of safety (F.S.) was 1.0, definition of marginally stable landslide. The results of our back-calculation analyses of landslide soil strengths are presented on Figure 1 and used in the pseudo-static (seismic) analyses.

Pseudo-Static Analysis

Typically, a Probabilistic Seismic Hazard Analysis (PSHA) is utilized to analyze earthquake loads for dams. PSHA analyzes possible earthquake scenarios while incorporating the probability of each individual event to occur. The probability is determined in the form of the recurrence interval, which is the average time for a specific earthquake acceleration to be exceeded. The design earthquake is not solely dependent on the fault with the closest distance to the site and/or the largest magnitude, but rather the probability of given seismic events occurring on both known and unknown faults, and higher magnitude events.

PG&E evaluated the seismicity at the site and determined the controlling ground motions would be the 84th percentile from deterministic seismic hazard analyses of a Magnitude 6.0 earthquake on the Bartlett Springs fault zone located in close proximity to the dam. Deterministic Seismic Hazard Analysis (DSHA) predicts the intensity of earthquake ground motions by analyzing the characteristics of nearby faults, distance to the faults/rupture zones, earthquake magnitudes, earthquake duration, and site-specific geologic conditions. The calculated DSHA acceleration at the dam site is 0.53 g.

We calculated the peak ground acceleration (PGA) for the 2% chance of exceedance in 50 years (2,475-year statistical return period) and the PGA for a 10% chance of exceedance in 50 years (475-year statistical return period) utilizing the USGS online Uniform Hazard Tool. The results of the analyses indicate the 2% in 50-year and 10% in 50-year PGAs are 0.87 g and 0.44 g, respectively.

For pseudo-static stability analyses, the PGA produced by an earthquake over a slope is reduced due to the variability of the ground motion direction over distance and depth. Based on the procedures outlined in ASCE's Guidelines for Analyzing and Mitigating Landslide Hazards in California (2002), the 10% in 50-year, 84th percentile DSHA, and 2% in 50-year ground motions induced on the landslide mass can be reduced to 0.18 g, 0.21 g, and 0.33 g, respectively.

The reduced ground accelerations discussed above were input into our stability model utilizing the back calculated slide plane soil strength values. The results of our 10% in 50-year, 84th percentile, and 2% in 50-year pseudo-static analyses are presented on Figures 2, 3 and 4, respectively, and indicate calculated factors of safety well below 1.0, indicating landslide displacements will occur during a strong seismic event. The lower the calculated factor of safety, the more unstable the slope is and more seismic movement would be expected to occur.

Seismic Displacement

We analyzed the potential slope displacement based on the procedures outlined by Bray & Travasarou (2007). The results of our analyses indicate that the anticipated range of seismic induced displacements is influenced by the soil strength profile and level of seismic shaking applied. The results of our displacement analyses indicated the landslide mass may move between 3 to 19-feet, as summarized on Figures 2, 3 and 4.

Conclusions

Based on our preliminary geotechnical and slope stability/displacement analyses, it is our professional opinion that the large landslide complex adjacent to, and possibly below the left abutment presents a significant geologic hazard to the dam that requires further investigation. Since the dam acts as strut across Eel River, the landslide mass may be applying significant soil pressure to the dam. In addition, the preliminary calculated seismic displacements are enough to cause concern about uplift or damage to the dam from landslide movement during a strong seismic event.

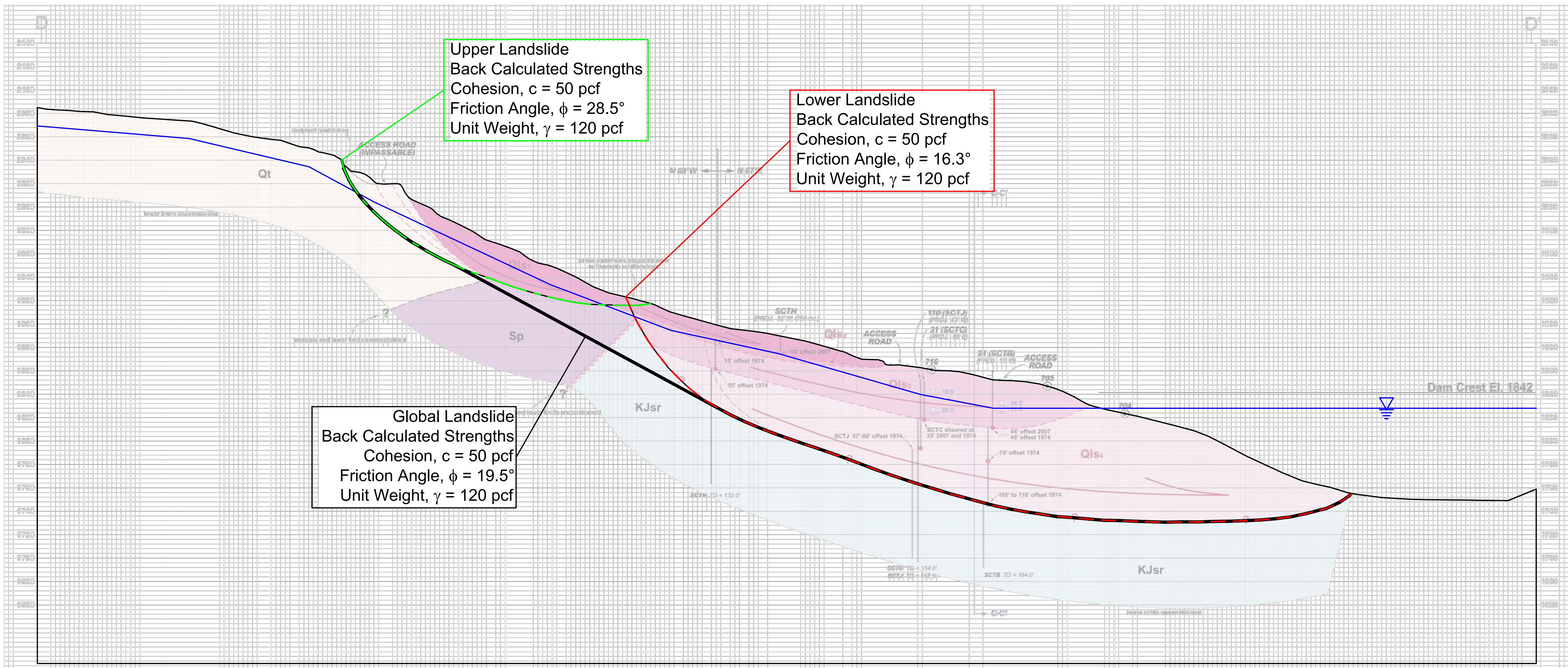
We recommend that PG&E and/or their geotechnical consultants preform a more detailed and sophisticated analyses of the potential effects of the active landslide mass on the dam. We would anticipate this may require subsurface exploration, laboratory testing of soil and bedrock samples, inclinometer installation and 3-dimensional (finite element) slope stability analyses.

We hope this provides you with the information you require at this time. Please do not hesitate to contact us with any questions or concerns.

Sincerely,
MILLER PACIFIC ENGINEERING GROUP

Scott Stephens
Geotechnical Engineer No. 2398
(Expires 6/30/19)

Attachments: Figures 1 through 4



SCALE

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MPEG MILLER PACIFIC ENGINEERING GROUP

FILE: xxx.dwg

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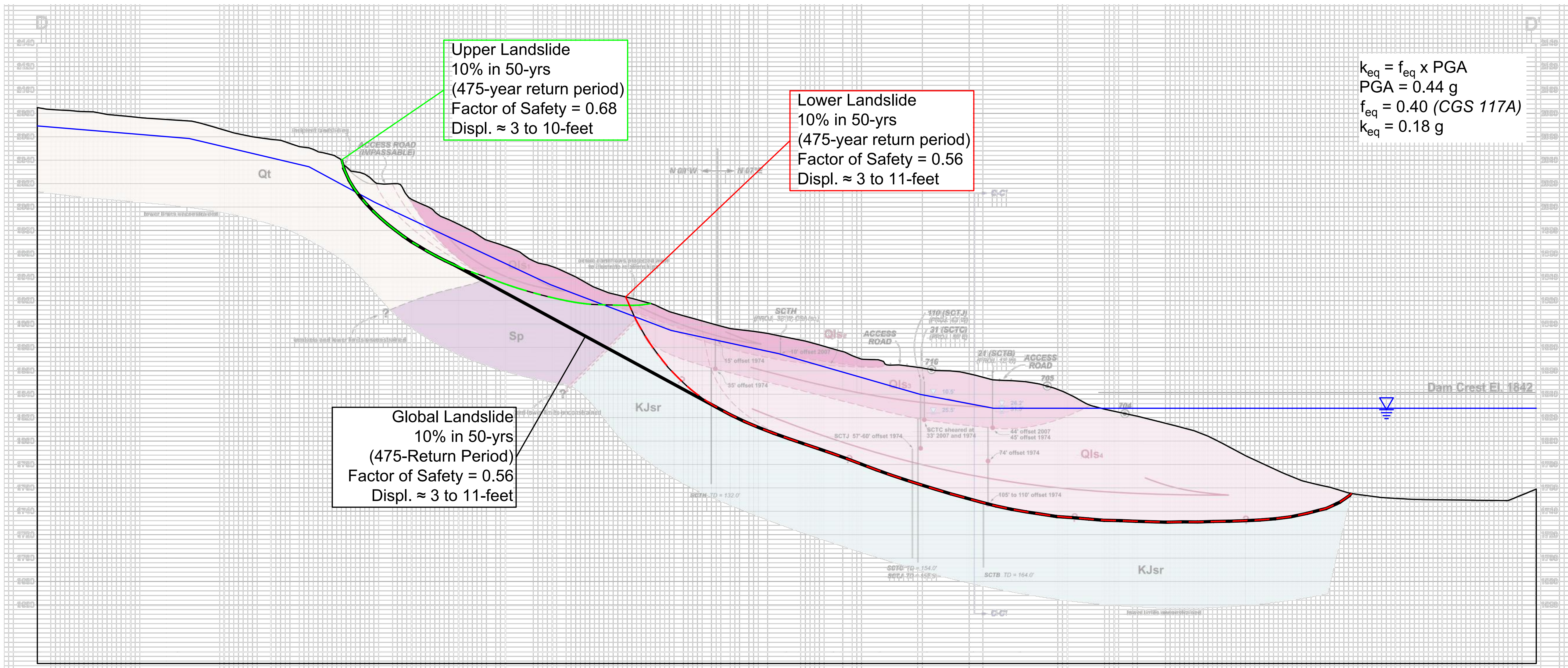
BACK CALCULATED RESULTS

Scott Dam Evaluation
Lake County, California

Project No. 1323.100 Date: 7/17/18

Designed BSP
Drawn BSP
Checked

1
FIGURE



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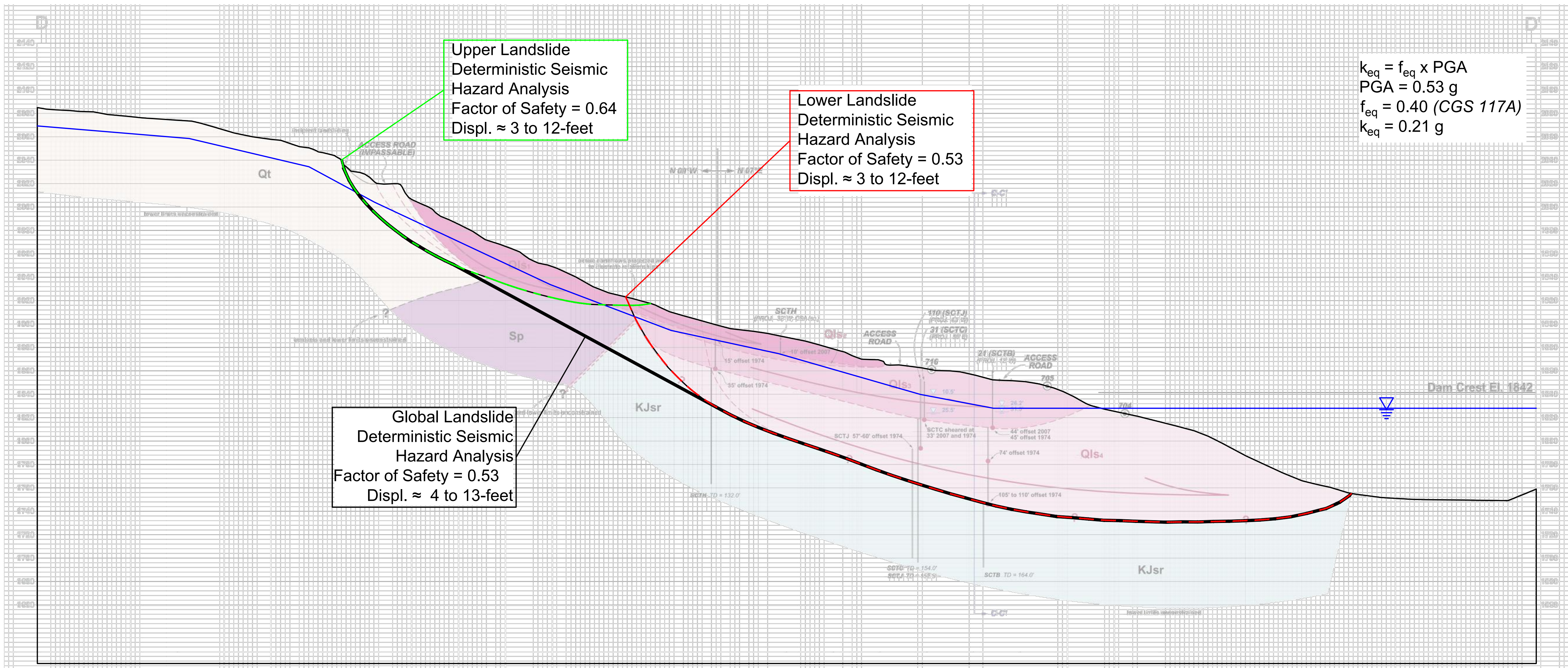
SEISMIC SLOPE STABILITY ANALYSES (10% in 50-yrs)

Scott Dam Evaluation
Lake County, California

Project No. 1323.100 Date: 7/17/18

Designed BSP
Drawn BSP
Checked

2
FIGURE



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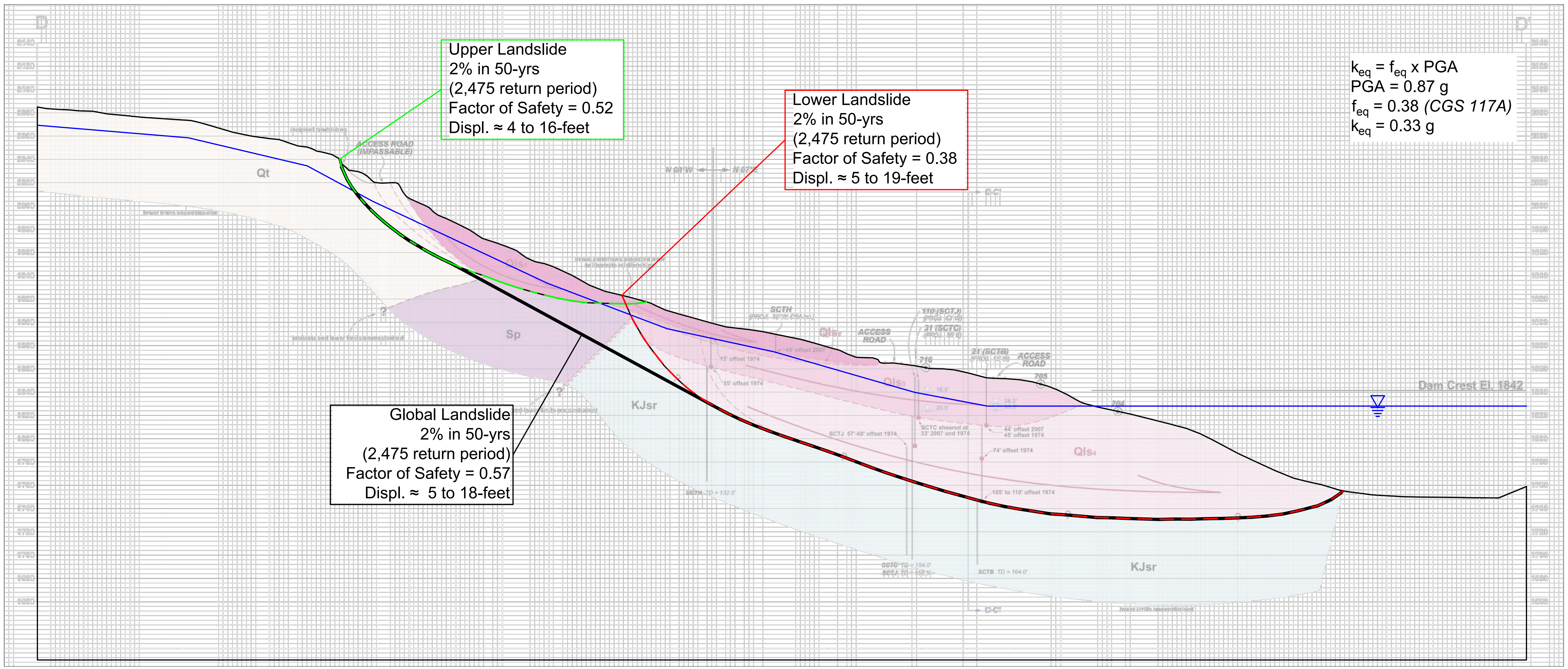
SEISMIC SLOPE STABILITY ANALYSES (DSHA)

Scott Dam Evaluation
Lake County, California

Project No. 1323.100 Date: 7/17/18

Designed BSP
Drawn BSP
Checked

3
FIGURE



SCALE

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SEISMIC SLOPE STABILITY ANALYSES (2% in 50-yrs)

Scott Dam Evaluation
Lake County, California

Project No. 1323.100 Date: 7/17/18

Designed BSP
Drawn BSP
Checked

4
FIGURE