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To: MR. TOM OSTROM
OFFICE OF EARTHQUAKE ENGINEERING
CHIEF

Date: April 16, 2013

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Alder Creek Bridge
Bridge No. 10-0116

Attention: Mr. Mark Yashinsky

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 (revisions in red), Alder Creek Bridge, Br. NO. 10-0116, Mendocino County, California

SUMMARY

Alder Creek Bridge, Br. No.10-0116, is crossed by the historically-active main trace of the San Andreas Fault (North Coast section) and should be designed for 18 feet of right lateral displacement on the N30-35W-trending fault. One foot of vertical displacement (either southwest or northeast side down on the vertical plane) should also be addressed. This displacement needs to be addressed everywhere south of Bent 2. No additional work is recommended at this time.

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. Alder Creek Bridge is situated within the EFZ established in 1974 for the Point Arena 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 Petersen et al (2011) and Abrahamson (2008). Both a deterministic fault displacement hazard analysis (DFDHA) and a probabilistic fault displacement hazard analysis (PFDHA) were performed using magnitude, slip rate (for PFDHA), previous displacement measurements, mapping and base map errors, and likelihood of secondary fault traces. If the main trace of the San Andreas Fault (North Coast section) crossed beneath the bridge, the expected displacement at the bridge would be about

24-1/2 feet deterministically or 18-1/2 feet probabilistically. Since the fault is well-studied at this latitude, we used the probabilistic value. Mark Yashinsky and Fadel Alameddine reviewed the bridge plans and determined the bridge could not withstand the estimated 18-1/2 feet displacement without modification. Therefore additional work, documented herein, was performed to better define the fault location and displacement.

Alder Creek Bridge was built in 1947 and is a two span bridge 124 feet long 33 feet wide supported on spread footings. According to the 12/15/1997 General Plan for Earthquake Retrofit Project No. 338, Alder Creek Bridge was earthquake-retrofitted through the addition of abutment lumber blocking with steel plates, shear keys/catcher blocks, and angle brackets (Caltrans, 1997).

FAULT RUPTURE EVALUATION

The evaluation consisted of:

- Review of existing data
- Review of aerial photography/Lidar interpretation
- Field reconnaissance

The evaluation reached the following conclusions:

- The mapped fault nearest to Alder Creek Bridge is the main trace of the San Andreas Fault (North Coast segment)
- It is likely that the main fault trace crosses beneath the bridge

REVIEW OF EXISTING DATA

The San Andreas Fault (North Coast section) is historically active with the most recent rupture occurring in 1906. A predecessor to the present-day bridge located about a half mile west of the present-day Alder Creek Bridge was destroyed by fault rupture in that earthquake. The estimated maximum magnitude earthquake expected for this section of the San Andreas Fault is **M**8. Figure 1 shows the AP map traces (CGS, 1974). Several lines of evidence reviewed suggest the fault trends beneath Alder Creek Bridge.

1. Figure 2 shows the location of work done for a master's thesis consisting of mapping, trenching, and (later) ground-penetrating radar (GPR) at a site directly southwest of the bridge (Baldwin, 1996; Baldwin et al, 2000). John Baldwin mapped several traces of the fault, including a main trace identified in trenches. The main trace of the fault was further studied in a GPR survey that confirmed the earlier location. The main trace is 1-3 m wide. If this trace is projected NW 100 feet to Alder Creek Bridge at the range of angles noted in the nearest trench

(30-34 degrees northwest), the fault crosses beneath the southern portion of the bridge (Figure 3).

2. If the main trace is extended northwest 1/3 mile towards the next locale where the fault has been identified near the mouth of Alder Creek, the main trace crosses the southern portion of the bridge (Figure 4).

3. A 1995 Preliminary Seismic, Geologic, and Foundation Information Memorandum for the proposed bridge retrofit noted that based on the 1945 General Plan the bridge is underlain by silt, clay, sand, gravel, and sheared shale bedrock (Caltrans memo to E.Wahl, 2/3/1995). Depth to bedrock was assumed to be between 10 and 80 feet. Sheared bedrock is characteristic of faulting, although the observation does not necessarily mean the main trace is under the bridge.

Review of aerial photos/Lidar data

Man-made features such as the bridge and highway obscure fault traces at the bridge. Aerial photos taken in 1956 and 1999 (Figure 3) were reviewed. No photos taken prior to bridge construction were available. The San Andreas Fault in this area consists of several linear strands seen clearly several hundred feet south of the bridge on the air photos. The Alder Creek drainage where the fault trends northwest of the bridge to the ocean contains fluvial deposits too recent to allow for observation of the fault. Lidar imaging (Figure 5) clearly reveals the main trace of the San Andreas Fault southeast of the bridge but not at or northwest of the bridge. The main trace is visible near the location of the bridge destroyed in 1906 near the mouth of Alder Creek.

Field Reconnaissance

A field reconnaissance of the bridge site was conducted on 11/15/2012 by K.Douglas Cook, C.E.G., Office of Geotechnical Design South II, and Martha Merriam (photos 1-6). Goals of the visit were to identify the fault with respect to the bridge and to determine where trenching or geophysical profiling might be performed. We noted that vegetation is too dense immediately northwest of the bridge. Were we able to trench northwest beyond the vegetation the distance would be too great to allow for any more accurate of a projection of the fault trend back to the bridge than we already have.

Note: After our field reconnaissance, I discussed with John Baldwin (cited above for his thesis work at the bridge) the possibility of using his techniques including trenching and a GPR survey on the western side of the bridge. Shallow bedrock southeast of the bridge made it possible for him and others to excavate trenches which revealed the fault. Also shallow bedrock and granular material resulted in effective GPR work for displaying the fault southeast of the bridge.

John indicated that dense foliation in this area (denser than when he did his excavations in 1996) would result in the need to go some distance west of the bridge in order to find open areas. The foliation also would result in problems using the GPR. The existence of probable deep alluvium to the west (based on John's comments and Prentice, 1989) would make difficult the use of either technique close enough to the bridge to pin down the fault location better than has already been done.

POTENTIAL FOR FAULT RUPTURE

Based on the above review, additional work would not likely lessen or eliminate the hazard of surface rupture potential from this bridge. Therefore we needed to estimate the expected displacement at this bridge. Since we had nearby measurements of amount of slip occurring during the 1906 event which we take to be the size of the maximum magnitude event, a probabilistic approach was justified to determine expected displacement. Parameters used were, **M**Max=8, a slip rate = 24 mm/yr, and an aseismic slip factor = 0 based on observations by Galehouse and Lienkaemper (2003) cited in Cashman et al, 2007. The displacement was divided between a main trace weighted 80% and a secondary trace weighted 20%. Two nearby measurements of lateral offset during the 1906 earthquake were also used

- 16-1/2 feet (Jordan, 1906, measured at old Alder Creek Bridge 1/3 mile northwest of Alder Creek)
- 16 feet (Baldwin et al, 2000, measured ¾ mile south of Alder Creek)

Based on these parameters and using methods described in Petersen et al (2011) and Abrahamson (2008), 18 feet of lateral offset may occur at this bridge (Figure 6) on the main fault trending NW30 to 35 degrees everywhere south of Bent 2. Because of local variations in the ground surface, one foot of vertical displacement (either southwest or northeast side down on the vertical plane) should also be addressed

RECOMMENDATIONS FOR ADDITIONAL INVESTIGATIONS

No additional work is recommended at this time. The fault projects under or nearly under the bridge; confirmation of the fault trace crossing beneath the south end of the bridge is the likely outcome of a field investigation.

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

Prepared by: Date: February 6, 2013

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Figure 1. Alder Creek Bridge. Red lines represent historically active traces of the San Andreas Fault, others are older traces. Two red lines near the bridge represent the main trace to the east and a secondary older trace to the west (Baldwin, 1996).

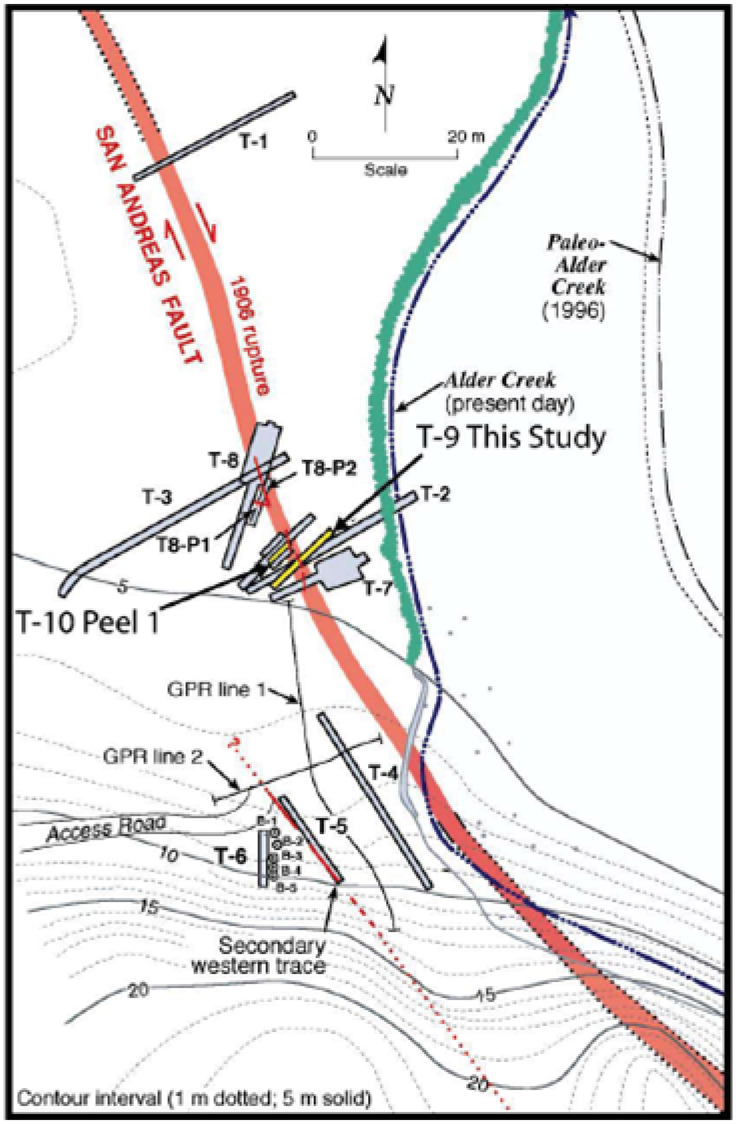

Figure 2. Excavations and geophysical lines performed southeast of Alder Creek Bridge. Trenches 1-8 and 10 from Baldwin (1996) and Baldwin et al, 2002); Trench 9 and Trench 10 peel of Baldwin's trench from Crawford (2007). Bridge location is approximately 100 feet north of T-1 on trend with the San Andreas Fault.

Figure 3. 1999 air photo showing location of 1996 Trench 1 and projection of the San Andreas Fault from Trench 1 towards the bridge. North is at top of image.

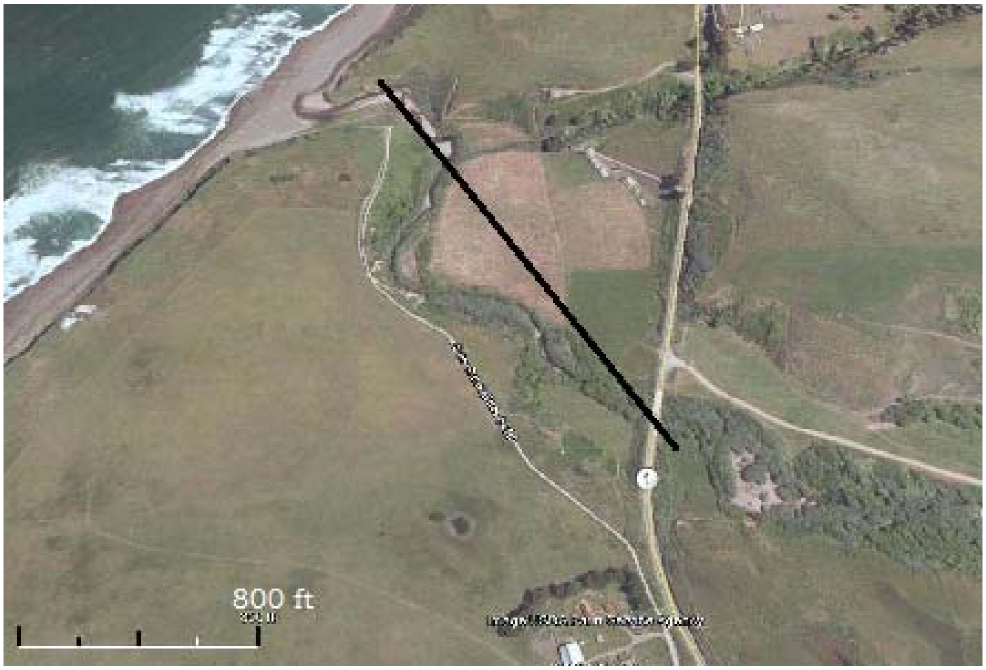

Figure 4. Black line connects known locations of the historically-active San Andreas Fault north and south of Alder Creek Bridge, and trends beneath southern end of Alder Creek Bridge.

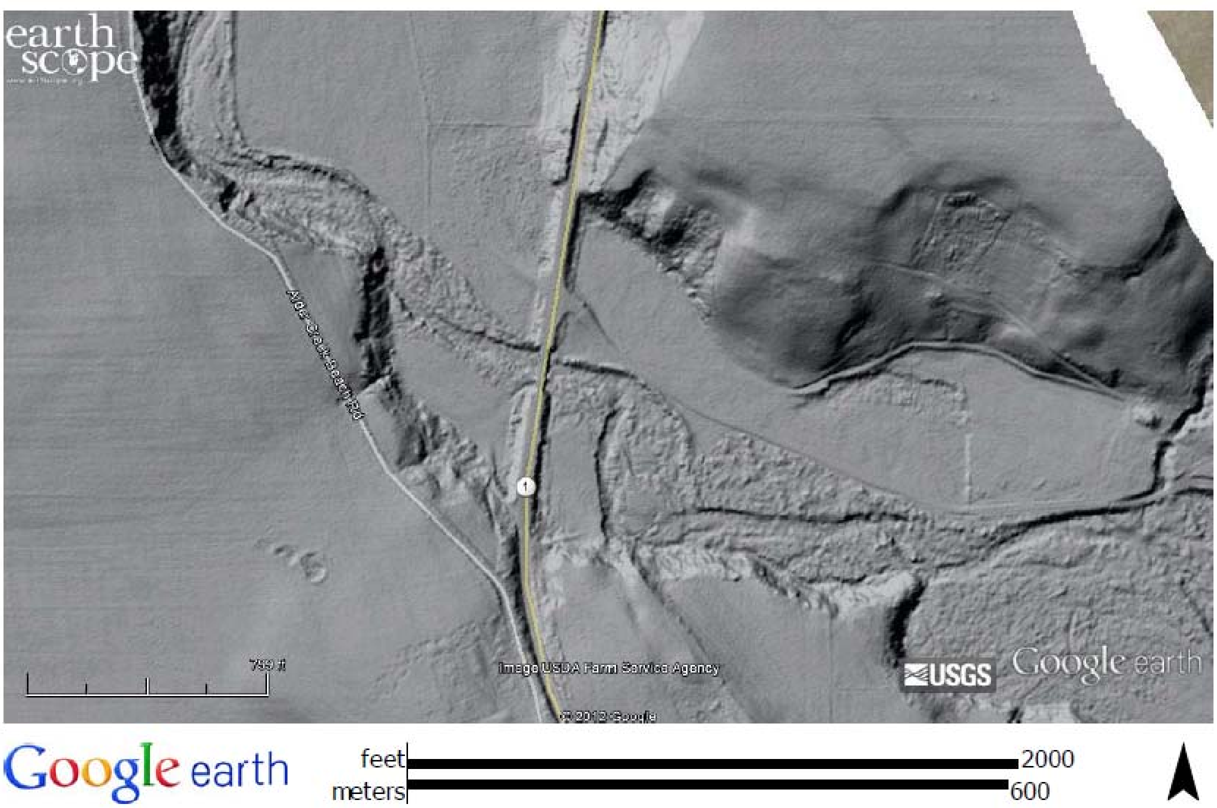

Figure 5. Lidar imagery, showing ridge south of the bridge. Fluvial deposits from the creek obscure the natural ground features in addition to man's activity such as construction of Hwy 1.

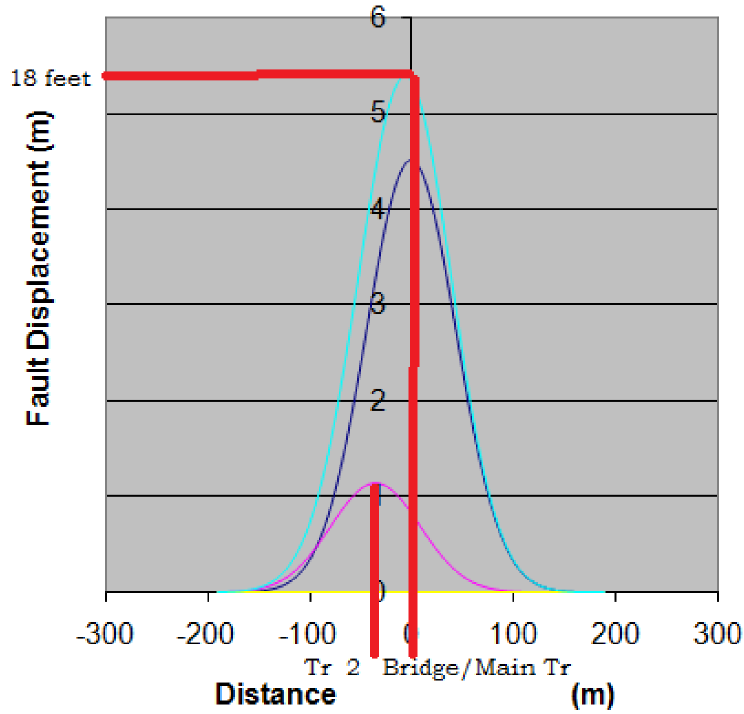

Figure 6. Light aqua line shows probabilistic design lateral offset – 18 feet at Alder Creek bridge. Parameters used were **M**Max =8, slip rate=24 mm/yr, asf= 0. Main trace is weighted 80%; secondary trace is 20%; traces are approximately located. No vertical offset is expected.

Photo 1. Looking northerly along Highway 1 across Alder Creek Bridge. Note vegetation.

Photo 2. Looking northerly at Alder Creek Bridge.

Photo 3. Looking southerly along Alder Creek Bridge.

Photo 4. Looking southeast from Alder Creek Bridge at location of 1996/2004 trenching investigation.

Photo 5. Looking southeast at Alder Creek Bridge from mouth of creek 1/3 mile northwest of bridge.

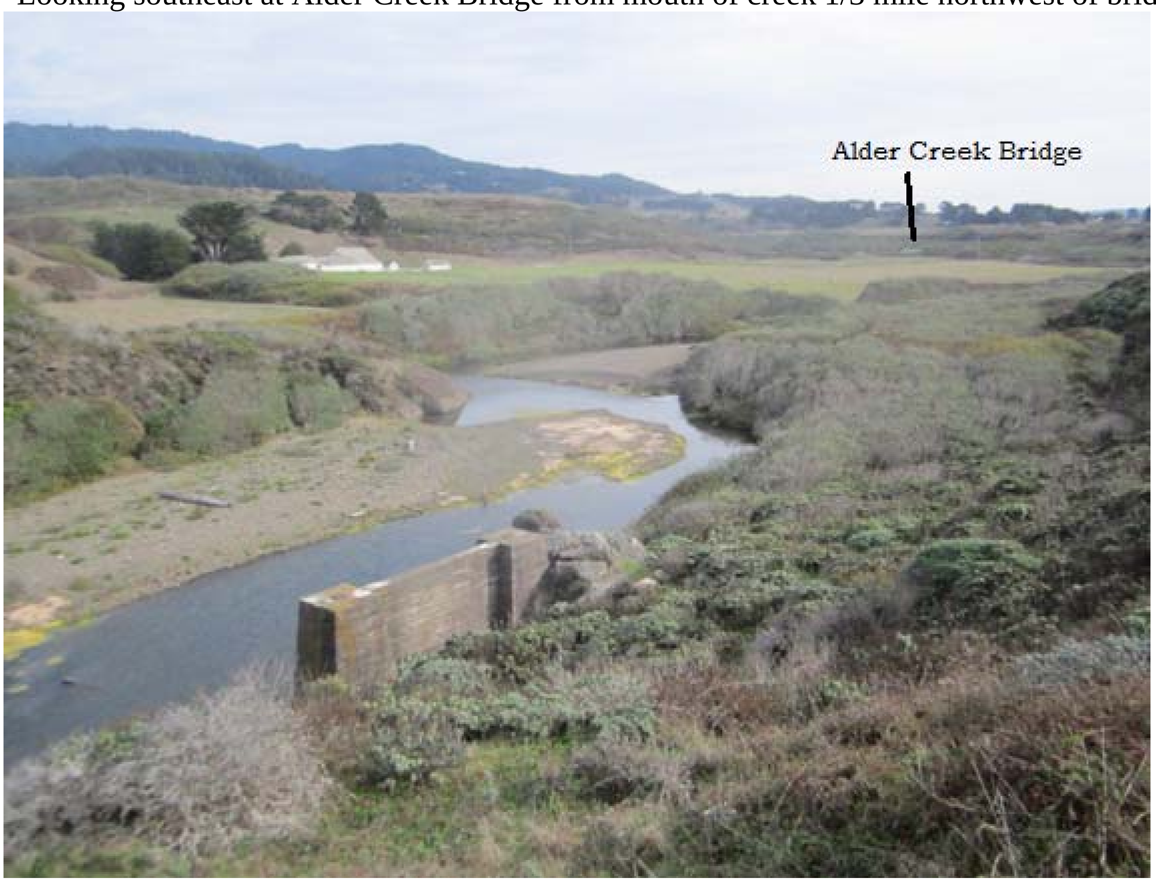

Photo 6. Same view as Photo 5 but from slightly further east; showing remains of old Alder Creek Bridge destroyed by fault rupture in 1906 earthquake.