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To: MR. TOM OSTROM, CHIEF
OFFICE OF EARTHQUAKE ENGINEERING

Date: April 2, 2013

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Frazier Mountain UC
Bridge No. 53-1776L/R

From: DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING SERVICES
Materials Engineering and Testing Services and Geotechnical Services
Office of Geotechnical Support – Geotechnical Instrumentation

Subject: Evaluation of Fault Rupture Potential, Frazier Mountain Undercrossing (UC), Los Angeles County

SUMMARY

Frazier Mountain Undercrossing (UC), Bridge No. 53-1776L/R, is located about 750 feet south of the nearest potentially active fault which is the southern trace of the Garlock fault (western strand). Since the fault was not be definitively located in the field during this evaluation, an estimate of fault rupture was made based on an unknown fault weighted 5% trending beneath the UC and a design value of either 4 inches (probabilistic) or 8 inches (deterministic) was determined for the UC. Please let us know if this displacement can be handled through existing design. Given the distance between the UC and the fault as well as the short distance between the UC and the San Andreas Fault (about 3,000 feet), ground displacement due to shaking must also be considered.

INTRODUCTION

This evaluation was prepared as part of the statewide evaluation of fault rupture potential at Caltrans bridges. Caltrans' policies regarding fault rupture at bridges are described in Memo to Designers (MTD) 20-10. Caltrans requires a fault rupture evaluation if a bridge is located within an Alquist Priolo Earthquake Fault Zone (EFZ) or within 1,000 feet of an un-zoned fault 15,000 years or younger in age. Frazier Mountain Undercrossing (UC) is situated within the EFZ established in 1974 for the Garlock fault in the Frazier Mountain 7-1/2' Quadrangle; therefore a fault evaluation was required.

An initial estimate of potential offset was based on an analysis developed by Division of Research and Innovation in collaboration with Geotechnical Services, using methods presented in Abrahamson (2008), Moss and Ross (2011), and Petersen,et al (2011). Both a deterministic fault

displacement analysis (DFDHA) and a probabilistic fault displacement analysis (PFDHA) were performed using magnitude, slip rate (for PFDHA), mapping and base map errors, and likelihood of secondary fault traces. If the main trace of the Garlock fault is the southern branch shown on the 1974 EFZ map, the expected displacement at the UC would be about 1.6 feet deterministically or slightly less probabilistically. Mark Yashinsky and Fadel Alameddine reviewed the bridge plans and determined the UC could not withstand the 1.6 feet displacements without modification. Therefore additional work, documented herein, was performed to better define the fault location.

Frazier Mountain UC was built in 1966 and consists of left and right three span bridges each 99 feet long and 68 feet wide, supported on driven concrete piles.

FAULT RUPTURE EVALUATION

The evaluation consisted of:

- Aerial photo review
- Review of existing data
- Field reconnaissance visit

AERIAL PHOTO REVIEW

Caltrans aerial photos from 1955, 1957, and 1992 were reviewed for evidence of faulting. Lineaments that could possibly be fault traces were identified north of Cuddy Creek on the 1955 and 1957 photos over 1000 feet north of the UC. East of the UC, lineaments were observed on the 1992 photos appear to be drainages (and described as such in an aerial photo review by an outside consultant (Smith-Gutcher and Associates, Inc., 1992). No evidence of faulting near the UC was apparent.

There is no Lidar coverage of the site available at this time.

REVIEW OF EXISTING DATA

The Garlock fault extends for approximately 155 miles from its junction with the San Andreas Fault near the UC northeasterly to the Death Valley fault zone. The principal sense of fault motion is left-lateral strike-slip and the fault in most locations is vertical to near-vertical. The Garlock fault forms the boundary between the Tehachapi Mountains, Sierra Nevada, and Basin and Range province on the north and the Mojave Desert province to the south (Bryant, 2000). The fault is considered active based on apparent Holocene movement, low level seismic activity, and aseismic creep. Despite its apparent activity, confirmed historical fault offset has been associated with seismic creep only (Pampeyan et al, 1988).

The UC is located nearest the western strand of the Garlock fault. According to the 1974 AP EFZ Map, the western strand splits into a north and south branch, with the south branch located closest to the UC. M.M.Clark (1973) did not show a southern branch on his large scale map of the Garlock fault, although the southern trace was considered by Crowell (2003) to be the main trace. The south branch is shown as concealed on the 1974 EFZ Map, and the location is based on Crowell (1964) mapping at a scale of 1:62,500 with no topography. The fault is probably mis-located on the EFZ Map, based on work done for the Kern Seismic Hazard Atlas (KHSA), Frazier Mountain Quad (1990) which shows the fault trace about 400 feet north of the EFZ mapped location.

The south branch of the fault is discussed in Appendix A of the KSHA as follows:

> "Fault displacement of gravel in the south bank of Cuddy Creek is observed about 1500 feet eastward from the Lebec Road Bridge. Clearly in this case, there has been offset of sand and gravel strata. This indicates that the south trace of the Garlock Fault controls the alignment and character of Cuddy Creek. Displacement may have occurred as recently as Historic time, based on age relationships observed at Fault Segment 34 [west of the UC] where part of a metal wagon wheel and charred wood are found embedded in stratified stream-bank gravel." (page 22)

Three AP EFZ studies completed prior to construction of new buildings in the area were reviewed. In 1989, two trenches were excavated for the property north and east of the UC and are shown in Figure 2 in yellow (Park, 1987; 1989). Both trenches were south of the trace identified in the KSHA. The northernmost trench backfill is currently exposed in the south bank of Cuddy Creek, indicating that significant southward erosion of the creek bed has occurred. Neither trenches revealed evidence of faulting. The two trenches were used to demonstrate lack of faulting in the two other AP studies as well (Buena Engineers, 1991; Smith-Gutcher and Associates, Inc., 1992).

The southern strand, located about 750 feet north of the UC per the KSHA, was treated as the main strand in this evaluation. The expected maximum magnitude earthquake for the Garlock fault is **M**7.7 (USGS, 2008) and slip rate is 7.6 mm/yr (Dawson and Weldon, 2012).

Field Reconnaissance

A field reconnaissance of the UC site vicinity was conducted on 1/10/2013 by Douglas Cook, CEG from the office of Geotechnical Design South - Branch 2, and Martha Merriam. A later field visit was made by the same team of geologists to walk the course of Cuddy Creek north of the UC and investigate the Kern County Seismic Atlas's (1990) description of the fault as observed in Cuddy Creek. We were unable to identify faulting in the creek bed or walls, however the creek in the suspect area has eroded approximately a foot per year southward in recent times. It is likely that the reported fault evidence has been removed through erosion, and the south branch is located

in and controls the Cuddy Creek flow. Elsewhere, road construction, vegetation, and natural erosion have concealed or removed any evidence of surface faulting in this area.

POTENTIAL FOR FAULT RUPTURE

As noted above, the south branch of the western trace of the Garlock fault is mapped 750 feet northwest of the UC. Since no trenches were completed at the UC or across strands that might trend beneath the UC, a secondary unknown trace weighted 5% was assumed to cross beneath the UC and an evaluation of fault displacement performed per Petersen et al (Figure 3). Based on that evaluation, potential fault rupture at the UC is estimated at either 4 inches probabilistically or 8 inches deterministically.

RECOMMENDATIONS FOR ADDITIONAL INVESTIGATIONS

No additional work is recommended at this time.

If you have any questions, please contact Martha Merriam at (916) 227-7135.

Prepared by: Date: April 2, 2013

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REFERENCES

Abrahamson, N., 2008, Appendix C, Probabilistic Fault Rupture Hazard Analysis, San Francisco PUC, General Seismic Requirements for the Design on New Facilities and Upgrade of Existing Facilities.

Bedrossian, T., 2012, Geologic Compilation of Quaternary Surficial Deposits in Southern California: CGS Special Report 217 (revised), 25 pp plus plates: http://www.conservation.ca.gov/cgs/fwgp/Pages/sr217.aspx

Buena Engineers, 1991, Jack in the Box Restaurant, Frazier Park Area, August 1, 1991 Review of geologic hazards addendum July 29, 1991, Response to a review of geologic hazards report dated July 22, 1991, CGS FIR 2560.

Bryant, W.A., compiler, 2000, Fault number 69a, Garlock fault zone, Western Garlock section, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, http://earthquakes.usgs.gov/hazards/qfaults, accessed 03/29/2013 04:34 PM, http://geohazards.usgs.gov/cfusion/qfault/qf_web_disp.cfm?qfault_or=1524&ims_cf_cd=cf&disp_cd=C

CGS, 2002, *Guidelines for evaluating hazard of surface fault rupture*, CGS Note 49, 4p: http://www.conservation.ca.gov/cgs/information/publications/cgs_notes/note_49/Documents/note_49.pdf

CGS, 1974, Special Studies Zone, Frazier Mountain Quad, http://gmw.consrv.ca.gov/shmp/download/ap/pdf/FRAZIER_MTN.PDF

Caltrans, 1955, Aerial photos, ASC 97, Film Can 54-36c28, Roll 28, Exposures 69-70, scale 1”=1320’, flown 1955.

Caltrans, 1957, Aerial photos, ASC 262 Loc 1, Film Can 57-124c, Roll 1, Exposures 4-11, scale 1”=250’, flown 9/19/1957.

Caltrans, 1992, Aerial photos, ASC 9212-22, Film Can 92-12c6, Roll 6, Exposures 41-48, scale 1”=300’, flown 4/9/1992.

Caltrans, 1992, Aerial photos, ASC 9212-23, Film Can 92-12c6, Roll 6, Exposures 709, scale 1”= 1000’, flown 2/25/1992.

Caltrans, 2012 (draft), MTD 20-10, *Fault Rupture:* http://onramp.dot.ca.gov/hq/esc/sd/bridge_design/gec/documents/MTD20-10%209%2024%2012.pdf

Clark, M.M., 1973, Map showing recently active breaks along the Garlock and associated faults,

California: U.S. Geological Survey Miscellaneous Geologic Investigations I-741, 3 sheets, scale 1:24,000.

Crowell, J., ed., 2003, Evolution of Ridge Basin, southern California: GSA Special Paper 367, 247 pp and 4 plates.

Crowell, J., 1964, The San Andreas fault zone from the Temblor Mountains to Antelope Valley, southern California in Pacific Section AAPG/SEPM and San Joaquin Geological Society Guidebook, pl. 1, 1:62,500 (in CGS FER 11: ftp://ftp.consrv.ca.gov/pub/dmg/pubs/fer/11/Maps/FIG2.pdf
.

Dawson, T., and Weldon, R., 2012, UCERF3, Appendix B: Geologic slip-rate data and geologic deformation model (July 9, 2012 draft), http://wgcep.org/sites/wgcep.org/files/AppendixB_GeologicDeformationModel_20120709.pdf

Kern Seismic Hazard Atlas (KSHA), 1990, Appendix A, Field evidence for faulting, Fault Segment 35, pp 22-23, and July 1990 Frazier Mountain map, scale 1:24,000.

Pampeyan, E., Holzer, T., and Clark, M., 1988, Modern ground failure in the Garlock fault zone, Fremont Valley, California: GSA Bull. 100, no.5, pp 677-691.

Park, W.H., 1989, Geological hazards investigation APN 255-310-30 and APN 255-310-42, 43, and 48, Section 34, T9N R19W, SBB&M, Kern County, CA, May, 1989, CGS FIR 2684.

Park, W.H., 1987, Geologic hazards investigation, Harold Johnson property, Sec.34, T9N, R19W, Kern County, CA, August 1989 and September 13, 1989 addendum, CGS FIR 2472.

Petersen, M., and others, 2011, Fault displacement hazard for strike-slip faults: Bull Seismol. Soc. Amer., Vol. 101, No. 2, pp. 805–825.

Smith-Gutcher and Associates, Inc., 1992, Addendum, Park, W.H., 1989, Geological hazards investigation APN 255-310-30 and APN 255-310-42, 43, and 48, December 3, 1992.

US Geological Survey, 2010, http://earthquake.usgs.gov/hazards/qfaults/google.php

US Geological Survey, 2008, National Seismic Hazard Maps – Fault Parameters, http://geohazards.usgs.gov/cfusion/hazfaults_search/hf_search_main.cfm

Wells, D., and Coppersmith, K., 1994, New empirical relationships among magnitude, rupture length, rupture width, rupture area, and surface displacement: Bulletin of the Seismological Society of America, Vol. 84, No. 4, pp. 974-1002.

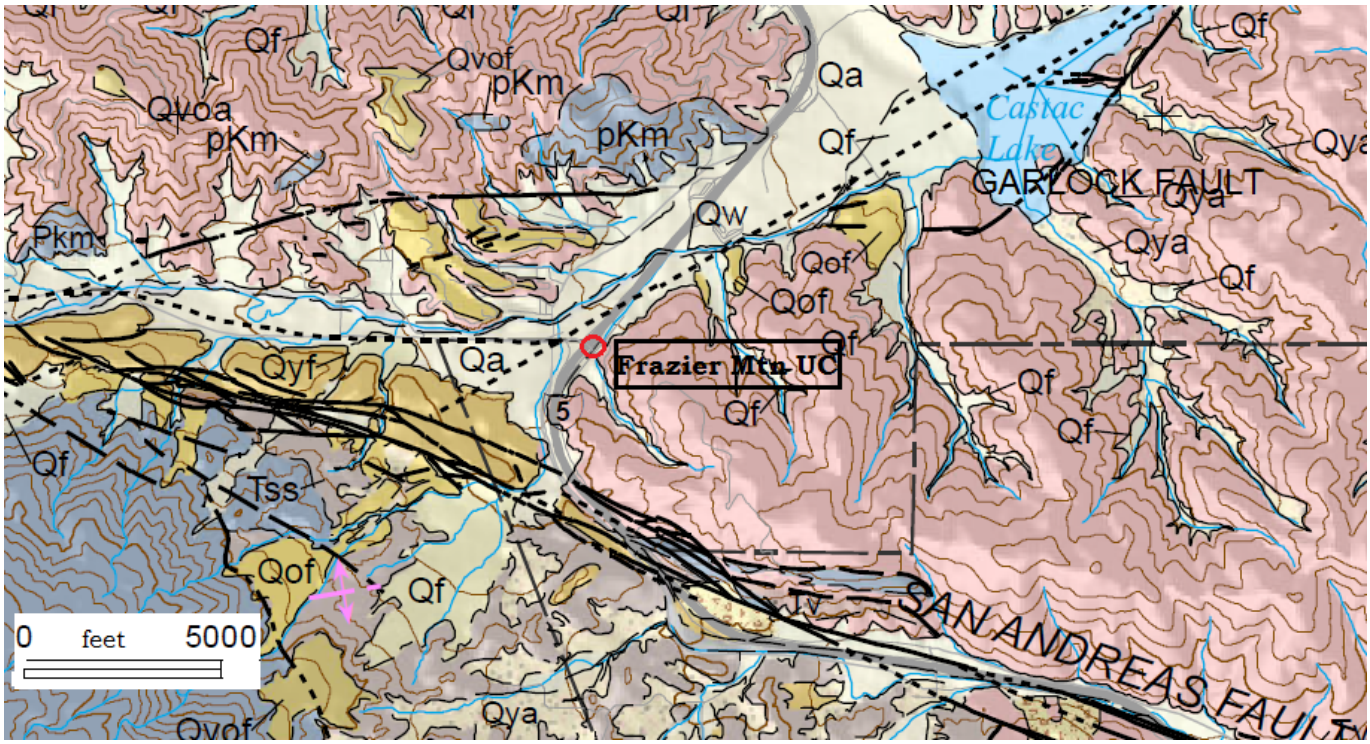

Figure 1. Area map showing south branch of the western trace of the Garlock fault near undercrossing (Bedrossian et al, 2012). Fault mapping is based on 1974 AP EFZ Frazier Mountain Quad and is approximate (dashed). Note nearby San Andreas Fault located about 3,000 feet south of the UC.

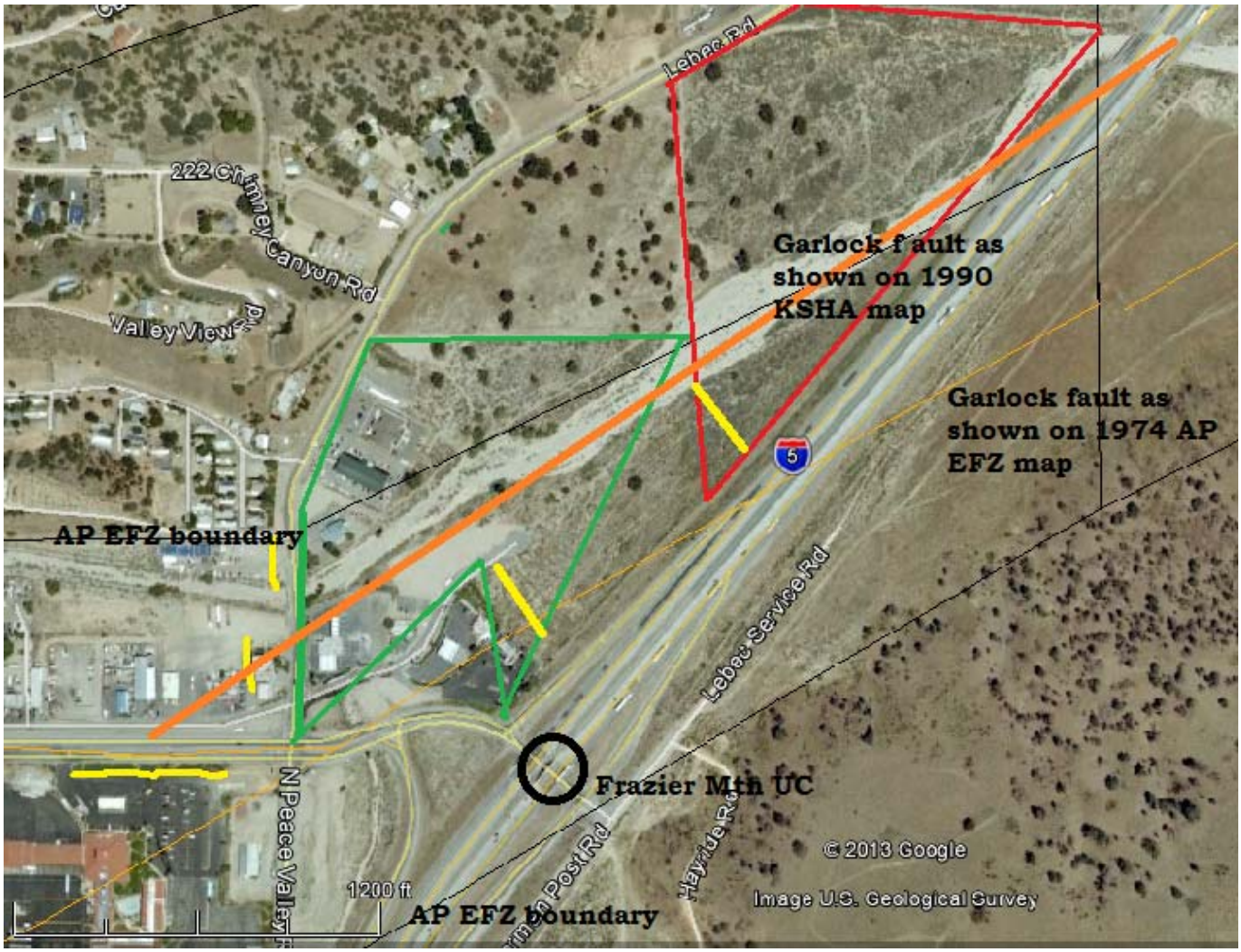

Figure 2. Google earth image showing features discussed in text. Yellow lines denote trenches excavated as part of AP EFZ studies, green and red polygons denote property lines of private owner's land where AP EFZ studies were carried out and reviewed in this study. Thin orange line denotes EFZ fault trace not found in trenches, EFZs are lines parallel to the AP EFZ fault trace and on either side. Thick orange line denotes Kern Seismic Hazard Atlas (KSHA) (1990) fault trace along Cuddy Creek.

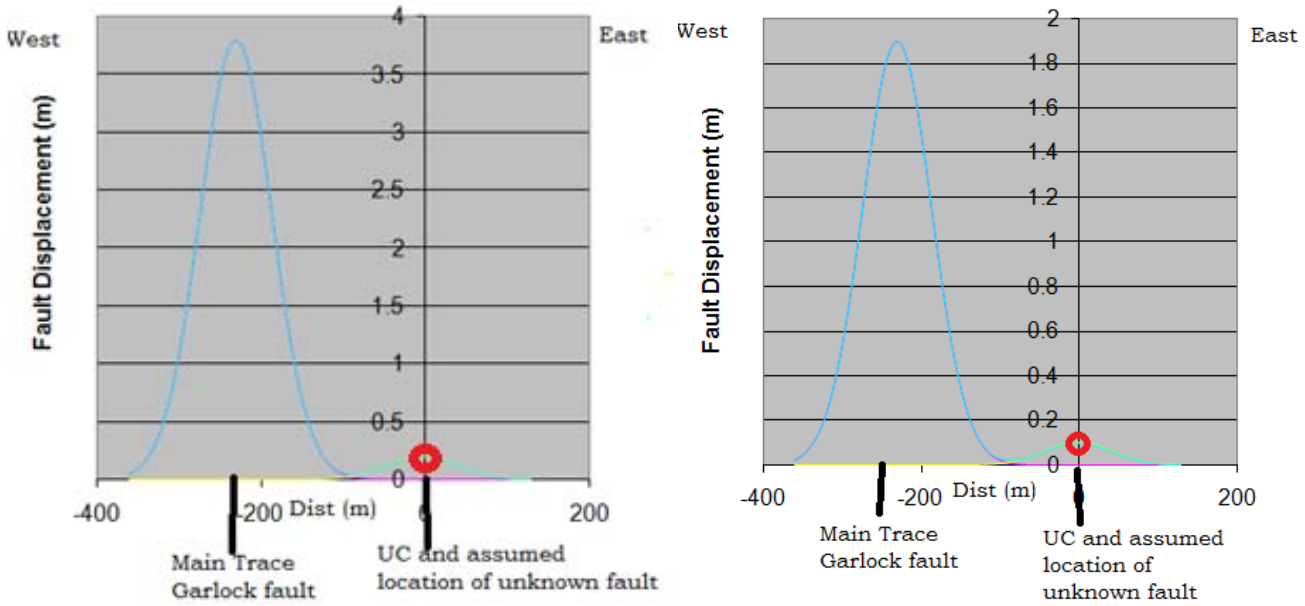

Figure 3. Estimated displacement at Frazier Mountain UC (assumed 95% on main trace; 5% on unknown fault). Left – deterministic value = 8 inches. Right – probabilistic value = 4 inches.