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Engineering – Hydrology – Stream Restoration – Water Resources

TECHNICAL MEMORANDUM

Date: 06 November 2015

To: Caroline Christman
Project Manager

Golden Gate National Parks Conservancy
Building 201 Fort Mason, 3rd Floor
San Francisco, CA 94123

From: Corin Pilkington, Bonnie Pryor and Jeffrey K. Anderson, P.E. (C50713)

Re: Santos Meadows Bridge (Bridge 9) Hydraulic Assessment

Introduction

The purpose of this work is to provide an estimate of the 100-year peak water surface elevation of Redwood Creek at Bridge 9 (Santos Meadows Bridge) in the Redwood Creek Trails Project and provide a brief discussion of the potential for channel migration in the project area.

The site is located within Mount Tamalpais State Park in Marin County, California, approximately 15 miles north of San Francisco (Figure 1). The proposed bridge is intended to replace a wet water crossing. The proposed bridge is at the 30% design stage (design by others).

A one-dimensional hydraulic model was used to estimate the existing 100-year water surface elevation at the proposed bridge location. Northern Hydrology and Engineering (NHE) was also tasked to model design conditions at the proposed bridge location to determine the effect the bridge would have on water surface elevation. During the bridge design process, a bridge design was selected that spanned the channel, placing the abutments outside the 100-year peak flow inundation extent and the bridge chord was set higher than the 100-year peak water surface elevation (Roth/LaMotte, 2014). With this clear span design, the 100-year peak water surface elevation will not be effected by the bridge and thus the design and existing water surface elevations are the same.

Model Development

The 100-year peak water surface elevation was estimated using the U.S. Army Corp of Engineers (COE) River Modeling System, HEC-RAS V4.1 (COE, 2010). HEC-RAS calculates one-dimensional water surface profiles and average channel velocities for both steady gradually varied flow, and unsteady flow through a network of channels. For this analysis, steady-state modeling was used to predict water surface elevation. For steady state modeling, inputs include channel geometry and roughness, upstream and downstream boundary conditions, and discharge.

Channel Geometry

The proposed bridge site was assessed in the field by Northern Hydrology and Engineering (NHE) staff. NHE identified that Frank Valley Bridge on Muir Woods Road (County Bridge) was a likely constriction that could affect water surface elevations at high flows at the proposed bridge location. Fourteen cross-sections were identified over a 1,080 channel reach that started

300 feet upstream of the proposed bridge alignment to 250 feet below Frank Valley Bridge (Project Reach).

Oberkamper & Associates surveyed cross-sections, a longitudinal profile, detailed channel and floodplain topography in the vicinity of the proposed bridge alignment, and the Frank Valley Bridge chord elevations and geometry (Figure 1).

To generate the HEC-RAS geometry, geo-referenced geometry files were created from the surveyed cross-sections using HEC-GeoRAS in ArcMap. Frank Valley Bridge geometry was input directly into the HEC-RAS bridge editor. The Frank Valley Bridge deck is skewed to the river course at approximately 45 degrees and has two rows of round piers that parallel the channel and are stationed along the bank toes (Figure 2). Under the bridge the channel banks have been constructed with concrete.

Manning' *n* Roughness

Manning' *n* roughness values and breaks for the Project Reach were calculated using the Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Flood Plains (USGS, 1989). NHE staff delineated areas with similar roughness characteristics (grain size, vegetation types and density) in the Project Reach. A pebble count was conducted utilizing a pebbleometer in the channel near the proposed bridge; the D50 was calculated to be approximately 16 millimeters. With these data, representative Manning' *n* values were assigned to the model cross-sections.

The Manning's n value of the low flow channel was estimated to be 0.035, the banks and lower terraces were estimated to be 0.06 to 0.07, and the floodplains between 0.085 and 0.1. The concrete constructed banks under the bridge were designated with a Manning' *n* value of 0.017 based on the HEC-RAS Hydraulic Reference Guide for normal unfinished concrete (COE, 2010).

Boundary Conditions

Normal depth was assumed for both the upstream and downstream boundary conditions using the existing channel slope of 0.5% and 0.4%, respectively.

Discharge

The 100-year peak discharge input into the model was 2,515 cubic feet per second. This discharge was estimated previous to this study by NHE for the 100-year peak flow at Frank Valley Bridge (NHE, 2015).

Calibration Data

No model calibration data was available at the project site.

Estimated 100-year Peak Flow Water Surface Elevation

Existing Conditions

The 100-year peak flow water surface elevation at the proposed bridge location is estimated to be 47.6 feet NAVD 88. Figure 3 shows the HEC-RAS model 100-year peak flow water surface profile for the Project Reach. The model results show that the water surface elevation at the proposed bridge location appears to be influenced by a backwater effect caused a flow constriction at Frank Valley Bridge.

Design

The location of the proposed bridge crossing (30% design) is located approximately 550 feet upstream of the Frank Valley Bridge (Figure 1). At this location, the trail leaves Muir Wood Road, crosses through the riparian forest (250 feet) to a wet crossing at Redwood Creek. On the far side of the creek, the trail continues up the opposite bank and within a short distance merges onto Redwood Creek Trail. The proposed bridge location is approximately 100 feet upstream of the current trail crossing. The west end of the bridge ties into the existing trail near where the trail departs Muir Woods Road. A new trail will be constructed at the east end of the bridge to connect with the existing Redwood Creek trail (Roth/LaMotte, 2014).

The proposed bridge design has an arched profile with the center of the bridge approximately 2 feet higher in elevation than the bridge ends. Therefore, the freeboard distance from the bottom chord of the bridge ranges from approximately 1 foot at the bridge abutments to 3 feet at the bridge center.

Channel Migration

The geomorphic history of the Redwood Creek watershed is described in Stillwater (2004) and portions relevant to the project site are summarized here.

The proposed trail crossing is located on Redwood Creek, near the border of the Upper and Lower Frank Valley sub-watersheds delineated by Stillwater (2004). Prior to European settlement (1840), the mainstem of Redwood Creek through Frank Valley is assumed to be a poorly defined in this area due to frequent overbank flooding and channel depositional processes during this period. Sediment from the tributaries was generally not delivered directly to the mainstem; rather, sediment was deposited on the valley floor. Water from tributaries spread across the valley floor and infiltrated into the subsurface.

This condition changed following settlement as dramatic shifts in land use and vegetation cover accelerated erosion of tributaries and the mainstem. Vegetation, land use changes and hillslope disturbances increased runoff and engineering measures were implemented to concentrate and confine flow which caused incision of the mainstem through the broad alluvial floodplain (Stillwater, 2004). Stillwater (2004) reports that the mainstem continues to slowly incise through the Upper Frank Valley, but may have stopped incising in the Lower Frank. The proposed bridge location is located near the divide between the Upper and Lower Frank Valley; therefore, the channel incision rate is likely low.

Although the proposed abutments are outside the 100-year peak flow inundation extent, they are still susceptible to erosion as the channel laterally migrates. Lateral erosion of the west channel bank is occurring adjacent to Muir Woods Road, just upstream of the proposed abutment location. This erosion could progress further downstream and intercept the proposed bridge abutment. Bank erosion was also identified on the east bank of the river on the outside of the meander bend and additional erosional features were identified that extended into the east terrace, downstream of the abutment. Recent flood deposits occur over nearly the full width between the bridge abutments. No bedrock was identified in the channel banks that would limit erosion in the vicinity of the proposed bridge location and bedrock was detected at greater than 50 feet in depth in 3 borings conducted near the abutment locations (Miller Pacific Engineering Group, 2014). Since the lateral erosion potential is high, and shallow bedrock does not exist to limit channel incision, abutments should be designed to withstand direct erosion from the channel and should be sufficiently deep to account for stream bed scour as well as continued channel incision.

During large floods, episodic aggradation and/or the formation of large wood jams can occur that will locally raise water levels. The freeboard above the 100-year peak flow water surface elevation reduces the risk of damage to the bridge during high flow events from moderate channel aggradation, localized wood jams, as well as from floating debris.

Bridge Pier Scour

The 30% bridge plans (dated 15 September 2015) show the helical piers encased in an 18 inch diameter concrete encasement that extends to a maximum of 16 feet below the bottom of the bridge abutment. The purpose of the concrete encasement is to provide scour protection of the helical piers (Caroline Christman, personal communication). Based on the 30% bridge plan dimensions, and a 100-yr water surface elevation of 47.6 feet (NAVD88), the proposed 16 foot encasement depth should extend approximately 9.3 feet below the existing channel bed elevation of 38.9 feet at the bridge location.

A detailed bridge scour analysis has not been conducted. Based on the provided thalweg survey (by others), the maximum pool depth in the vicinity of the bridge is 5.5 feet, which exists approximately 150 feet upstream of the bridge location. At the proposed bridge location a 9.3 foot deep pool would need to scour before reaching the bottom of the proposed 16 foot deep concrete encasement. Based on the observed pool depths in the reach, the proposed pier encasement will provide some level of pier scour protection.

It is recommended that the maximum 16 foot concrete encasement depth be targeted for all piers, as this will provide the maximum pier scour protection for what is currently proposed on the 30% bridge plans.

References

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Roth/LaMotte Landscape Architecture (Roth/LaMotte), 2014. Redwood Creek Bridge at Sanotos Meadow 30% Design Development Plan Set. Prepared for Golden Gate National Parks Conservancy, 25 November 2014.

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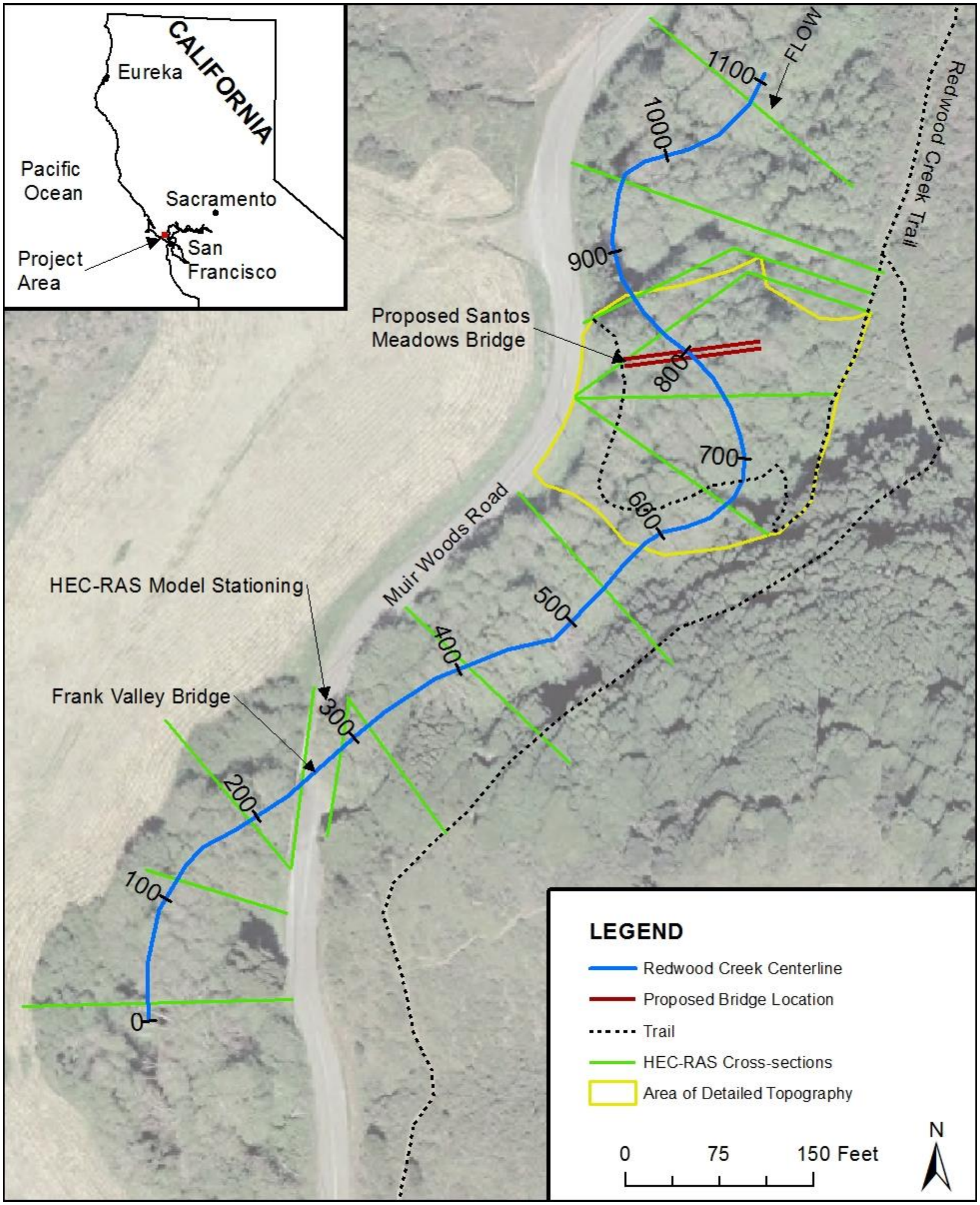

Figure 1. Location map of the proposed Santos Meadows Bridge (Bridge 9).

Figure 2. Looking downstream at Frank Valley Bridge.

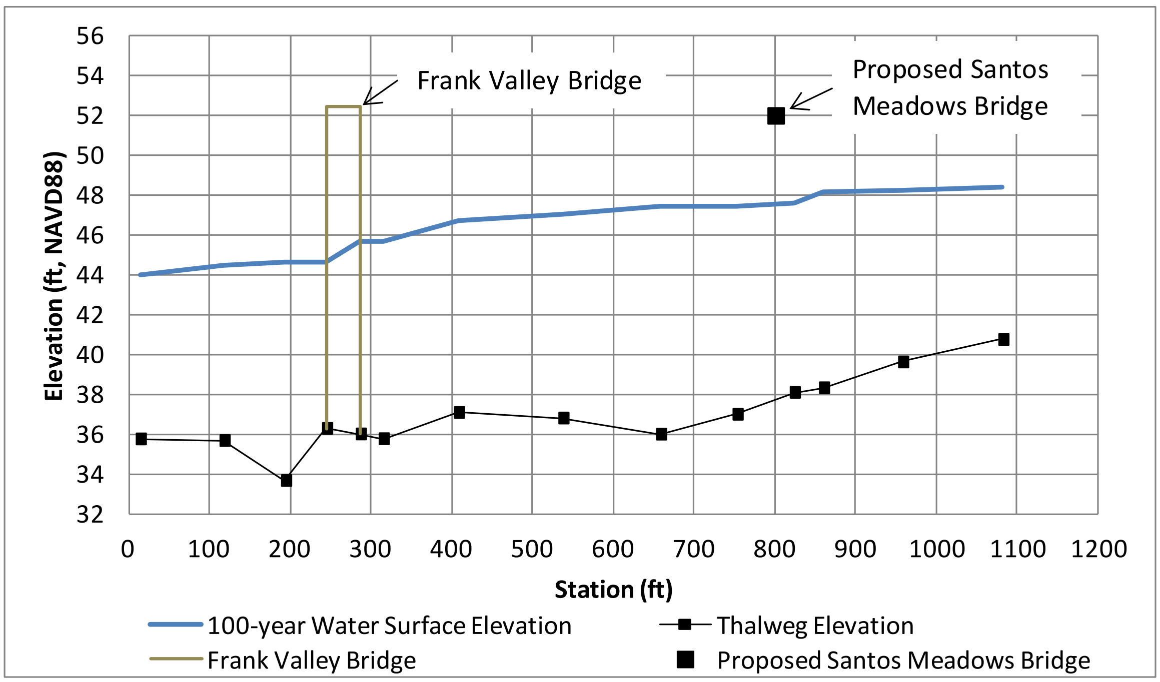

Figure 3. HEC-RAS model estimated 100-year peak flow water surface profile.