EXISTING AND PROPOSED CONDITIONS RELATED TO SCOUR
Mill Creek Wetlands Recreation and Restoration Demonstration Project[1]

Prepared by Geosyntec Consultants
December 19, 2008

1 INTRODUCTION

The Mill Creek Wetlands Recreation and Restoration Demonstration Project (Project) proposes to create recreational and habitat opportunities while treating stormwater runoff from the Cucamonga Creek watershed. The multiple goals of the Project will be met by the creation of a series of hydraulically connected basins that incorporate wetland and riparian areas, recreational trails and educational kiosks, and water treatment components.

The purpose of this memorandum is to discuss potential project-induced impacts to the geomorphic stability of the creek, the floodplain and Project features. The Project proposes to cut into the existing floodplain to create the extended detention/constructed wetland basins and allow for gravity flow from the diversion along Cucamonga Channel through the system. To preserve design storage criteria while maintaining gravity flow and minimizing cut/fill differences, berms will be constructed on the channel side of the Desilting Basin and Ponds 2, 3 and 4. The berm surrounding the Desilting Basin will be constructed starting at the northeast edge of the pond and will extend around the eastern perimeter and tie into existing grades in the southwest corner. The berm surrounding Ponds 2, 3, and 4 will be constructed between the northeast corner of Pond 2 to just west of Pond 3 (see Figure 1). In general, the channel and floodplain hydraulics will be modified by the construction of the Project on the floodplain through encroachment of the floodplain by the constructed berm and localized grading. The floodplain modifications for any given location are unique based on preliminary Project design and existing topography and therefore modifications to the hydraulics throughout the reach of Mill Creek adjacent to the Project will vary as well.

This memorandum has been prepared as an attachment to the Conceptual Hydrologic and Hydraulic Project Design and Function memorandum prepared by Geosyntec Consultants (December 12, 2008). General project setting information is therefore contained in the above

[1] Funding for this project has been provided in full or in part through an agreement with the State Water Resources Control Board. The contents of this document do not necessarily reflect the views and policies of the State Water Resources Control Board, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.” (Gov. Code 7550, 40 CFR 31.20)

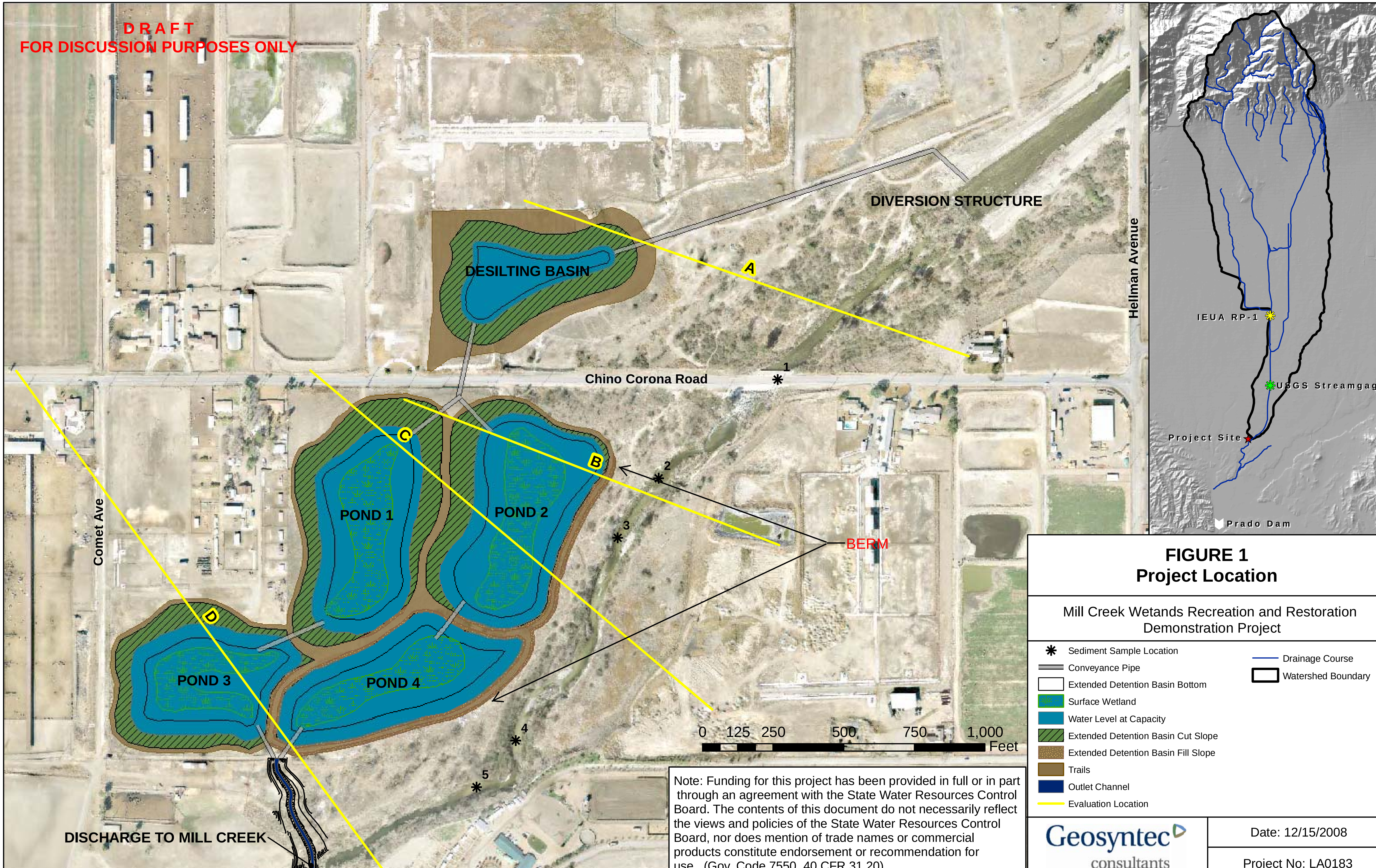

FIGURE 1
Project Location

Mill Creek Wetands Recreation and Restoration Demonstration Project

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Geosyntec consultants

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Project No: LA0183

mentioned memorandum and is not repeated here. Please reference the above document for general information regarding Project location, watershed characteristics and discharge conditions.

2 GENERAL MORPHOLOGIC SETTING

2.1. Existing Influences on Channel Morphology

The Project is adjacent to Cucamonga Channel near its terminus and transition to Mill Creek. The Project site is located on the northwest floodplain (right, looking downstream) of the channel through this transition reach. The floodplain and Project site is bisected by Chino Corona Road, which runs in the east-west direction, and crosses the channel over a series of 10 culverts. Site slopes are generally mild from north to south, with somewhat steeper slopes in the creek corridor. Because the Project site is within the floodplain, it is subject to inundation under flood conditions when flows in the adjacent channel overtop the channel banks. The connection between the channel and floodplain varies along the length of the Project and therefore the Project site is inundated under varying conditions in different places.

In addition to general watershed characteristics, the morphology of Mill Creek in the reach adjacent to the Project also reflects significant alterations to the hydrologic and hydraulic regime resulting from:

- The connection of Mill Creek to Cucamonga Channel (not naturally connected), and
- The construction of the Chino Corona Road crossing.

These modifications to the hydrologic and hydraulic regime of the creek have significantly modified the natural channel morphology and sediment transport processes and have resulted in degraded morphologic conditions downstream of the terminus of Cucamonga Channel.

The connection of Mill Creek to Cucamonga Channel likely occurred after 1928, the latest year for which aerial photographs do not depict the natural connection between the two watercourses. The connection of Mill Creek to Cucamonga Channel increased the tributary area to the creek immensely and likely resulted in significant alterations to the channel size and shape. Additionally, the channelization of Cucamonga Channel in the 1970’s likely changed the natural Mill Creek reach adjacent to the Project. The exact impacts of these modifications to the hydraulic regime of the channel have not been evaluated in detail; however, it is likely that they are still influencing current morphologic processes and adjustments.

The 10 culverts which convey flows in Mill Creek under Chino Corona Road have also modified the hydrologic and hydraulic regime within the vicinity of the Project. As sized, the culverts effectively convey low flows and result in backwater effects up Mill Creek and Cucamonga

Channel under medium to high flow conditions. Under high flow conditions, the culverts act as an Arizona Crossing and flows overtop the road and are conveyed back into the channel on the downstream end. Chino Corona Road, because it is higher than the adjacent floodplain, acts as a partial dam on the floodplain and prevents flood waters up to a certain water surface elevation from draining downstream along the floodplain. These conditions have facilitated overtopping of the channel banks and sediment deposition in the reach immediately upstream of the culverts.

Downstream of the culverts, the Mill Creek channel is degraded, potentially the result of the impacts of the culverts on sediment transport processes within the reach and upstream increases in hydrologic source loading. Because of the backwater effects and reduced velocities upstream of the culverts, sediments in suspension may be deposited under a range of flows upstream of the culverts. The flows through the culverts, therefore, lose a portion of their sediment load and are discharged to the downstream reach deficient in sediment. To account for sediment losses upstream, flows downstream of the culverts erode the channel bed and banks. The channel, in this reach, is therefore deeply incised with steep channel banks. Because of this channel geometry, the channel has lost its natural connection with the floodplain and the frequency of floodplain inundation in this reach is less than that upstream of the Chino Corona Road culverts. It is also noted that the artificial connection of Cucamonga Channel to Mill Creek constructed in first half of the century likely had dramatic effects on the hydrologic regime in the channel at that time and the channel may still be adjusting today.

2.2. Sediment Grain Sizes

Creek sediments were sampled at five locations by Vandermost Consultants in June 2008. The representative samples were recovered from approximately 1 ft below the sediment surface. The results of the creek sediment samples are summarized in more detail in the letter from Chris Conkle and Neven Matasovic regarding sediment sampling and testing, July 15, 2008. The locations of the sediment samples are illustrated in Figure 1 and the D_{50} for each sample is summarized in Table 1 below. In general, creek sediments can be characterized as either poorly graded sand or silty sand.

Table 1. Grain Size Diameters of Creek Sediment Samples

Sample ID	D_{50} (mm)
1	1.25
2	1.25
3	0.40
4	0.25
5	0.50

Floodplain sediments were evaluated at approximately 18 locations using Cone Penetration Tests (CPT) and borings by Geosyntec Consultants. Detailed information on the floodplain sediments can be found in the Geotechnical Report: Mill Creek Wetlands Recreation and Restoration Demonstration Project (Geosyntec Consultants, November, 2008). In general, the topmost floodplain sediments are comprised of clayey silt, sandy silt and silty sand.

3 EXISTING VS. PROPOSED SCOUR CONDITIONS

Evaluations of existing and proposed shear stresses and velocities in Mill Creek and along the floodplain are based on results of existing and proposed conditions HEC-RAS models developed by AECOM and discussed in more detail in the Cucamonga Channel/Mill Creek Diversion Flow HEC-RAS Analysis (AECOM, 2008). For the purposes of this analysis, the basins were modeled as full in order to accurately account for expected high flow conditions. Discussions of existing and proposed scour conditions evaluated in this way do not take into account the decreases to the frequency of peak discharges through the adjacent reach resulting from the Project.

Shear stresses and velocities resulting in Mill Creek from the range of possible flows up to the Probable Maximum Flood (PMF) (52,000 cfs) were evaluated for existing and proposed floodplain conditions along four cross-sections along Mill Creek adjacent to the Project. The locations evaluated are shown in Figure 1 and graphical comparisons of in-channel and right overbank results for each location are illustrated in Figure 2 and 3 respectively. While brief discussions are provided for conditions on the left floodplain, condition descriptions focus on in-channel and right-overbank conditions because 1) for most cross-sections, the left overbank area does not act as a floodplain but rather as an extension of the channel, and 2) the Project will be constructed on portions of the right floodplain.

3.1. Cross-Section A

Cross-section A is located upstream of Chino Corona Road as shown in Figure 1. The Project berm surrounding the Desilting Basin is minimally located on the floodplain in this area. In-channel sediments have been characterized as poorly graded sand (Sample #1). Floodplain sediments are likely silty sand to sandy silt however no samples were taken for this Project in the floodplain north of Chino Corona Road. The right channel banks at this location are overtopped for discharges greater than 6,000 cfs and the Project berm begins to result in small changes to cross-section hydraulics for flows greater than 30,000 cfs.

In-channel shear stresses (lbs/ft^2) and velocities for flows under 30,000 cfs do not change under Project conditions. However, because a small part of the Project berm is located on the floodplain, in-channel shear stresses and velocities increase slightly under Project conditions for flows greater than 30,000 cfs. Shear stresses and velocities increase at most for the PMF from

FIGURE 2. In-Channel Shear Stress and Velocities for Existing and Proposed Conditions

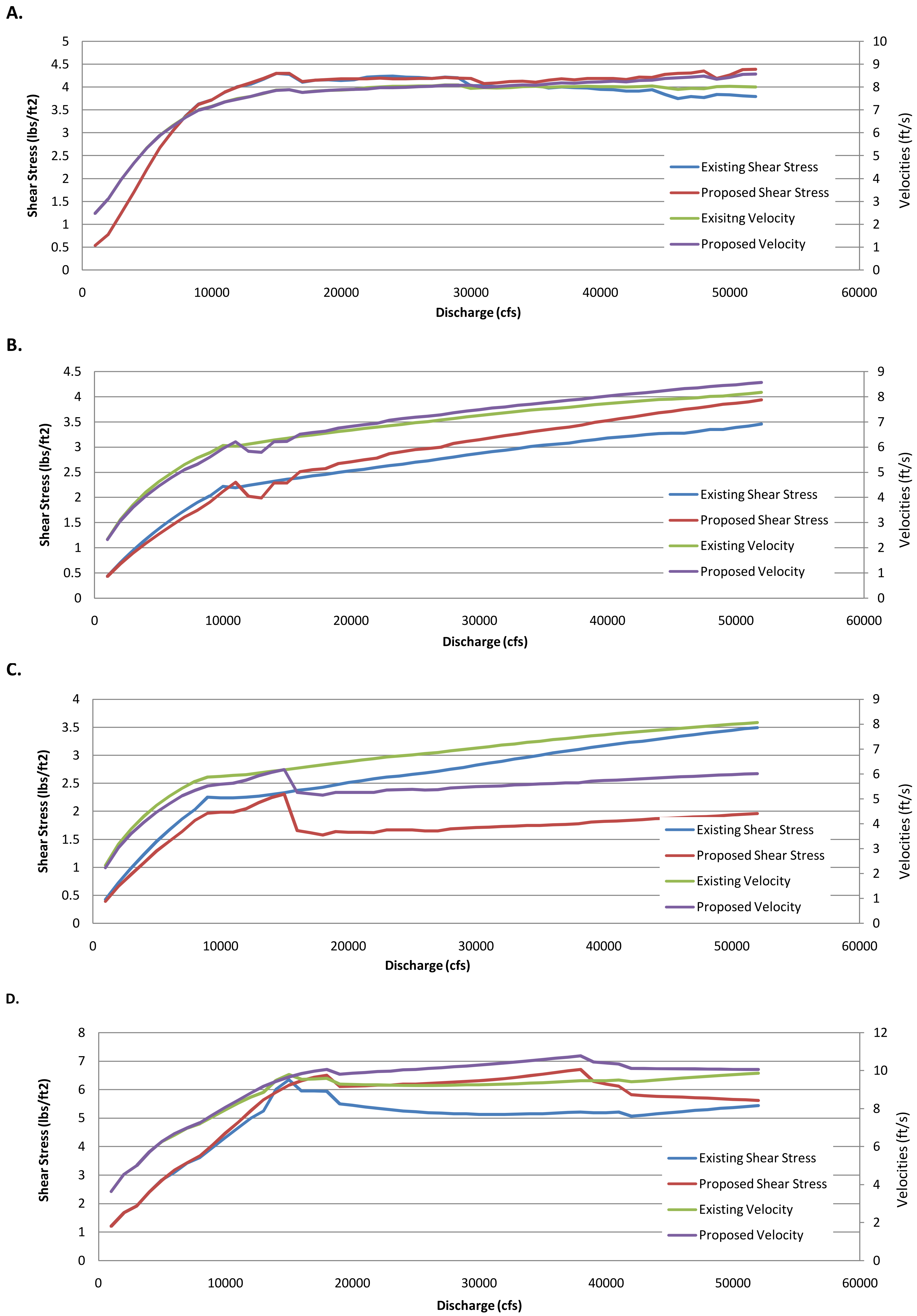
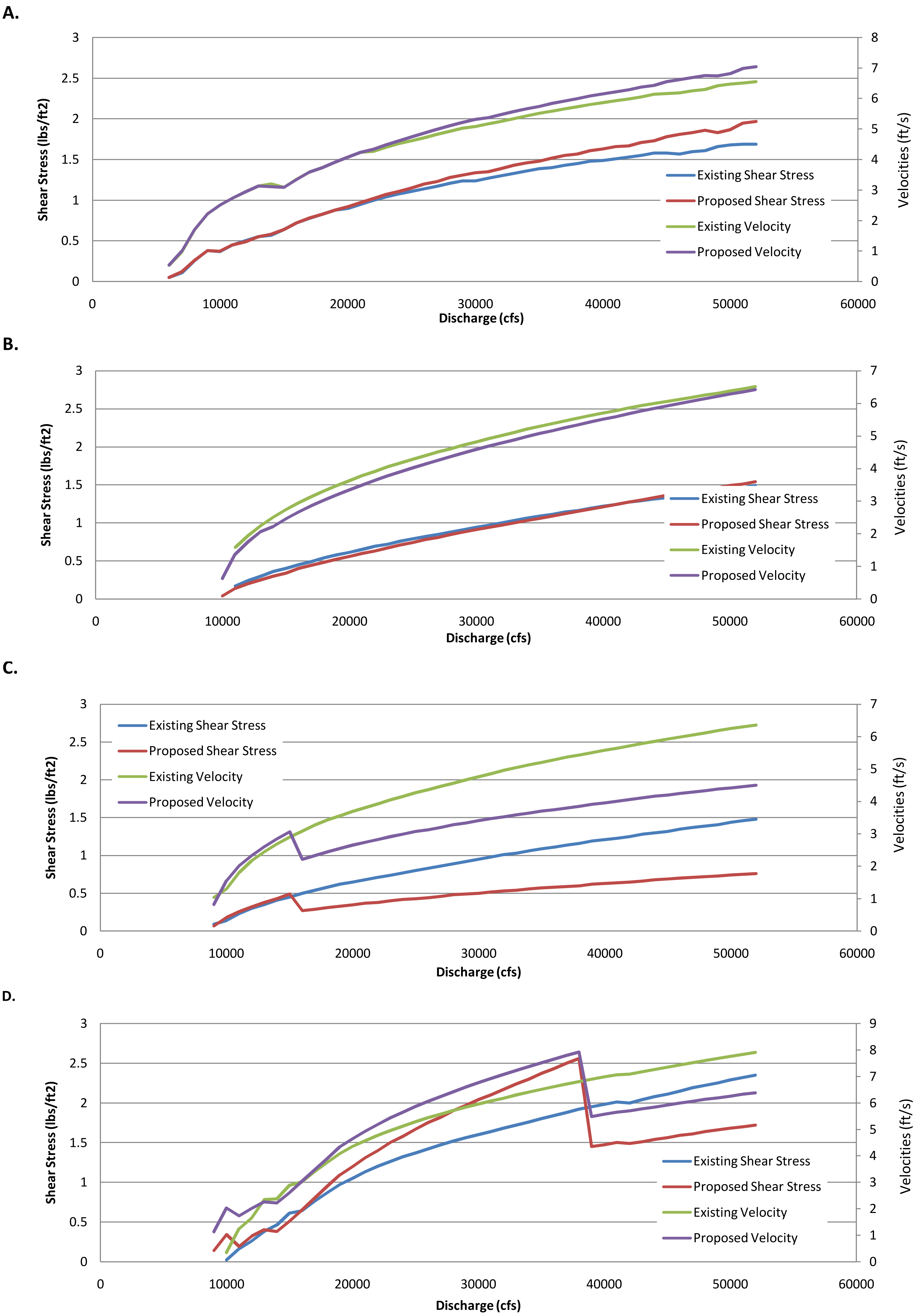


FIGURE 3. Right Overbank Shear Stresses and Velocities for Existing and Proposed Conditions



3.75 lbs/ft^2 and 8 ft/s under existing conditions to 4.25 lbs/ft^2 and 8.7 ft/s under proposed conditions.

Shear stresses and velocities on the right floodplain for flows between 6,000 and 24,000 cfs remain relatively unchanged from existing under proposed conditions. For flows greater than 24,000 cfs, however, right overbank shear stresses and velocities are slightly greater under proposed conditions. At most, shear stresses and velocities increase from 1.7 lbs/ft^2 and 8 ft/s under existing conditions to 2 lbs/ft^2 and 8.6 ft/s under proposed conditions.

Shear stresses and velocities on the left floodplain remain relatively unchanged from existing under all proposed conditions except for the PMF[2]. Under PMF flow conditions, shear stresses on the left floodplain increase from 1.37 lbs/ft^2 to 1/54 lbs/f^2 and velocities increase from 5.69 ft/s to 5.98 ft/s.

3.2. Cross-Section B

Cross-section B is located just downstream of Chino Corona Road as shown in Figure 1. The Project berm surrounding Pond 2, while present in the cross-section, does not impact in-channel velocities or shear-stresses for proposed conditions for any range of flows. However, the proposed geometry results in small changes in cross-section hydraulics described below. In-channel and floodplain sediments have been characterized as poorly graded sand (Sample #2) and silty sand to sandy silt respectively. The right channel banks at this location are overtopped for discharges greater than 10,000 cfs.

At cross-section B, shear stresses and velocities for discharges under 11,000 cfs remain relatively unchanged between existing and proposed in-channel conditions. Between discharges of 11,000 and 15,000 cfs, when flows overtop the Project berm and inundate Pond 2, proposed conditions result in slightly lower velocities and shear stresses. Shear stresses and velocities under proposed conditions for discharges greater than 15,000 cfs are between 0.1 and 0.5 lbs/ft^2 and 0.1 and 0.5 ft/s greater than for existing conditions. Shear stresses and velocities increase at most for the PMF.

Right overbank shear stresses and velocities for the range of flows evaluated remain relatively unchanged from existing conditions under proposed conditions. Left overbank shear stresse and velocities decrease for all flows evaluated at this cross-section.

3.3. Cross-Section C

Cross-section C is located halfway down the Mill Creek reach adjacent to the Project downstream of Chino Corona Road. In this particular location, proposed topography results in

[2] AECOM HEC-RAS analysis assumed critical depth downstream channel boundary conditions for all scenarios, including the PMF.

increases to floodplain storage for discharges greater than 15,000 cfs. In-channel and floodplain sediments have been characterized as silty sand (Sample #3) and silty sand to sandy silt respectively. The channel banks at this location are overtopped for discharges greater than 9,000 cfs.

In-channel shear stresses and velocities for flows less than that required for Project berm overtopping (15,000 cfs) remain relatively unchanged between existing and proposed conditions. For flows greater than 15,000 cfs, shear stresses and velocities in the channel for proposed conditions are less than for existing conditions likely because the proposed conditions geometry of the ponds provides additional floodplain storage.

For flows between 9,000 and 15,000 cfs, right overbank shear stresses and velocities remain unchanged. As in the channel, shear stresses and velocities decrease under proposed conditions for flows greater than 15,000 cfs due to the additional floodplain storage of the ponds.

Left overbank velocities and shear stresses are minimally greater under proposed conditions than under existing conditions for flows up to 15,000 cfs. For flows greater than 15,000 cfs, proposed conditions left overbank shear stresses and velocities are less than those under existing conditions.

3.4. Cross-Section D

Cross-section D is located close to the furthest downstream extent of the Project. The Project berm surrounding Basin 4 and a portion of Basin 4 are located on the existing floodplain in this cross-section, resulting in small changes to cross-section hydraulics for a range of flows. In-channel and floodplain sediments have been characterized as poorly graded sand (Sample #5) and silty sand to sandy silt respectively. The right channel banks at this location are overtopped for discharges greater than 10,000 cfs. The Project begins to result in small changes to the cross-section hydraulics for flows between 15,000 and 38,000 cfs, discharges greater than which would overtop the Project berm and take advantage of the additional floodplain storage allowed by the basins.

Shear stresses and velocities remain unchanged for existing and proposed conditions for flows under 15,000 cfs. For flows greater than 15,000 cfs, in-channel shear stresses and velocities increase most under 38,000 cfs flow conditions from 5.2 lbs/ft^2 to 6.7 lbs/ft^2 and 9.5 ft/s to 10.5 ft/s. The velocities through this area under proposed conditions are greater than those under existing conditions due to the location of the berm and Basin 4 on the existing floodplain.

Right overbank shear stresses and velocities resulting from flows between 10,000 and 38,000 cfs are generally greater for proposed conditions than for existing conditions due to the location of the Project on the right floodplain. For flows greater than 38,000 cfs, floodplain storage is

increased under proposed conditions as flows overtop the berm into Basin 4, reducing velocities and shear stresses.

Left overbank conditions are similar to those discussed for the right overbank floodplain above. Shear stresses and velocities are generally greater for proposed conditions for flows greater than 18,000 cfs. Shear stresses and velocities increase under proposed conditions most for flows of 38,000 cfs where shear stresses increase from 0.84 lbs/ft^2 to 1.1 lbs/ft^2 and velocities increase from 3.92 to 4.43 ft/s.

4 RECOMMENDED PROTECTIVE MEASURES FOR THE PROJECT

4.1. Levee Toe-Down Depths

Preliminary levee design toe-down depths for the Project berm at each cross-section given the right overbank conditions described above are summarized in Table 2. Scour depths were calculated for General and Local scour only as other forms of scour are not applicable (i.e. long-term bed degradation, bend scour, low flow incisement, bed form height, etc). Scour depths were calculated using the methods outlined for General and Local scour in the Los Angeles County Sedimentation Manual (LACDPW, 2006) for velocities associated with the 100-year design discharge (32,000 cfs).

Table 2. Levee Toe-Down Depths

Location	100-year Right Overbank Velocity (ft/s)	General Scour (ft)	Local Scour (ft)	Levee Toe-Down Depth (ft)
A	5.47	0.85	2	2.85
B	4.78	0.7	2	2.7
C	3.53	0.45	2	2.45
D	7.08	1.25	2	3.25

4.2. Protection Design Criteria

Measures protecting the creek and engineered fill berm will be incorporated into Project designs where necessary. Various materials are available for use in protection of channel banks or engineered fill. Protective measures for the channel banks and the engineered fill berm will be recommended based on the right overbank velocities and shear stresses resulting under the proposed conditions and the maximum velocities and shear stresses permissible for each protective measure as summarized in Table 3.

Table 3. Typical Levee and Channel Protection Materials and Associated Permissible Hydraulic Conditions

Protective Material	Maximum Permissible Velocity (ft/s)	Maximum Permissible Shear Stress (lb/ ft^2)
BARE SOIL [1]		
Fine Sand	1.5	0.027
Sandy loam	1.75	0.037
VEGETATED APPROACHES		
Natural Grassed Channel[2]	2.5 - 8.0	0.35 – 3.7[3]
Reinforced Vegetative Approaches[4]	up to 15.0	up to 8.00
RIPRAP[5]		
D50 = 6 in	6.2	2.00
D50 = 12 in	8.8	4.00
D50 = 18 in	10.5	6.00
D50 = 24 in	12.0	8.00

Sources :
1 - Open Channel Hydraulics, Chow 1959
2 - NRCS , 1986
3- Chen, Y.H, and G.K. Cotton. 1988. Design of Roadside Channels with Flexible Linings. Federal Highway Administration, HEC #15. National Technical Information Service, Springfield, VA. 124 pgs.
4 - Storm Water Technology Fact Sheet: Turf Reinforcement Mats - EPA - 832F99002 - Sept 1999
5 – LA County Sedimentation Manual Appendix C-10 (Velocities) and Federal Highway Administration, Design of Roadside Channels with Flexible Linings, HEC-15, 1988 (Shear Stress)

5 DISCUSSION

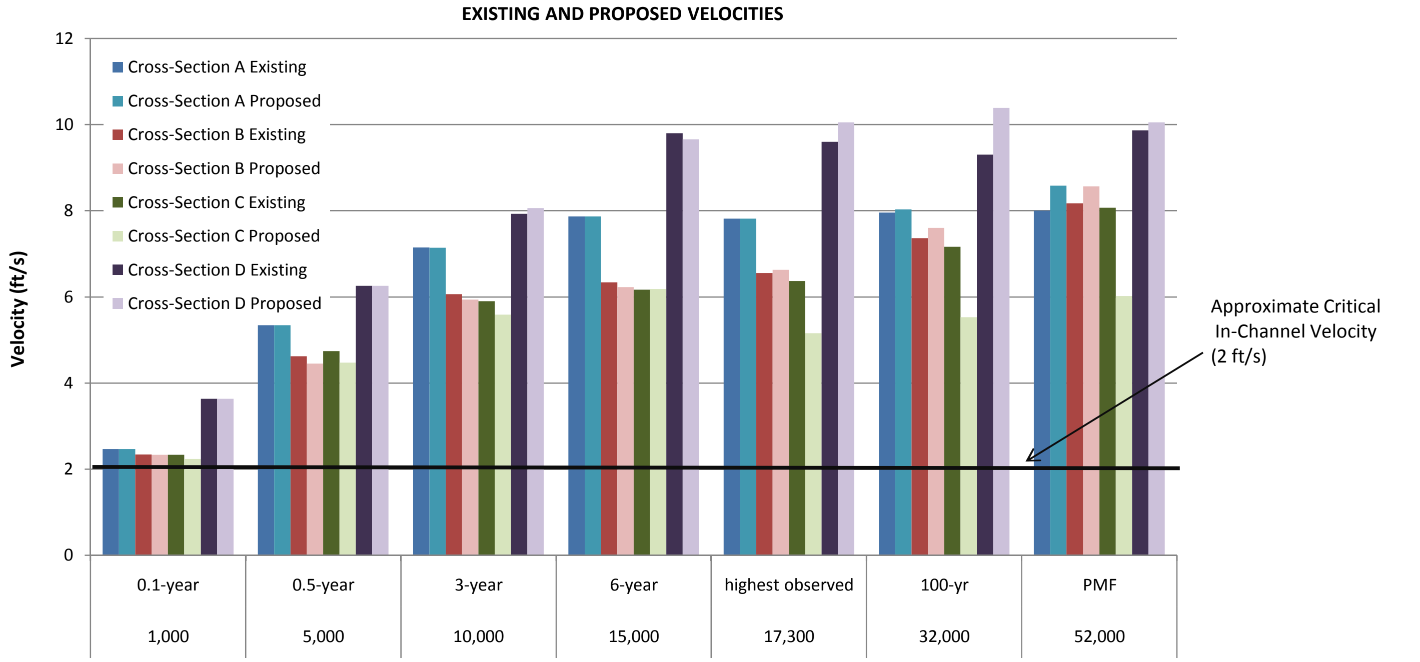
As discussed above in Section 2, the portion of Mill Creek adjacent to the Project is not currently functioning in equilibrium and appears to be degrading. The impacts of increased hydrologic loading, the channelization of and connection to Cucamonga Channel and the construction of the culverts under Chino Corona Road have disrupted natural sediment processes throughout the reach. Mill Creek is still adjusting to the changes in the hydrologic and hydraulic regime resulting from these channel modifications and therefore the morphology is dynamic. The Project will take this into account in design of the Project berm and protective measures.

Figures 4 and 5 illustrate the differences in velocities and shear stresses respectively between existing and proposed conditions for the channel and floodplain. Conditions under seven different flow conditions including 1,000 cfs, 5,000 cfs, 10,000 cfs, 15,000 cfs, 17,300 cfs (highest observed flow), 32,000 cfs (100-year flow) and 52,000 cfs (PMF) are depicted. Also highlighted on this figures are the critical thresholds for sediment entrainment as determined

based on the values in Table 3. Because the channel in general, is comprised of sandy sediments with some bank vegetation, the critical shear stress and velocity assumed were 2 ft/s and 0.35 lbs/ft^2 respectively. Because the floodplains are comprised of similar sediments and vegetation, the same thresholds for sediment entrainment as the channel were assumed for the floodplains as well.

As shown in Figures 4 and 5, flows through Mill Creek in its current state are generally erosive for the conditions evaluated. Only flows of 1,000 cfs, 5,000 cfs and 10,000 cfs result in hydraulic conditions that do not foster scour at some cross-sections. While the Project will result in small changes in shear stresses and velocities for a subset of flows, the scour regimes (i.e. erosive or non-erosive) of the flows in the channel and along the floodplains overall remain unchanged between existing and proposed conditions.

FIGURE 4. In-Channel Shear Stresses and Velocities vs. Critical Thresholds



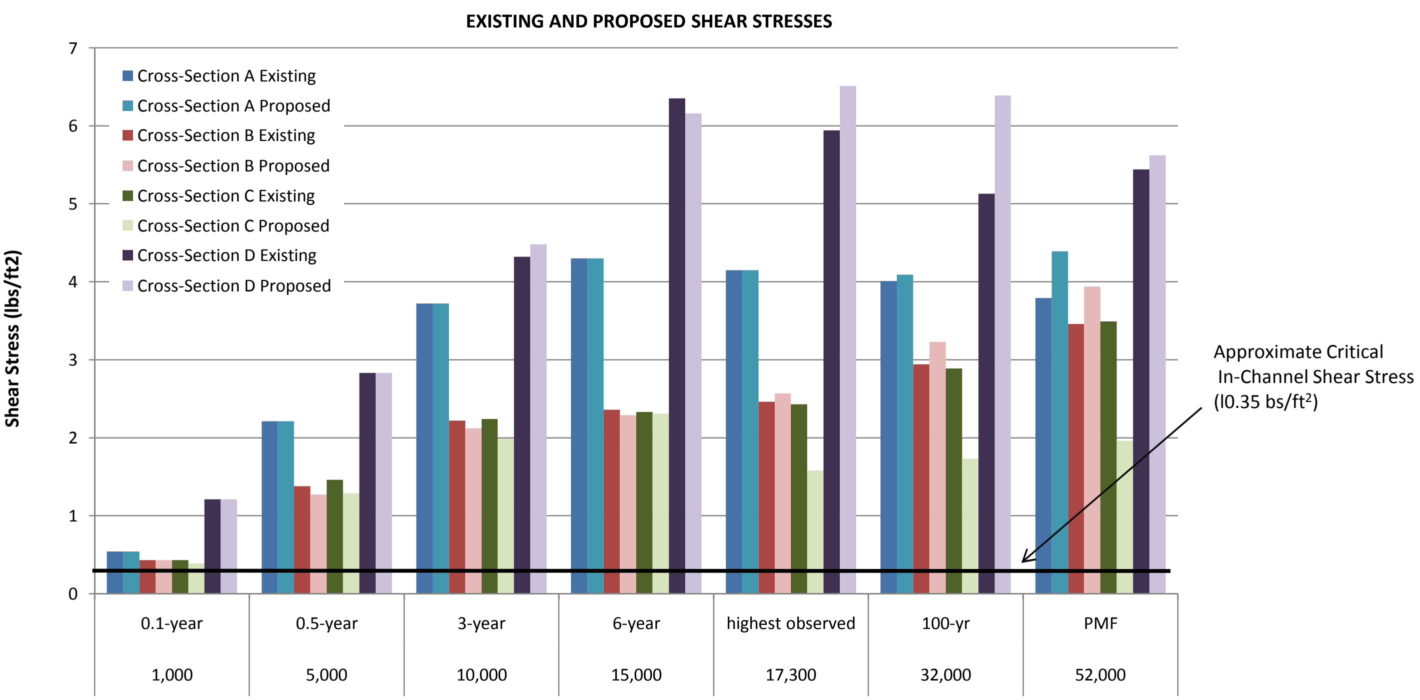
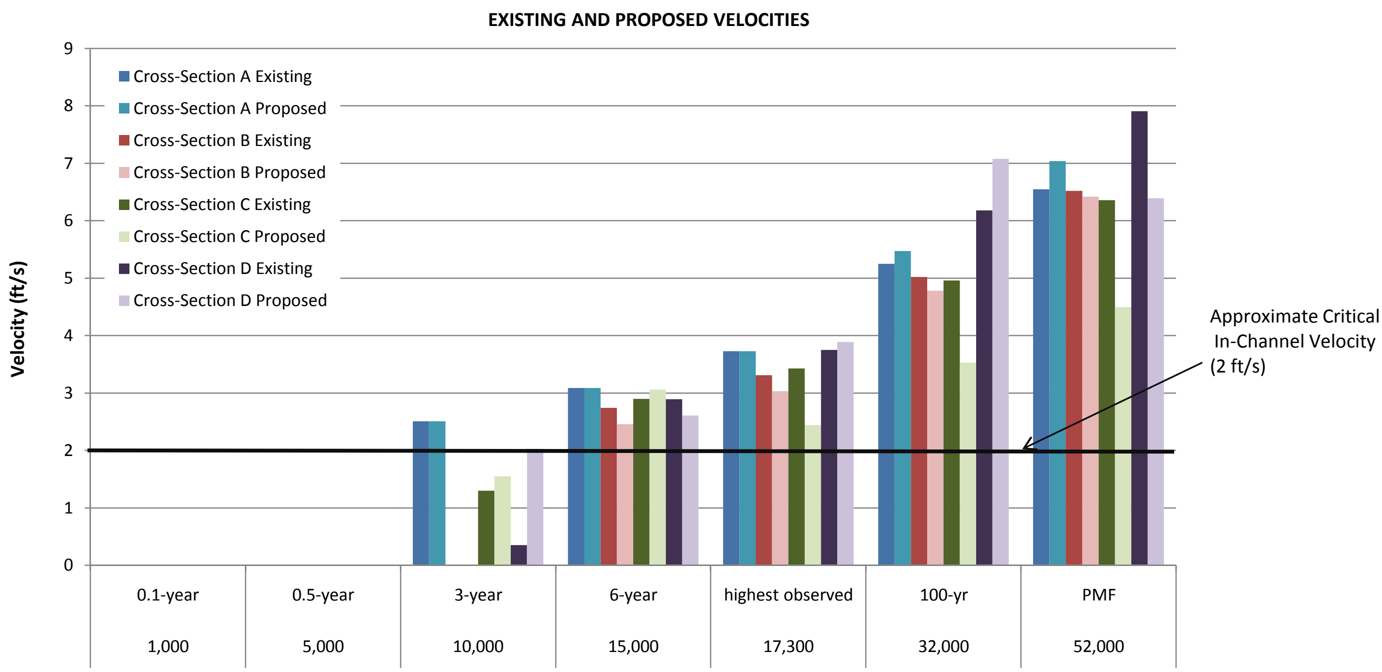
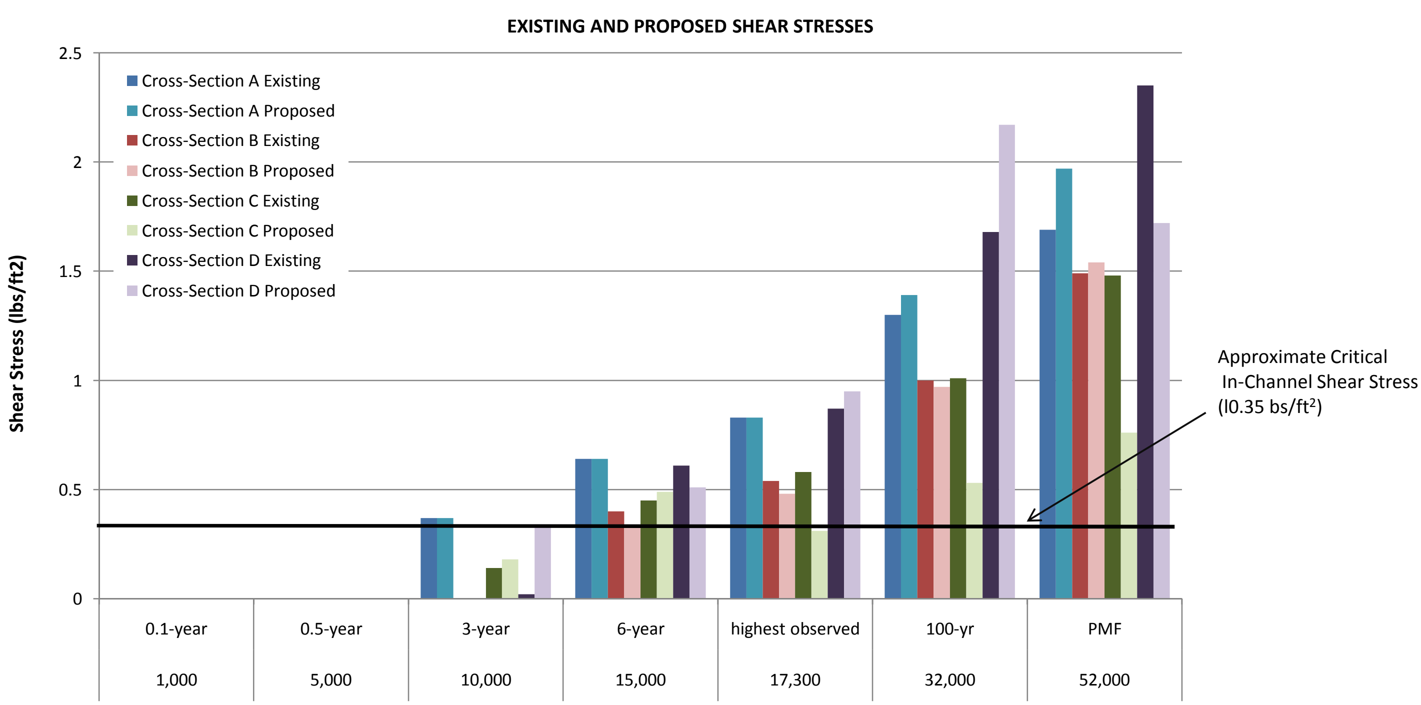


FIGURE 5. Right Overbank Shear Stresses and Velocities vs. Critical Thresholds





6 LIMITATIONS

The information presented in this document is conceptual and intended to evaluate potential impacts caused by the Project with respect to scour conditions and present information that can be used for environmental clearance efforts.

The information herein does not take the place of a Final Engineering Study, which will be required to confirm the validity of these conceptual analyses for final design and construction. The design criteria cited within this document is not of enough detail/accuracy for final design or construction.

The conclusions contained in this investigation are based on technical studies, data collected, preliminary design concepts and project objectives and developed with the Project team. Work conducted by others was not verified or checked by Geosyntec. No warranty, expressed or implied, is made regarding the professional opinions expressed in this report or concerning the completeness of the data presented to us.

Geosyntec is not liable for any use of the information contained in this report by persons other than for the stated project purpose.

7 REFERENCES

AECOM, 2008, Memorandum Summarizing Mill Creek Wetlands Project HEC-RAS Modeling Effort.

Geosyntec Consultants, 2008, Letter from Chris Conkle and Neven Matasovic Regarding Sediment Sampling and Testing, July 15, 2008

Geosyntec Consultants, 2008, Geotechnical Report: Mill Creek Wetlands Recreation and Restoration Demonstration Project, November, 2008.

Los Angeles County Department of Public Works, Sedimentation Manual, 2nd Edition, March 2006.