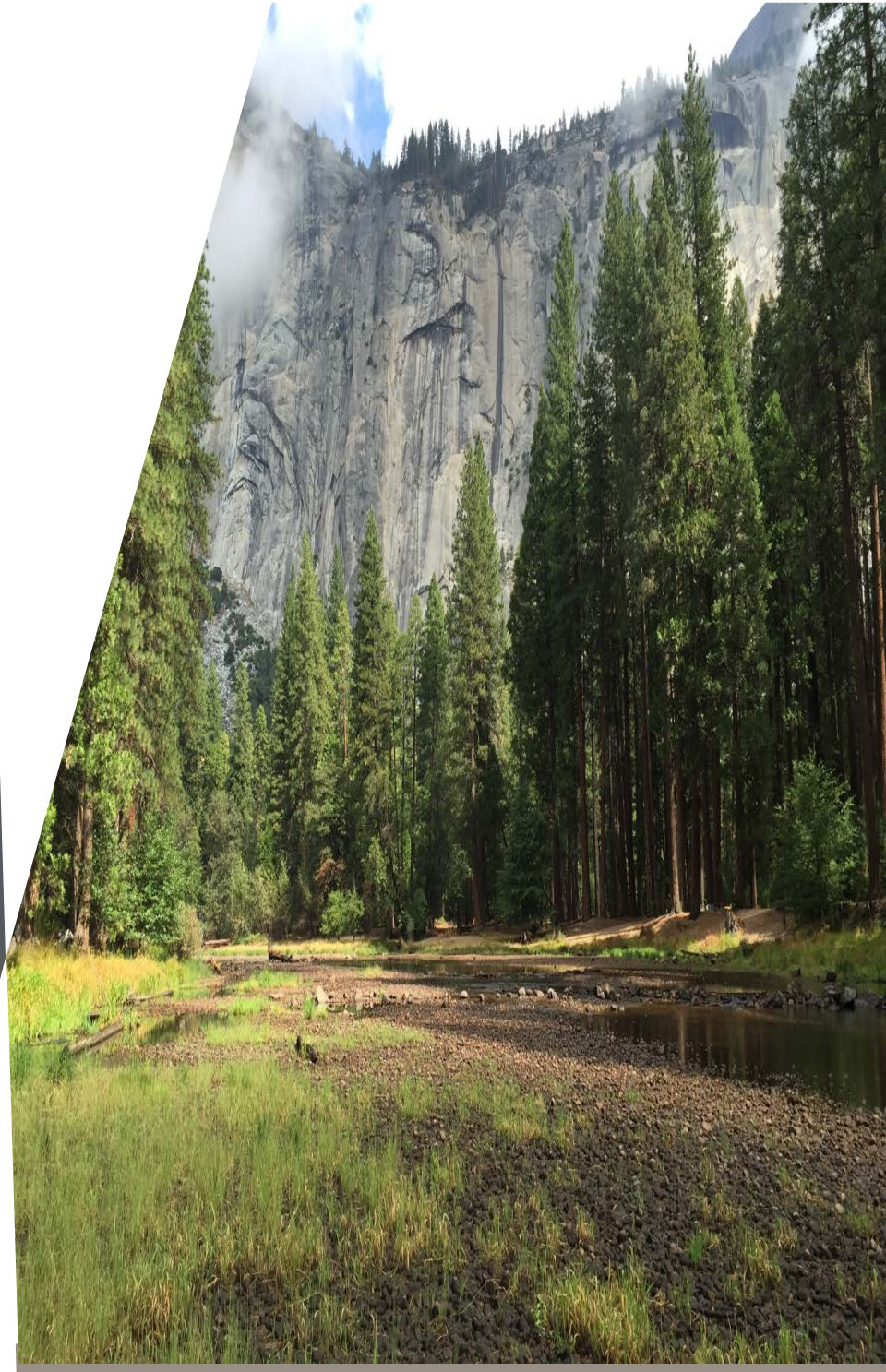
Merced River Riparian Corridor Restoration in Yosemite Valley

Restoration Concept Designs

March 2016



Prepared for The University of California, Santa Barbara, Californian Cooperative Ecosystem Studies Unit

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Shaping the Future

Merced River Riparian Corridor Restoration in Yosemite Valley

Restoration Concept Designs

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1 Introduction

This memorandum (Memo) describes restoration design concepts for the Merced River Restoration in Yosemite Valley Project (Project). Cardno is a member of the river analysis and restoration design team led by the University of California Santa Barbara, who is helping guide the National Park Service's (NPS) efforts to manage the river and riparian corridor through Yosemite Valley (Figure 1). This is a multi-year and multi-phased program to design and plan restoration treatments to enhance the geomorphic conditions of the Merced River and the ecological functionality of the riparian corridor, extending from Sentinel Bridge upstream to Happy Isle Bridge (Restoration Area).

The purposes of this Memo are to: (1) report existing conditions and issues based on Cardno's 2015 field inspections and review of prior reports; (2) recommend small-scale treatments that can be implemented by NPS staff in the near-term; and, (3) identify potential opportunities and restoration concepts that holistically address the river and riparian corridor, but require additional analyses. This Memo does not include the reach between Sugar Pine Bridge and Ahwahnee Bridge, which will be investigated in a future reach-specific study (Study).

Proposed small-scale treatments that could be implemented in the short-term include bioengineered structures and plantings designed to promote habitat diversity and a more natural riparian corridor. Potential large-scale and/or holistic design concepts could be considered options to achieve longer-term restoration goals, such as addressing bridge-induced geomorphic impacts. These concepts are qualitative and will need to be further developed and informed by modeling and analyses prior to implementation, which is the beyond the scope of this effort. The proposed small-scale treatments are intended to provide independent restoration benefits, and be compatible and synergistic with future restoration actions along the Merced River.

1.1 Project Objectives

The following broad restoration goals identified by NPS for the Merced River in Yosemite Valley are addressed in this Memo:

- Increase vertical and horizontal channel and riparian zone complexity by increasing plant species diversity and enhancing the herbaceous, shrub, and deciduous tree layers in the riparian zone.
- Narrow the channel to enhance overbank flooding and floodplain function.

2 Concept-Level Restoration Treatments

The concept-level restoration treatments were informed by field inspections conducted in summer and fall of 2015, supplemented by information from previous reports and unpublished materials and personal communications with the NPS. The 2015 field inspections focused on identifying impacted areas; defining geomorphic and riparian problems and issues; and collecting data to inform the restoration treatment concepts. Additionally, numerous relevant reports were reviewed, including the *Merced Wild and Scenic River Final Comprehensive Management Plan and Environmental Impacts Statement* (NPS 2014); *Hydraulic and Geomorphic Assessment of the Merced River and Historic Bridges in Eastern Yosemite Valley, Yosemite National Park, California* (Minear and Wright 2013); *Merced River and Riparian Vegetation Assessment* (Cardno ENTRIX 2012); and *Analysis of bank erosion on the Merced River, Yosemite Valley, Yosemite National Park, California, USA* (Madej et al. 1994). Personal communications with and unpublished materials provided by NPS staff, such as historical cross-sections, also informed the treatments. The goals and restoration treatment activities articulated in the *Merced Wild and Scenic River Final Comprehensive Management Plan and Environmental Impacts Statement* provided an over-arching framework for the concept-level restoration treatments.

The Restoration Area was delineated into ten shorter reaches based on channel morphological characteristics and/or distinct sections of river between bridges (Figure 1). A river mile (RM) system was also developed, beginning at river mile (RM) 0, downstream of Sentinel Bridge. The river mile designations provide consistency for referencing locations within the Restoration Area and relating these data to other studies. Right and left bank references are based on facing in the downstream direction. The reaches include:

- Reach 1 (RM 0 – 0.19): Sentinel Bridge to RM 0.19
- Reach 2 (RM 0.19 – 0.35): RM 0.19 to RM 0.35 (the downstream extent of Housekeeping Camp)
- Reach 3 (RM 0.35 – 0.85): RM 0.35 (the downstream extent of Housekeeping Camp) to Housekeeping Bridge
- Reach 4 (RM 0.85 – 1.22): Housekeeping Bridge to Stoneman Bridge
- Reach 5 (RM 1.22 – 1.51): Stoneman Bridge to Ahwahnee Bridge
- Reach 6 (RM 1.51 – 1.74): Ahwahnee Bridge to Sugar Pine Bridge
- Reach 7 (RM 1.74 – 1.97): Sugar Pine Bridge to RM 1.97
- Reach 8 (RM 1.97 – 2.18): RM 1.97 to Clarks Bridge
- Reach 9 (RM 2.18-2.71): Clarks Bridge to RM 2.71
- Reach 10 (RM 2.71 – 2.95): RM 2.71 to Happy Isle Bridge

The restoration concepts are described in the following text sections below by reach, beginning at Sentinel Bridge (Reach 1) extending upstream to Happy Isle Bridge (Reach 10). Restoration concepts for Reach 6 are not included in this document, and will be based on a future reach-specific study.

A summary of the types of problems and issues within the Restoration Area, organized by reach, are listed and defined in Table 1. An overview of the types of potential treatment techniques by reach are listed and defined in Table 2.

Detailed information for each reach is provided in Appendix A, including:

- Map of the treatment types and sites

- Table of site-scale descriptions and guidance
    - Existing condition (problems and issues)
    - Treatment objectives
    - Treatment type (independent and/or combined)
    - Implementation needs (analyses, design, and field oversight)

Several treatment types have been recommended to address specific issues or realize opportunities within each reach. All of the treatment types address site-specific issues and can be implemented independently. However, to fully accomplish the desired restoration objectives within certain reaches, a holistic approach is necessary involving the strategic combination of multiple treatment types to function together.

In order to provide the opportunity and flexibility for phased treatment implementation, site-specific treatment type recommendations have been categorized by feasibility. For example, some treatments are readily "proposed" due to a minimal level of planning and effort, while others are categorized as "potential" because they will require additional planning effort before they could be fully evaluated for implementation. All treatments will need visual surveys to refine the treatment boundaries prior to implementation. The color-coding system for the treatment sites is defined below.

Color-code for Treatment Sites.

Color	Category	Characteristics
	Proposed Treatments	Requires no or minimal additional information and/or direction
	Proposed Treatments	Requires some additional information and/or direction
	Potential Treatments	Requires additional quantitative analysis, modeling, and engineering; also requires construction direction

Photographs of representative conditions and treatment opportunities are provided in Appendix B. Typical concept graphics for the range of treatment types are provided in Appendix C.

2.1 Reach 1 (RM 0 – 0.19)

Reach 1 extends from Sentinel Bridge upstream to RM 0.19 (Map 1). Issues within this reach include unstable streambanks caused by recreation activity primarily along the left streambank; an overwide channel; a disconnected floodplain; and a riparian corridor with reduced functionality and structural complexity. The site-specific treatments are summarized in Appendix A.

To alleviate erosion caused by recreation use, hardened river access to direct activity (Treatment 1-1) and riparian buffer enhancement with fencing would limit recreation access within the riparian corridor (Treatment 1-8). Streambank reconstruction (Treatment 1-7) would stabilize the streambank and enhance the riparian corridor. Construction of a mid-bar-forming engineered log feature (ELF) (Treatment 1-4) and lowering of the right streambank to reconnect the floodplain (Treatment 1-5) together would reduce velocities along the eroding left streambank, promote sediment deposition to narrow the channel, and enhance the riparian corridor. Additional modeling analyses will be required prior to implementation of these two potential treatment concepts to determine the value and design of the floodplain reconnection and engineered features.

2.2 Reach 2 (RM 0.19 – 0.35)

Reach 2 extends from RM 0.19 upstream to RM 0.35 at the downstream end of Housekeeping Camp (Map 1). Issues within this reach include: (1) untreated stormwater runoff flow paths from the adjacent road that flow into the river channel are causing streambank erosion and can also reduce water quality; (2) disconnected right floodplain; (3) floodplain fill (right floodplain); and (4) a riparian corridor along the left streambank with reduced structural complexity, species diversity, and functionality. The site-specific treatments are summarized in Appendix A.

Stormwater pretreatment to direct and slow runoff during storm events would reduce localized erosion and improve water quality (Treatment 2-3). Opportunities for reactivation of overflow channels on the right floodplain in Reaches 2 and 3 (Treatments 2-2 and 3-3), would enhance the riparian corridor and have the potential to reduce bank erosion within the reach. Additional hydraulic modeling and evaluation will be required to determine the value of the treatment and for the design. Removal of the parking area at Camp 6, with the removal of non-native fill, re-contouring of the topography, and native vegetation planting would enhance the quality of the riparian corridor (Treatment 2-1). On the left streambank, the riparian corridor is confined to a narrow line of trees, constricted by riprap along the river and Southside Drive. Due to the need to continue to protect the existing infrastructure, no treatments are proposed to address vegetation issues in the riparian corridor on the left bank.

2.3 Reach 3 (RM 0.35 – 0.85)

Reach 3 extends from RM 0.35 upstream to Housekeeping Bridge (Map 1). Issues within this reach include localized streambank erosion, lateral confinement, and a disconnected floodplain. The site-specific treatments are summarized in Appendix A.

To address localized areas with streambank erosion, rock wall repair and streambank reconstruction with vegetation plantings would stabilize the streambanks (Treatments 3-1, 3-2, and 3-6). Opportunities for floodplain reactivation on the right floodplain are present at two locations within the reach where historic swale and high flow features were observed, at RM 0.67 and RM 0.50 (Treatments 3-3 and 3-5). The high flow channels re-connect to the main channel in Reach 2 at Treatment 2-2. Determining the potential value, persistence, and design of these features will require additional analyses.

2.4 Reach 4 (RM 0.85 – 1.22)

Reach 4 extends from Housekeeping Bridge upstream to Stoneman Bridge (Map 1). Issues within this reach include a riparian corridor on the right floodplain with reduced structural complexity, species diversity, and functionality and streambank erosion on the left streambank. The site-specific treatments are summarized in Appendix A.

Hardened river access to encourage recreation use in certain areas (Treatment 4-2), regrading and pine tree removal, and replanting with native riparian species plantings within the floodplain (Treatment 4-6) would enhance the riparian corridor on the right streambank and floodplain. Along the left streambank, engineered features (Treatments 4-7 and 4-8) and reconstructed streambanks (Treatments 4-3 and 4-4) with revegetation would stabilize the streambanks and have the potential to promote sediment deposition to narrow the channel. Downstream from Stoneman Bridge (Treatment 4-8), a crib structure is recommended to address bank erosion. Additional analyses will be required to determine the specification and design of the crib structure or to determine if other engineered features may be sufficient for stabilizing the bank. In the vicinity of Housekeeping Camp, treatments include a combination of selective riprap removal, revegetation with fencing, and reconstructed streambanks to stabilize the streambanks while enhancing the riparian corridor (Treatments 4-1, 4-3, and 4-4). Treatment 4-5 would involve removing existing rip rap that is not functioning to protect the streambanks (e.g., along upper

banks that experience lower hydraulic stress). In some areas, riprap that supports existing well-established vegetation would be retained.

2.5 Reach 5 (RM 1.22 – 1.51)

Reach 5 extends from Stoneman Bridge upstream to Ahwahnee Bridge (Map 1). Issues within this reach include: (1) riparian corridor with reduced structural complexity, species diversity, and functionality; (2) eroding streambanks and over-widened channel; and (3) simplified channel morphology. The site-specific treatments are summarized in Appendix A.

To enhance the condition of the riparian corridor, general treatments such as fencing (Treatment 5-1) and hardened river access (Treatment 5-2) would limit and focus recreation access into certain locations. This reach is a credible candidate for a combination of bioengineered treatments to build floodplains (Treatments 5-4 and5-5), stabilize banks (Treatment 5-7) and re-direct flows (Treatments 5-3 and 5-6) to address channel widening, local bridge-induced scour, and the simplified channel morphology. Treatments 5-4, 5-5, and 5-6 should be implemented together to fully realize the desired treatment objectives for the reach. The supporting analyses, specifications, and designs for these features are beyond the scope of this concept design memo. The existing artificial bank protection on the right stream bank downstream from Ahwahnee Bridge is recommended to remain in place (Treatment 5-8). Vegetation is already existing at the site, and in combination with the existing bank protection, is providing bank stability.

2.6 Reach 6 (RM 1.51 – 1.74)

Pending investigation of the reach-specific study.

2.7 Reach 7 (RM 1.74 – 1.97)

Reach 7 extends from Sugar Pine Bridge upstream to approximately the middle of North Pines and Lower Pines campgrounds (RM 1.97) (Map 1). Tenaya Creek joins the Merced River at RM 1.833. Issues within this reach include: (1) channel widening, bank instability, and a riparian corridor with reduced structural complexity, species diversity, and functionality from recreation use in the vicinity of the North Pines and Lower Pines campgrounds; and (2) erosion on the right streambank above Sugar Pine Bridge. The site-specific treatments are summarized in Appendix A.

Potential treatments to address channel widening and bank instability near the campgrounds include reconstructed banks (Treatment 7-5) and lateral engineered wood features (Treatment 7-4) to promote sediment deposition. Planting and limiting recreation access via fencing would also enhance the riparian corridor (Treatments 7-6 and 7-7).

Construction of a combination of treatments in Reach 7, including reactivation of historic swale features on the left floodplain (Treatment 7-2), engineered features to direct flows (Treatment 7-1), and floodplain grading (Treatment 7-3) would allow for high flows to overbank into these features, enhancing floodplain function and the riparian corridor. Additional hydraulic modeling and engineering design would be required to inform any such design in this area to ensure sustainability of the treatments prior to implementation.

2.8 Reach 8 (RM 1.97 – 2.18)

Reach 8 extends from RM 1.97 upstream to Clarks Bridge (Map 1). Issues within this reach include streambank erosion and a riparian corridor with reduced structural complexity, species diversity, and functionality in the vicinity of North Pines and Lower River Pines campgrounds. The site-specific treatments are summarized in Appendix A.

Treatments that exclude and redirect river access to specified locations (Treatments 8-1, 8-2, and 8-3), and revegetation and brush layering (Treatment 8-1) would enhance the riparian corridor and provide additional bank stability.

2.9 Reach 9 (RM 2.18 – 2.71)

Reach 9 extends from Clarks Bridge upstream to RM 2.71 (Map 1). Issues within this reach include eroding streambanks and a riparian corridor with reduced structural complexity, species diversity, and functionality. The primary issue in this reach is the actively eroding left streambank, which has minimal vegetated cover on the bank face and top of the bank.

Treatments involve actions to reduce foot traffic within the riparian corridor and along the banks, with plantings (Treatments 9-1 and 9-3). Treatment 9-2 includes the removal of the Upper Pines Dump Station, which is proposed in the *Merced Wild and Scenic River Final Comprehensive Management Plan and Environmental Impacts Statement.* To encourage a diverse and complex riparian corridor after removal, the restoration concept includes soil decompaction, regrading, and vegetation planting.

2.10 Reach 10 (RM 2.71 – 2.95)

Reach 10 extends from RM 2.71 upstream to Happy Isle Bridge at the head of the Restoration Area (Map 1). Three main issues have been identified: (1) unstable streambanks; (2) local down-cutting with the bridge footings are exposed by one to two meters; and (3) simplified vegetation structure. The site-specific issues by treatment locations are specified in Appendix A.

To address bank instability along the right bank, potential treatments involve removal of existing riprap and revegetation (Treatments 10-1 and 10-2). Localized down-cutting and bank erosion immediately downstream of Happy Isle Bridge are potentially caused by the disconnection of high flow channels upstream of the bridge such that now all the high flow is being directed through the bridge. Historically, a portion of the high flows were directed into the high flow channels through a culvert located on the left floodplain. At some point in time, these high flow channels were blocked by large cobbles and boulders. The potential restoration concept at Happy Isle Bridge involves reactivating these high flow channels to allow high flows to be directed through the culverts, and return into the main channel downstream of the bridge (Treatments 10-4 and 10-5). This will reduce channel velocities at the bridge, and it is anticipated it will reduce channel down-cutting and erosion of the right streambank immediately downstream from the bridge. Additional river modeling and engineering design would be required to inform the design prior to implementation.

3 References

Cardno ENTRIX. 2012. *Merced River and Riparian Vegetation Assessment.* Prepared for Yosemite National Park, National Park Service.

Madej, M.A., W.E. Weaver, and D.K. Hagans. 1994. Analysis of Bank Erosion on the Merced River, Yosemite Valley, Yosemite National Park, California, USA. Environmental Management 18:235-250.

Minear, J.T. and S.A. Wright. 2013. *Hydraulic and Geomorphic Assessment of the Merced River and Historic Bridges in Eastern Yosemite Valley, Yosemite National Park, California.* United States Geological Survey Open-File Report 2013-1016. 88 pp.

National Park Service (NPS). 2014. *Merced Wild and Scenic River Final Comprehensive Management Plan and Environmental Impacts Statement.* Yosemite National Park. February 2014.

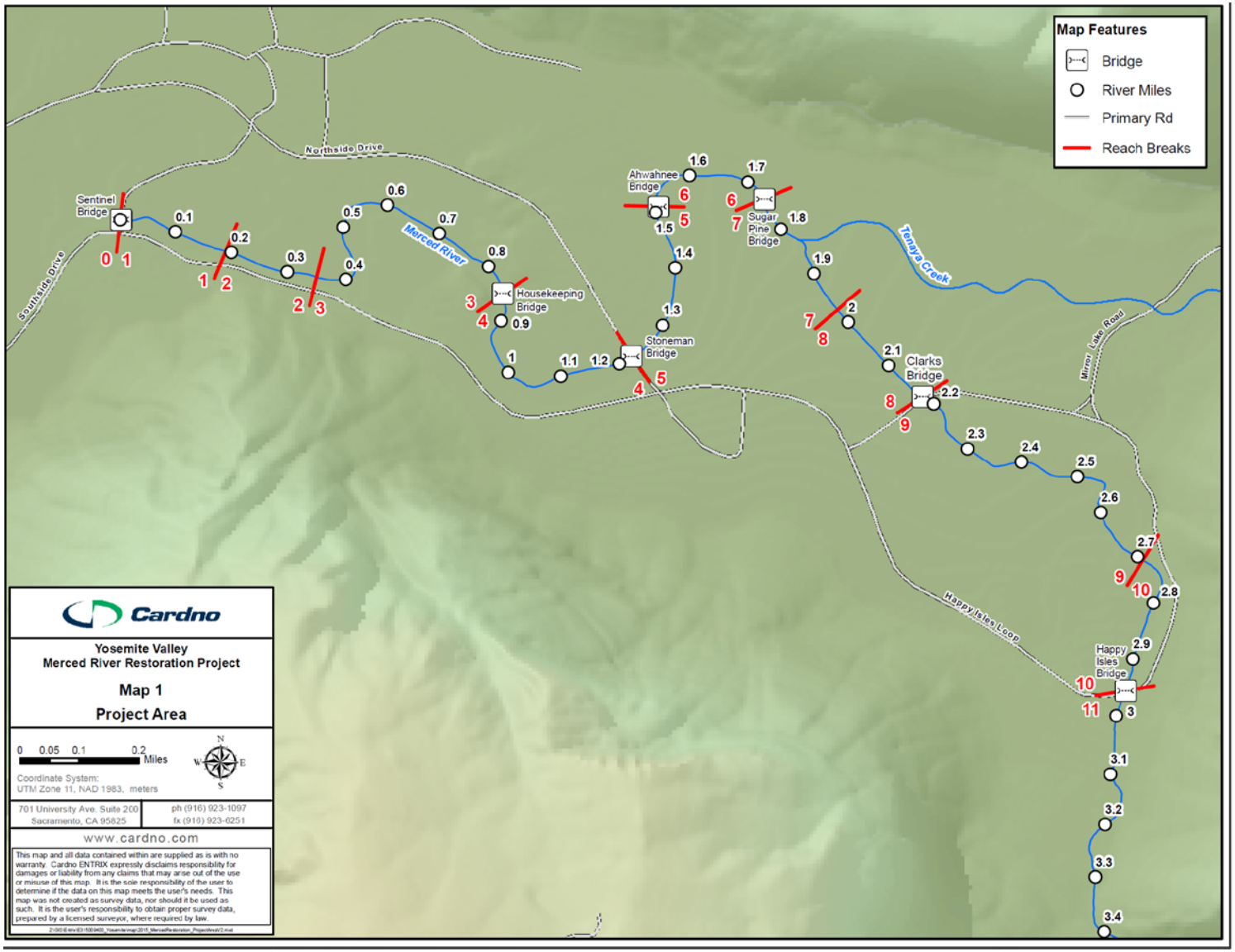


Figure 1 **Merced River Riparian Corridor Restoration in Yosemite Valley – Restoration Area.**

Table 1 Summary of Issues in the Restoration Area by River Reach.

Issue	Definition	Reach 1	2	3	4	5	6[1]	7	8	9	10
Upland											
Stormwater Drainage Infrastructure	Lacking or ineffective stormwater drainage infrastructure		●							●	
Floodplain											
Disconnected Floodplain / Entrenched Channel	Channel and floodplain lack connectivity because channel is incised and/or entrenched	●	●	●	●	●		●			●
Floodplain Fill	Land use encroachment in the floodplain with fill	●	●			●		●	●		
Compacted / Dewatered Soils	Soils are compressed and/or otherwise lack water-holding capacity	●	●					●			
Simplified Vegetation Structure	Vegetation lacks multiple canopy layers and/or age classes	●	●		●	●			●		●
Low Plant Species Diversity	Limited number of plant species		●		●	●			●		
Minimal Vegetation Recruitment	Little evidence of natural plant reproduction/ propagation	●	●		●	●			●		●
Streambank											
Artificial Bank Protection	Includes several types of riprap (i.e. stacked rock wall, rounded boulders, scattered angular riprap)	●	●	●	●	●			●	●	●
Eroding Banks (Toe)	Active and potential eroding streambank toe	●		●	●				●	●	
Eroding Banks (Face)	Active and potential eroding streambank face	●?		●	●			●	●	●	●
Denuded and/or Compacted Soils	Bare areas with compacted soils and little or no vegetation	●	●	●	●	●		●	●	●	●
Simplified Vegetation Structure	Vegetation lacks multiple canopy layers and/or age classes	●	●	●	●	●		●	●	●	●
Low Plant Species Diversity	Limited number of plant species		●	●	●	●		●	●		
Minimal Vegetation Recruitment	Little evidence of natural plant reproduction/ propagation	●	●	●	●	●		●	●	●	●
Channel											
Bridge Alignment[2]	Historic bridge alignment does not match the present main channel orientation; subject of subsequent project phases				●?	●?		●?			
Bridge Conveyance	Bridge conveyance is restricted during high flows (due to blockage; subject of subsequent project phases)										●?
Simplified Channel Morphology	Channel cross-section shape and bedform lack diversity	●				●			●		
Localized Channel Scour	Spatially-limited area of scour near artificial constriction			●	●						●
Disconnected Floodplain / Overwide Channel	Channel and floodplain lack connectivity because channel capacity is high due to historic widening	●			●	●		●			
Unstable Tributary Confluence[2]	Tributary entering main channel not to grade with nick-points and/or active erosion				●					●	
Lateral Confinement[2]	Natural or artificial limitation on channel migration or movement	●	●	●					●	●	●

Key: ? Requires further analysis to determine need and/or best option (hydraulic modeling and/or bank stability modeling)

[1] Pending investigation of the reach-specific study

[2] No specific treatments are recommended to address this problem/issue.

Table 2 Summary of Concept-level Restoration Techniques in the Restoration Area by River Reach.

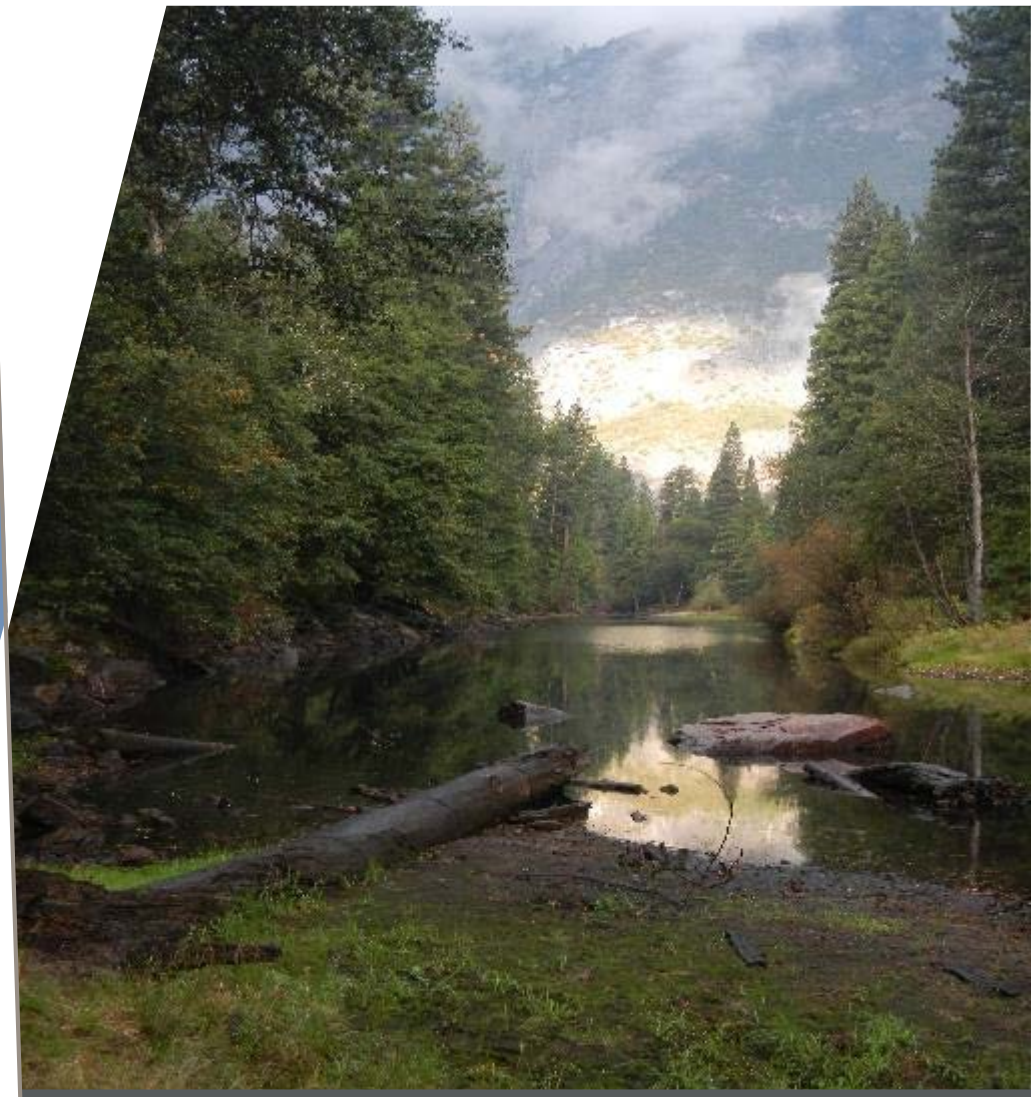
Treatment[2]	Description	Reach 1	2	3	4	5	6[1]	7	8	9	10
Upland											
Stormwater Pre-treatment	Installation of a range of possible pre-treatments (i.e. vegetated swale, rock-lined channel) to slow/deposit sediment and capture oil and grease prior to discharging to creek		●							●	
Floodplain											
Floodplain Grading and Soil Modifications	Floodplain topographic modifications (regrading to create microtopographic variation) and soil changes (decompaction and/or soil amendments)	●	●		●	●		●	●	●	●
Bank Lowering with Floodplain Reconnection	Lower river bank to allow high flows to escape onto floodplain	●?									
Bank Lowering with Overflow Channel Reactivation	Lower river bank to allow high flows to reach historic overflow channels/swales		●?	●?							●?
Floodplain Fill Removal	Strategic removal of artificial fill material	●	●								
Trail/Road Removal	*Not itemized in treatment table					●				●	●
Streambank											
Crib Structure	Structure built with logs, rocks, and slash material to resist scour and stabilize banks				●			●			
Flow-deflecting ELF	Engineered log feature constructed with wood and buried rock that redirects flow away from banks to enhance bank condition					●					
Reconstructed Bank	Constructed wood and rock to trap sediment with brush layering and other revegetation methods and re-build the bank	●		●	●	●		●			
Bank Grading and Soil Modifications[3]	Bank regrading to create stable bank slope and/or soil changes (decompaction and/or soil amendments) (primary treatment type)				●				●	●	
Selective Riprap Removal	Remove existing riprap. Removal of either all existing riprap or only remove riprap along the upper bank (retaining riprap at the toe of the bank for stability)	●			●	●					●
Retain Artificial Bank Protection	Retain the artificial bank protection (stable rounded rocks, rock walls). Repair and preserve as needed to stabilize banks	●	●	●	●	●			●	●	●
Brush Layering	Install willow brush layers				●			●	●		
Riparian Buffer Enhancement	Install fencing to exclude recreation access through riparian corridor and along the streambank and revegetate. May include the remove formal or informal recreation trails	●		●	●	●		●	●	●	
Hardened River Access	Provide hardened recreation river access to focus recreation activity to specific areas	●			●				●		
Channel											
Mid Bar-forming ELF	Engineered log feature constructed in-channel to slow flows and allow sediment to deposit and form bar downstream of feature; subject of subsequent project phases	●				●					
Lateral Bar-forming ELF	Engineered log feature constructed in-channel to slow flows and allow sediment to deposit and form bar downstream and to one side of feature; subject of subsequent project phases				●			●			
Floodplain-building Logs	Partially bury logs at the proposed channel toe to trap sediment from returning to channel which over time will build up floodplain				●	●					
LWD Relocation	Directed Large Wood Debris relocation in specific locations or management after events yielding LWD material							●			

Key: ? Requires further analysis (hydraulic modeling and/or bank stability modeling) to determine whether the treatment is needed and/or best option.

[1] Pending investigation of the reach-specific study

[2] Revegetation is a component of nearly all treatment types and will be fully described in specifications. Plant native species (container and/or poles) to improve the condition of the riparian corridor and build long-term root structure within the banks to provide additional stability. Species mix dependent on surrounding community.

[3] Bank grading and soil modifications are combined with nearly all other bank treatments.



Appendix A

SITE-SCALE CONCEPTUAL RESTORATION DESIGN GUIDANCE BY REACH AND RIVER MILE

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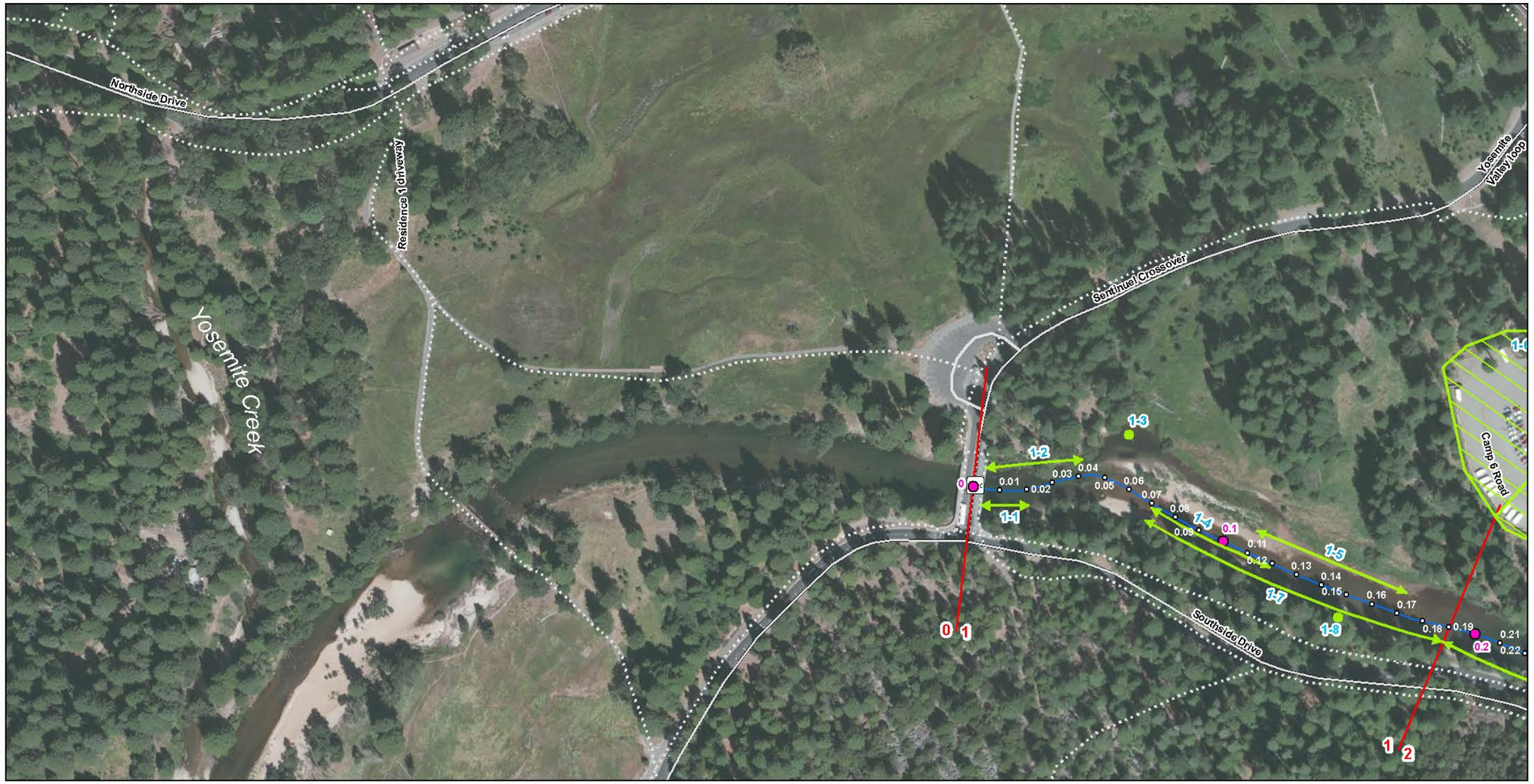
REACH 1



Map Features

- Bridge
- Campground
- Picnic Area
- Waterfall
- Primary Rd
- Secondary/Local Rd
- Trail
- Reach Breaks

Restoration Treatment Features

- Treament ID Number

Restoration Treatment Locations:

Yosemite Valley
Merced River Restoration Project

Reach and Treatment ID

Map 1 of 7

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Coordinate System:
UTM Zone 11, NAD 1983, meters

N W E S

0 50 100 200 Feet

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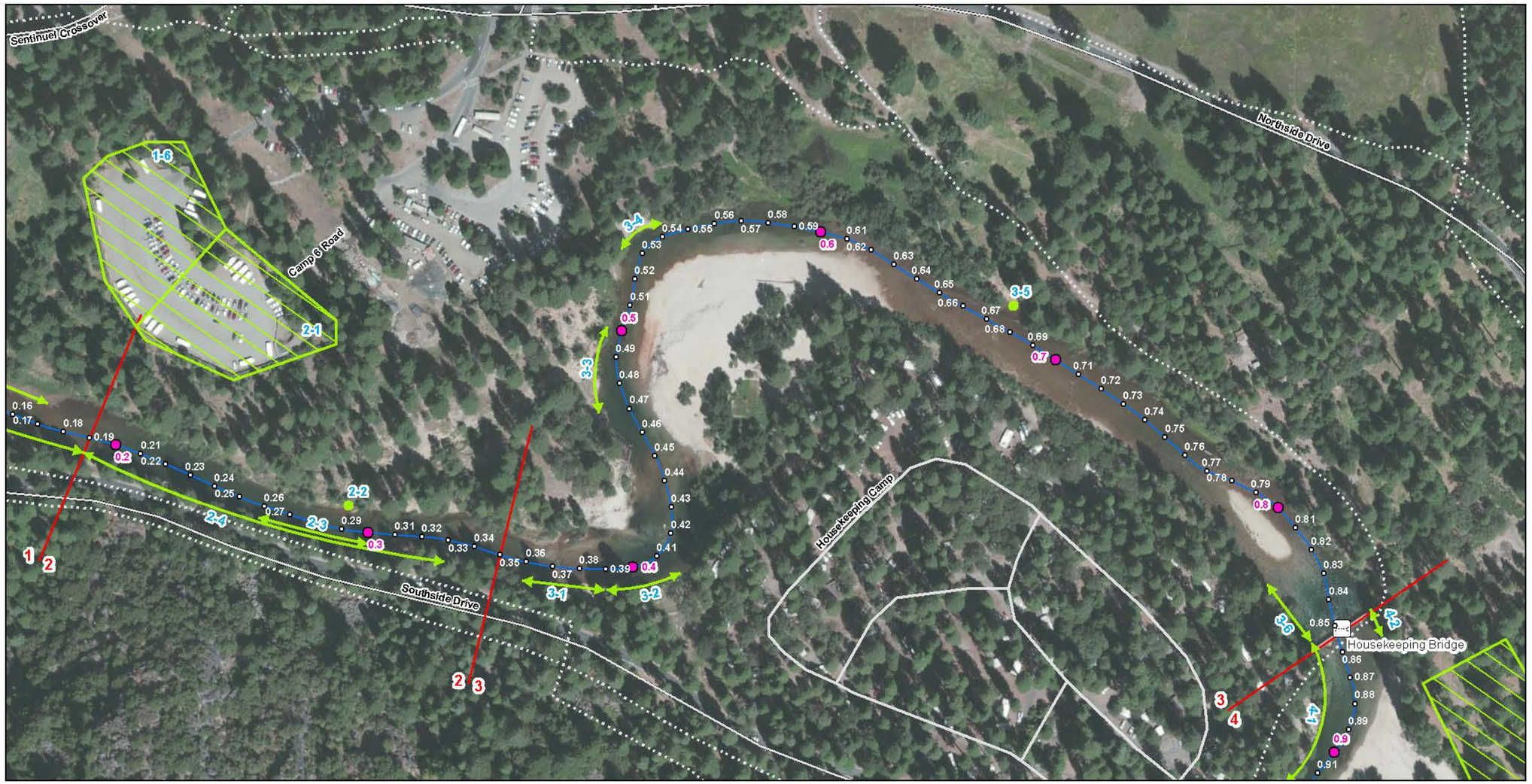
Reach and Treatment ID # (Map ID)	Location (River Miles) (LB or RB)	Existing Condition and Recommendations			Implementation Needs		
		Problems and Issues	**Treatment Objective**	**Treatment Type**	**Analyses**	**Design**	**Field Oversight**
Reach 1	**RM 0-0.19**						
1-1	0-0.02 (LB)	• Artificial Bank Protection • Eroding Banks (toe) • Eroding Bank (face) • Denuded and/or Compacted Soils • Lateral Confinement	**Stabilize streambank and enhance riparian corridor**. Provide hardened access point for recreation to reduce area and magnitude of impacts to riparian corridor and bank.	• Hardened River Access • Retain Artificial Bank Protection	• Visual Survey	• Materials List / Quantities	• Staking
1-2	0-0.04 (RB)	• Artificial Bank Protection • Eroding Banks (toe)	**Enhance riparian corridor**. Retain riprap where vegetation is already established.	• Retain Artificial Bank Protection	-	-	-
1-3	0.05 (RB)	• Artificial Bank Protection • Disconnected Floodplain / Overwide Channel	**Stabilize streambank**. Remove riprap that is able to be "plucked" from bank.	• Selective Riprap Removal (Typical Graphic C-2)	-	• Materials List / Quantities	• Construction Training
1-4	0.07-0.12 (mid-channel)	• Disconnected Floodplain / Overwide Channel • Simplified Channel Morphology	**Promote mid-channel bar formation** to narrow channel and reactivate floodplain.	• Mid Bar-forming ELF (Typical Graphic C-6) In combination with Treatments 1-4 and 1-5.	• Ballasting Calculations • Hydraulic Modeling	• Details • Specifications • Materials List / Quantities • Cost Estimate	• Construction Direction • Inspection
1-5	0.11-0.17 (RB)	• Disconnected Floodplain / Overwide Channel	**Reconnect floodplain**.	• Bank Lowering with Floodplain Reconnection (Typical Graphic C-8) In combination with Treatments 1-4 and 1-5.	• Hydraulic Modeling • Bank Stability Modeling	• Details • Specifications • Materials List / Quantities • Cost Estimate	• Staking • Construction Direction • Inspection
1-6	0.16-0.19 (RB)	• Compacted/Dewatered Soils • Floodplain Fill	**Restore native vegetation**. Remove non-native fill material, re-contour the topography, and reintroduce native vegetation to restored areas.	• Floodplain Fill Removal • Floodplain Grading and Soil Modification	• Visual Survey • Soils Analysis	• Materials List / Quantities -	• Staking
1-7	0.07-0.19 (LB)	• Eroding Banks (toe) • Eroding Banks (face) • Lateral Confinement • Simplified Vegetation Structure • Minimal Vegetation Recruitment	**Stabilize streambank and enhance riparian corridor**.	• Reconstructed Bank (Typical Graphic C-1)	• Topographic and Visual Survey • Bank Stability Modeling • Ballasting Calculations	• Details • Specifications • Materials List/Quantities • Cost Estimate	• Staking • Construction Training • Inspection
1-8	0.15 (LB)	• Eroding Banks (toe) • Eroding Banks (face) • Lateral Confinement • Denuded and/or Compacted Soils • Simplified Vegetation Structure • Minimal Vegetation Recruitment	**Stabilize streambank and enhance riparian corridor.** Exclude / redirect recreation access.	• Riparian Buffer Enhancement	• Visual Survey	-	• Staking

REACH 2



Map Features

- Bridge
- Campground
- Picnic Area
- Waterfall
- Primary Rd
- Secondary/Local Rd
- Trail
- Reach Breaks

Restoration Treatment Features

- Treament ID Number

Restoration Treatment Locations:

Yosemite Valley
Merced River Restoration Project

Reach and Treatment ID

Map 2 of 7

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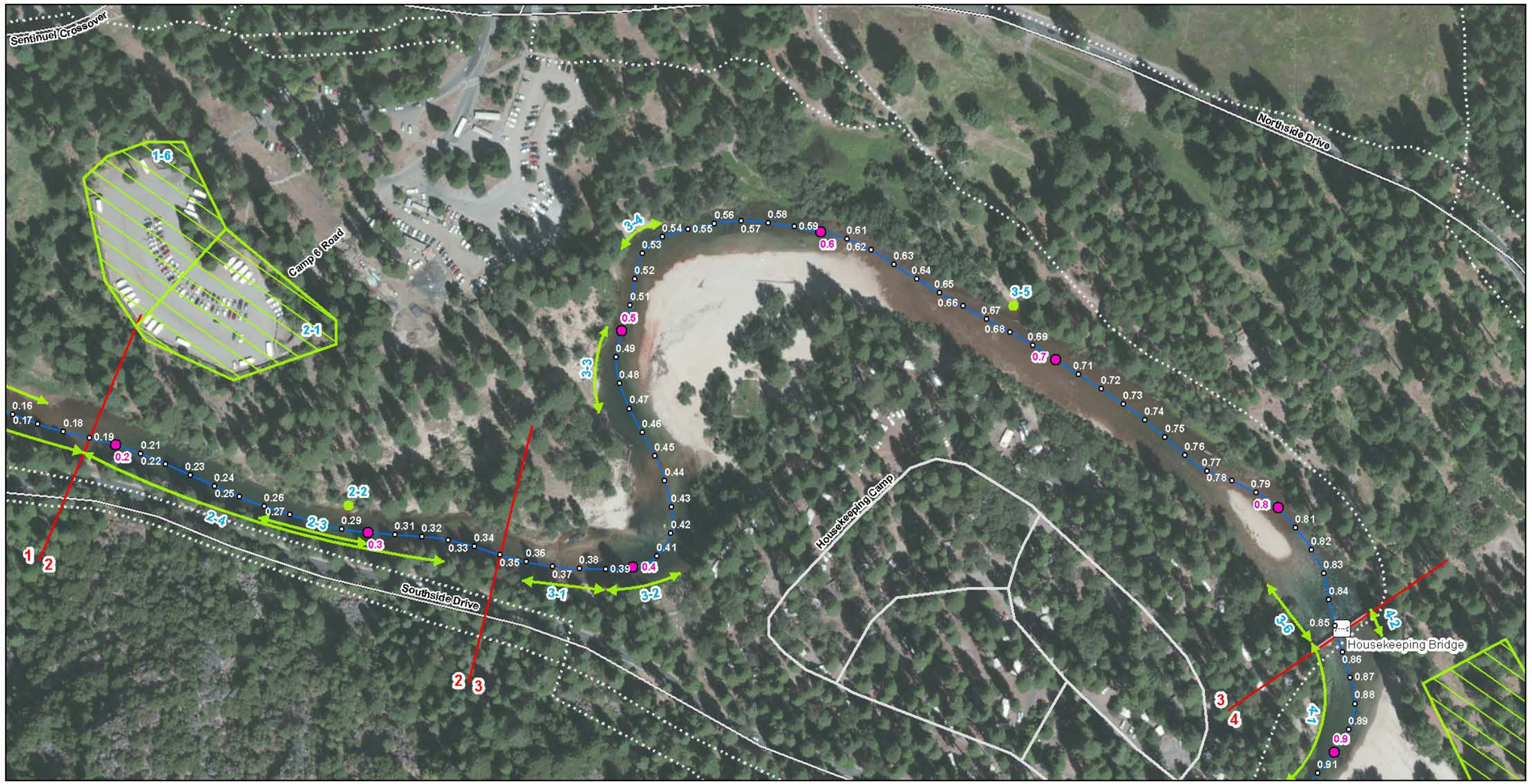
Reach and Treatment ID # (Map ID)	Location (River Miles) (LB or RB)	Existing Condition and Recommendations			Implementation Needs		
		Problems and Issues	Treatment Objective	Treatment Type	Analyses	Design	Field Oversight
Reach 2	**RM 0.19-0.35**						
2-1	0.19-0.25 (RB)	• Compacted/Dewatered Soils • Floodplain Fill	**Restore native vegetation**. Remove non-native fill material, re-contour the topography, and reintroduce native vegetation to restored areas.	• Floodplain Fill Removal • Floodplain Grading and Soil Modification	• Visual Survey • Soils Analysis	• Materials List / Quantities	• Staking
2-2	0.29 (RB)	• Disconnected Floodplain / Entrenched Channel	**Reactivate overflow channel and protect return flows.**	• Bank Lowering with Overflow Channel Reactivation (Typical Graphic C-8) Required with Treatment 3-3.	• Hydraulic Modeling • Bank Stability Modeling	• Details • Specifications • Materials List/Quantities • Cost Estimate	• Staking • Construction Direction • Inspection
2-3	0.26-0.3 (LB)	• Stormwater Drainage Infrastructure	**Reduce erosion and improve water quality**. Direct/control runoff paths and slowing runoff flows from the road before they enter the river.	• Stormwater Pre-treatment	• Visual Survey to identify runoff flow paths • Hydrologic Calculations for Culvert Design/ Detention Volume	• Details • Specifications • Materials List/Quantities • Cost Estimate	• Construction Direction • Inspection
2-4	0.19-0.33 (LB)	• Artificial Bank Protection • Lateral Confinement • Minimal Vegetation Recruitment • Simplified Vegetation Structure • Low Species Diversity • Denuded and/or Compacted Soils	**Stabilize streambank and protect road.** Retain existing riprap to protect road.	• Retain Artificial Bank Protection	-	-	-

REACH 3



Map Features

- Bridge
- Campground
- Picnic Area
- Waterfall
- Primary Rd
- Secondary/Local Rd
- Trail
- Reach Breaks

Restoration Treatment Features

- Treament ID Number

Restoration Treatment Locations:

Yosemite Valley
Merced River Restoration Project

Reach and Treatment ID

Map 2 of 7

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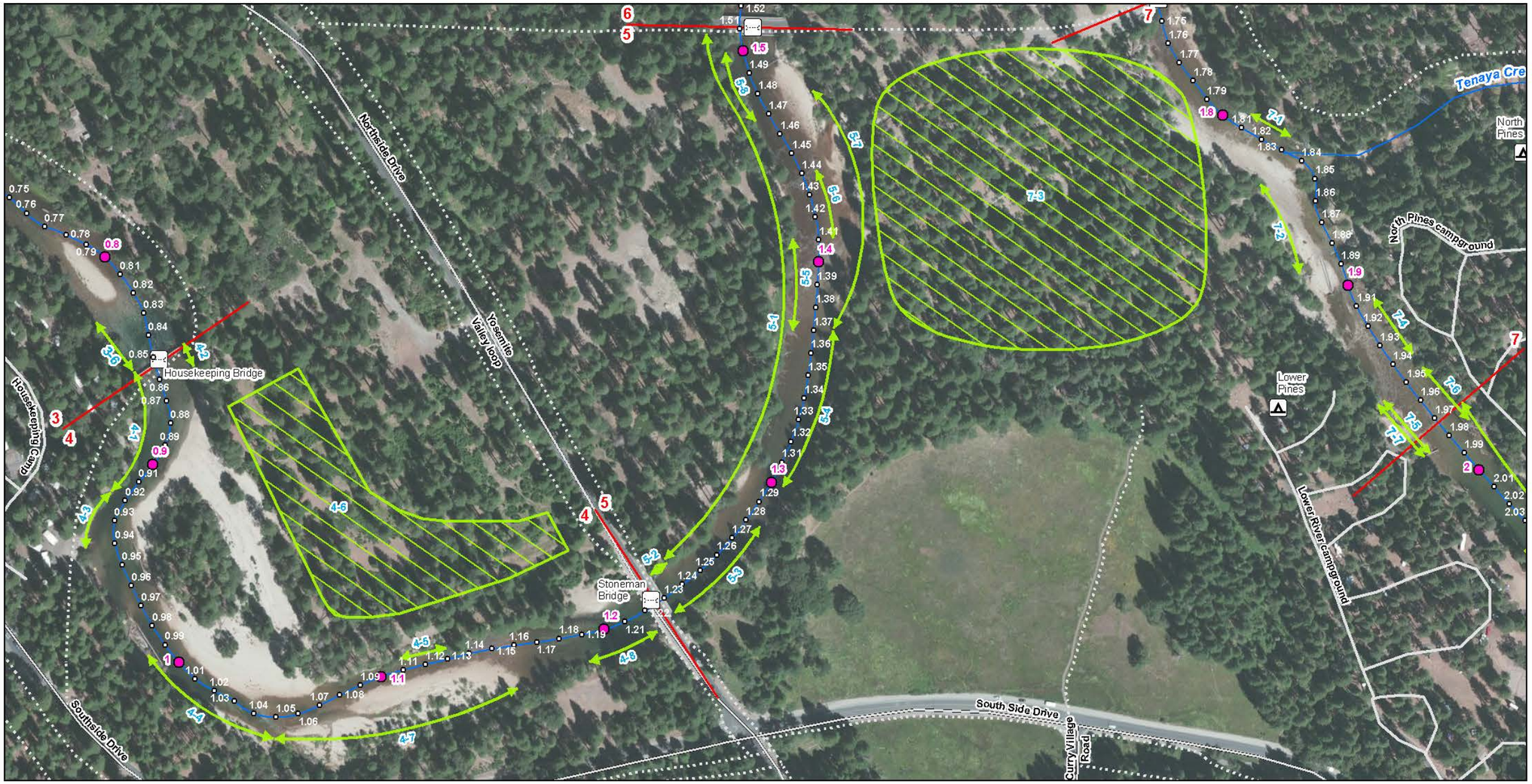
Reach and Treatment ID # (Map ID)	Location (River Miles) (LB or RB)	Existing Condition and Recommendations			Implementation Needs		
		Problems and Issues	**Treatment Objective**	**Treatment Type**	**Analyses**	**Design**	**Field Oversight**
Reach 3	**RM 0.35-0.85**						
3-1	0.36-0.39 (LB)	• Eroding Banks (toe) • Eroding Banks (face) • Simplified Vegetation Structure • Low Plant Species Diversity • Minimal Vegetation Recruitment	**Stabilize streambank and enhance riparian corridor (incorporate existing large wood)**.	• Reconstructed Bank (Typical Graphic C-1)	• Topographic and/or Quantity Survey • Hydraulic Modeling • Ballasting Calculations	• Details • Specifications • Materials List/Quantities • Cost Estimate	• Staking • Construction Direction • Inspection
3-2	0.39-0.41 (LB)	• Eroding Banks (toe) • Eroding Banks (face) • Denuded and/or Compacted Soils	**Stabilize streambank and enhance riparian corridor (incorporate existing rock)**.	• Reconstructed Bank (Typical Graphic C-1)	• Topographic and/or Quantity Survey • Hydraulic Modeling • Ballasting Calculations	• Details • Specifications • Materials List/Quantities • Cost Estimate	• Staking • Construction Direction • Inspection
3-3	0.47-0.50 (RB)	• Disconnected Floodplain / Entrenched Channel	**Reactivate floodplain and enhance riparian corridor.** Direct high flows into historic swale and onto the floodplain and return flows to the main channel.	• Bank Lowering with Overflow Channel Reactivation (Typical Graphic C-8) Required with Treatment 2-2	• Topographic and/or Quantity Survey • Hydraulic Modeling	• Details • Specifications • Materials List/Quantities • Cost Estimate	• Staking • Construction Direction • Inspection
3-4	0.53-0.54 (RB)	• Eroding Banks (toe) • Eroding Banks (face) • Denuded and/or Compacted Soils	**Enhance riparian corridor**. Exclude/ redirect recreation access.	• Riparian Buffer Enhancement	• Visual Survey	-	• Staking
3-5	0.67 (RB)	• Disconnected Floodplain / Entrenched Channel	**Reactivate overflow channels and enhance riparian corridor.** Direct high flows into historic swale and onto the floodplain and return flows to the main channel.	• Bank Lowering with Overflow Channel Reactivation (Typical Graphic C-8)	• Topographic and Visual Survey	• Details • Specifications • Materials List/Quantities • Cost Estimate	• Staking • Construction Direction • Inspection
3-6	0.83-0.85 (LB)	• Artificial Bank Protection • Eroding Banks (toe) • Eroding Banks (face) • Localized Channel Scour • Lateral Confinement	**Stabilize streambank and enhance riparian corridor.** Maintain/repair existing riprap wall and plant vegetation to enhance streambank corridor.	• Retain Artificial Bank Protection • Reconstructed Bank (Typical Graphic C-1)	• Topographic and/or Quantity Survey • Bank Stability Modeling • Ballasting Calculations	• Details • Specifications • Materials List/Quantities • Cost Estimate	• Staking • Construction Direction • Inspection

REACH 4



Map Features

- Bridge
- Campground
- Picnic Area
- Waterfall
- Primary Rd
- Secondary/Local Rd
- Trail
- Reach Breaks

Restoration Treatment Features

- Treament ID Number

Restoration Treatment Locations:

Yosemite Valley
Merced River Restoration Project

Reach and Treatment ID

Map 3 of 7

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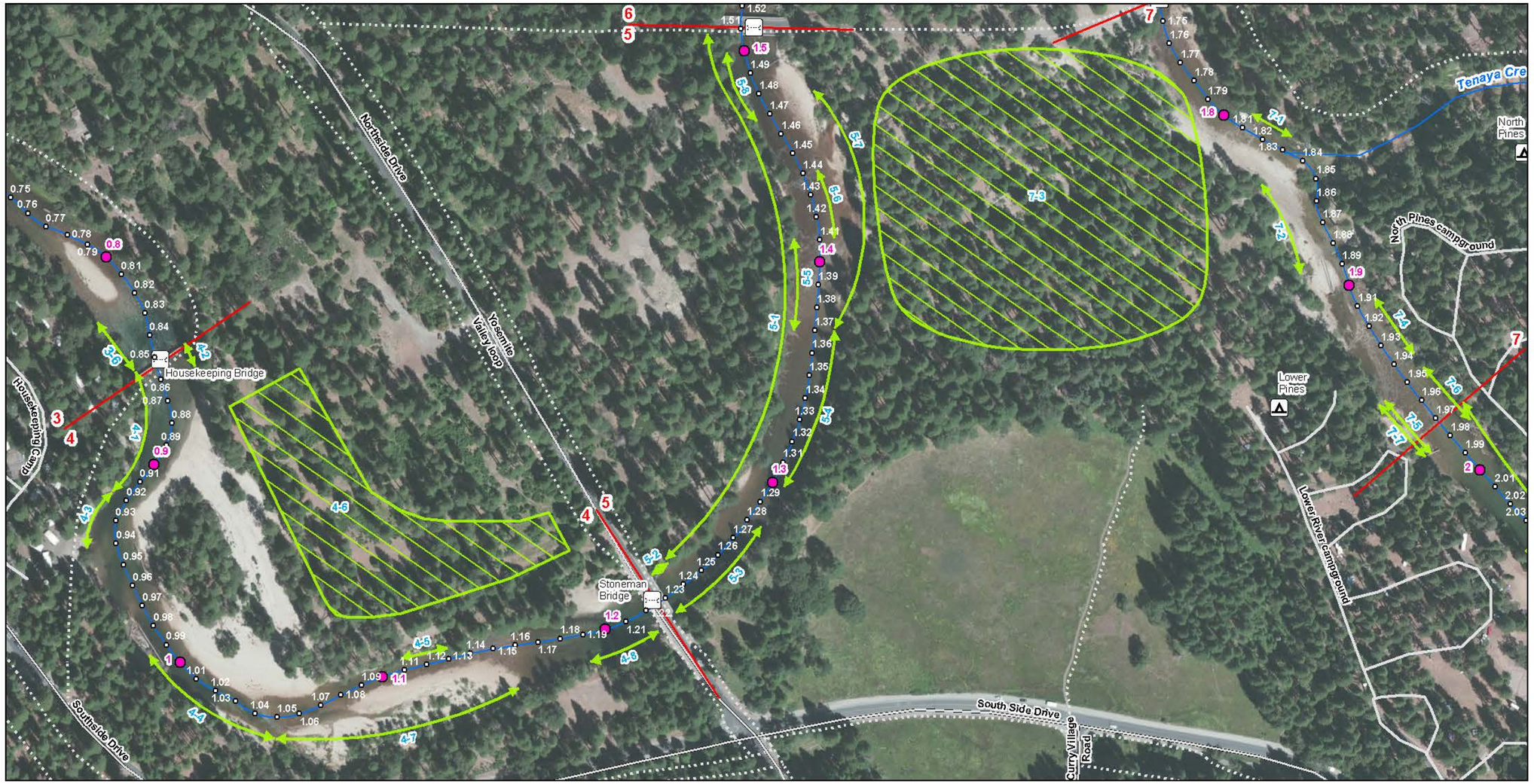
Reach and Treatment ID # (Map ID)	Location (River Miles) (LB or RB)	Existing Condition and Recommendations			Implementation Needs		
		Problems and Issues	**Treatment Objective**	**Treatment Type**	**Analyses**	**Design**	**Field Oversight**
Reach 4	**RM 0.85-1.22**						
4-1	0.85-0.92 (LB)	• Bridge Alignment (?) • Artificial Bank Protection • Eroding Banks (toe) • Eroding Banks (face) • Denuded and/or Compacted Soils • Minimal Vegetation Recruitment • Low Species Diversity • Simplified Vegetation Structure	**Stabilize streambank and enhance riparian corridor.** Retain rock at the toe, plant native vegetation on the upper bank, and exclude recreation access.	• Selective Riprap Removal (Typical Graphic C-2) • Riparian Buffer Enhancement • Bank Grading and Soil Modification	• Hydraulic Modeling • Bank Stability Modeling	• Details • Materials List/Quantities	• Staking • Inspection
4-2	0.85-0.86 (RB)	• Bridge Alignment (?) Artificial Bank Protection • Denuded and/or Compacted Soils	**Enhance riparian corridor.** Exclude/ redirect recreation access.	• Retain Artificial Bank Protection • Riparian Buffer Enhancement • Hardened River Access	• Visual Survey	-	• Staking
4-3	0.92-0.94 (LB)	• Disconnected Floodplain / Overwide Channel • Artificial Bank Protection • Simplified Channel Morphology • Denuded and/or Compacted Soils • Minimal Vegetation Recruitment • Simplified Vegetation Structure • Low Species Diversity	**Stabilize streambank and enhance riparian corridor.**	• Reconstructed Bank (Typical Graphic C-1) • Selective Riprap Removal (Typical Graphic C-2) • Riparian Buffer Enhancement • Bank Grading and Soil Modification	• Topographic and/or Quantity Survey • Hydraulic Modeling • Ballasting Calculations	• Details • Specifications • Materials List/Quantities • Cost Estimate	• Staking • Construction Direction • Inspection
4-4	0.99-1.05 (LB)	• Eroding Banks (face) • Denuded and/or Compacted Soils • Minimal Vegetation Recruitment • Simplified Vegetation Structure • Low Species Diversity • Unstable Tributary Confluence	**Stabilize streambank and enhance riparian corridor.**	• Reconstructed Bank (Typical Graphic C-1) • Brush Layering • Floodplain-building Logs (Typical Graphic C-5)	• Topographic and/or Quantity Survey • Hydraulic Calculations • Ballasting Calculations	• Details • Specifications • Materials List/Quantities • Cost Estimate	• Staking • Construction Direction • Inspection
4-5	1.11-1.13 (RB)	• Artificial Bank Protection • Eroding Banks (toe) • Eroding Banks (face) • Denuded and/or Compacted Soils • Simplified Vegetation Structure • Low Species Diversity	**Stabilize streambank and enhance riparian corridor**.	• Selective Riprap Removal (Typical Graphic C-2)	• Visual Survey	-	• Staking
4-6	0.88-1.21 (RB)	• Compacted / Dewatered Soils • Disconnected Floodplain / Entrenched Channel • Simplified Vegetation Structure • Low Species Diversity	**Enhance riparian corridor**. Remove dense pines; decompact soils, create microtopographic variation, and plant with various native floodplain species.	• Floodplain Grading and Soil Modification	• Visual Survey	• Specifications • Materials List/Quantities	• Staking
Reach 4	**RM 0.85-1.22**						

Reach and Treatment ID # (Map ID)	Location (River Miles) (LB or RB)	Existing Condition and Recommendations			Implementation Needs		
		Problems and Issues	Treatment Objective	Treatment Type	Analyses	Design	Field Oversight
4-7	1.05 to 1.16 (LB)	• Disconnected Floodplain / Overwide Channel	**Promote bar formation and narrow channel**. Place additional wood along the streambank to promote continued deposition of bar-forming materials.	• Lateral Bar-forming ELF (Typical Graphic C-7)	• Hydraulic Modeling • Ballasting Calculations	• Details • Specifications • Materials List/Quantities • Cost Estimate	• Staking • Construction Direction • Inspection
4-8	1.19-1.22 (LB)	• Localized Channel Scour • Eroding Banks (toe) • Eroding Banks (face) • Denuded and/or Compacted Soils • Minimal Vegetation Recruitment • Simplified Vegetation Structure • Low Plant Species Diversity	**Stabilize streambank and enhance riparian corridor**.	• Crib Structure (Typical Graphic C-3)	• Topographic and/or Quantity Survey • Ballasting Calculations	• Details • Specifications • Materials List/Quantities • Cost Estimate	• Staking • Construction Direction • Inspection

REACH 5



Map Features

- Bridge
- Campground
- Picnic Area
- Waterfall
- Primary Rd
- Secondary/Local Rd
- Trail
- Reach Breaks

Restoration Treatment Features

- Treament ID Number

Restoration Treatment Locations:

Yosemite Valley
Merced River Restoration Project

Reach and Treatment ID

Map 3 of 7

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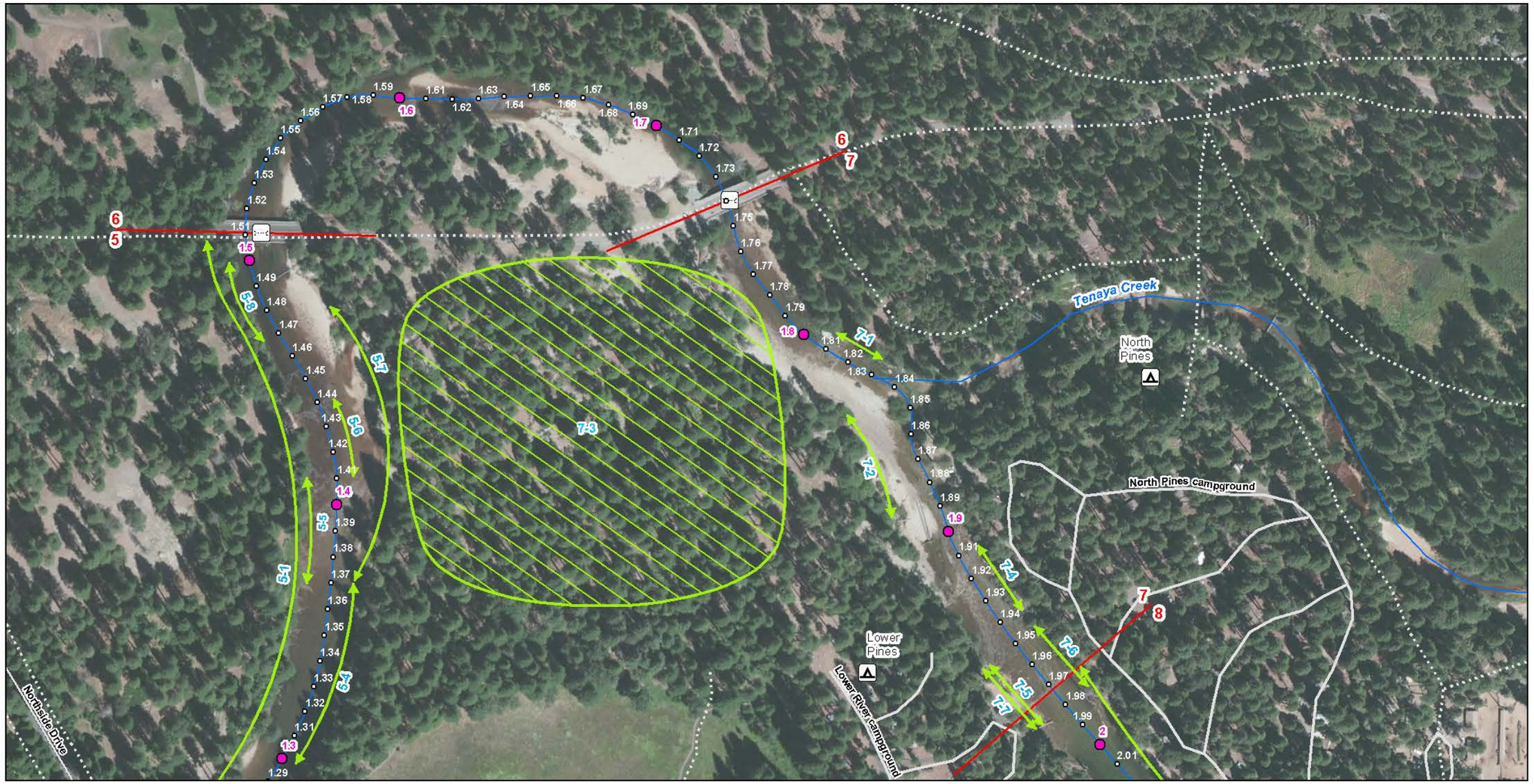
Reach and Treatment ID # (Map ID)	Location (River Miles) (LB or RB)	Existing Condition and Recommendations			Implementation Needs		
		Problems and Issues	**Treatment Objective**	**Treatment Type**	**Analyses**	**Design**	**Field Oversight**
Reach 5	**RM 1.22-1.51**						
5-1	1.24-1.51 (RB)	• Floodplain Fill • Denuded and/or Compacted Soils • Minimal Vegetation Recruitment • Low Species Diversity • Simplified Vegetation Structure	**Enhance riparian corridor**. Exclude/ redirect recreation access.	• Riparian Buffer Enhancement	• Visual Survey	-	• Staking
5-2	1.22-1.24 (RB)	• Denuded and/or Compacted Soils	**Enhance riparian corridor**. Exclude/ redirect recreation access.	• Hardened River Access	• Visual Survey	• Materials List/Quantities	• Staking
5-3	1.23 to 1.28 (LB)	• Artificial Bank Protection • Simplified Vegetation Structure • Bridge Alignment (?)	**Stabilize streambank and enhance riparian corridor**. Retain riprap to maintain stability and construct flow deflecting ELF to deflect flows away from the bank.	• Flow-deflecting ELF (Typical Graphic C-4) • Selective Riprap Removal (Typical Graphic C-2) • Bank Grading and Soil Modification	• Topographic and/or Quantity Survey • Hydraulic Modeling • Bank Stability Modeling • Ballasting Calculations	• Details • Specifications • Materials List/Quantities • Cost Estimate	• Staking • Construction Direction • Inspection
5-4	1.3 to 1.37 (LB)	• Disconnected Floodplain/ Overwide Channel • Simplified Channel Morphology • Minimal Vegetation Recruitment • Simplified Vegetation Structure	**Promote channel narrowing and enhance riparian corridor**. Bury logs near channel toe so that flows overtop logs and sediment settles behind logs, enlarge incipient floodplain surfaces and plant.	• Floodplain-building Logs (Typical Graphic C-5) Combine with Treatments 5-5 and 5-6	• Visual Survey	• Details • Specifications • Materials List/Quantities • Cost Estimate	• Staking • Construction Training • Inspection
5-5	1.37 to 1.41 (RB)	• Disconnected Floodplain/ Overwide Channel • Simplified Channel Morphology • Minimal Vegetation Recruitment • Simplified Vegetation Structure	**Promote channel narrowing and enhance riparian corridor**. Bury logs near channel toe so that flows overtop logs and sediment settles behind logs, enlarge incipient floodplain surfaces and plant.	• Floodplain-building Logs (Typical Graphic C-5) Combine with Treatments 5-4 and 5-6	• Visual Survey	• Details • Specifications • Materials List/Quantities • Cost Estimate	• Staking • Construction Training • Inspection
5-6	1.41-1.44 (LB)	• Disconnected Floodplain/ Overwide Channel • Simplified Channel Morphology	**Diversify channel morphology.** Prompt mid-channel bar-formation, raising the bed profile.	• Mid Bar-forming ELF (Typical Graphic C-6) Combine with Treatments 5-4 and 5-5	• Visual Survey • Ballasting Calculations	• Details • Specifications • Materials List/Quantities • Cost Estimate	• Staking • Construction Direction • Inspection
5-7	1.37-1.47 (LB)	• Disconnected Floodplain / Entrenched Channel • Minimal Vegetation Recruitment • Simplified Vegetation Structure	**Stabilize streambank and enhance riparian corridor**. **Reactivate overflow channel and protect return flows (from Treatment 7-2).**	• Bank Lowering with Overflow Channel Reactivation (Typical Graphic C-8) • Reconstructed Bank (Typical Graphic C-1) Required with Treatment 7-2	• Topographic and/or Quantity Survey • Hydraulic Modeling • Bank Stability Modeling • Ballasting Calculations	• Details • Specifications • Materials List/Quantities Cost Estimate	• Staking • Construction Direction • Inspection
5-8	1.47-1.50 (RB)	• Artificial Bank Protection	**Stabilize streambank while protecting existing vegetation**.	• Retain Artificial Bank Protection	-	-	-

REACH 6



Map Features

- Bridge
- Campground
- Picnic Area
- Waterfall
- Primary Rd
- Secondary/Local Rd
- Trail
- Reach Breaks

Restoration Treatment Features

- Treament ID Number

Restoration Treatment Locations:

Yosemite Valley
Merced River Restoration Project

Reach and Treatment ID

Map 4 of 7

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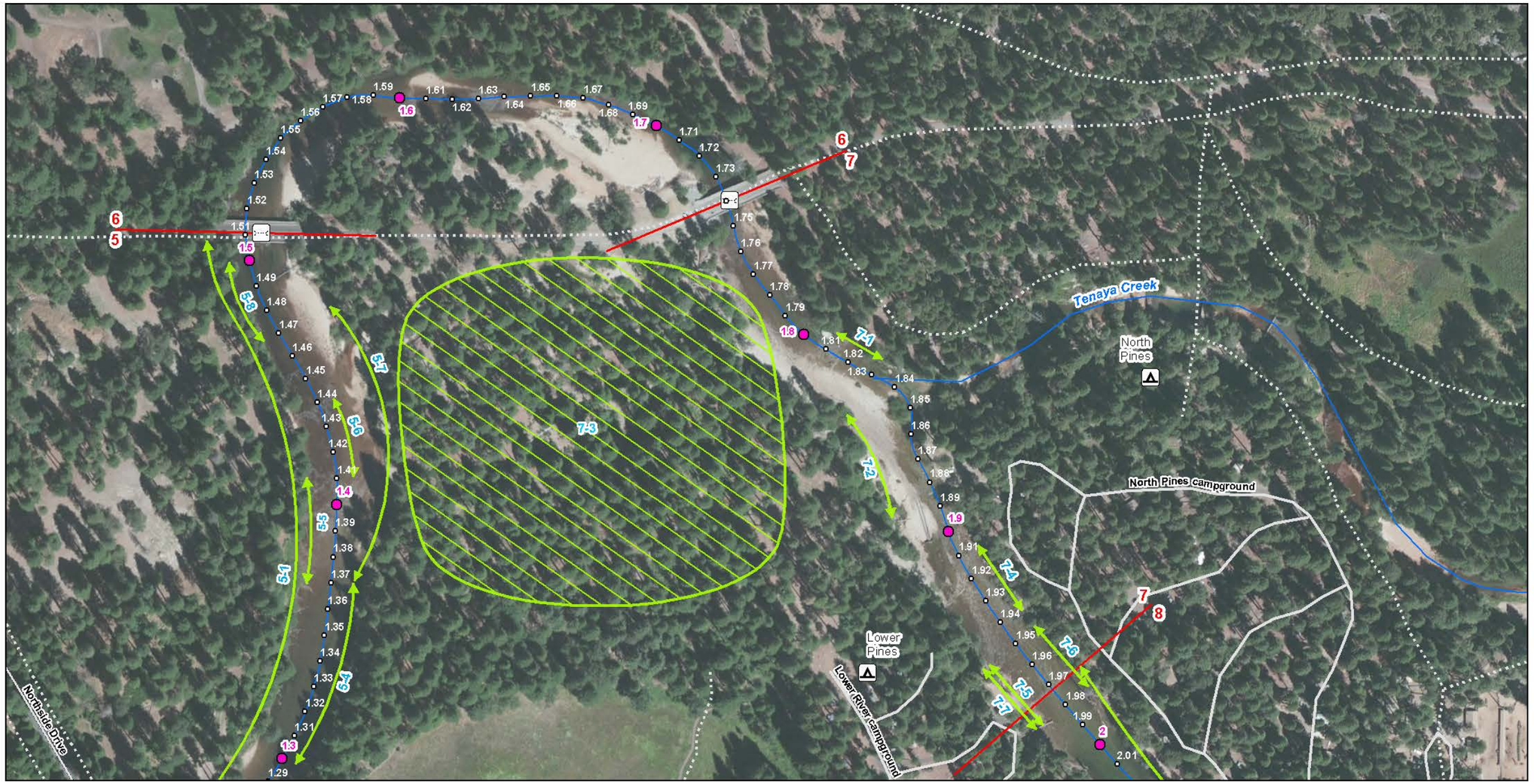
Reach and Treatment ID # (Map ID)	Location (River Miles) (LB or RB)	Existing Condition and Recommendations			Implementation Needs		
		Problems and Issues	Treatment Objective	Treatment Type	Analyses	Design	Field Oversight
Reach 6	**RM 1.51-1.74**						
Pending Investigation of the Reach-Specific Study							

REACH 7



Map Features

- Bridge
- Campground
- Picnic Area
- Waterfall
- Primary Rd
- Secondary/Local Rd
- Trail
- Reach Breaks

Restoration Treatment Features

- Treament ID Number

Restoration Treatment Locations:

Yosemite Valley
Merced River Restoration Project

Reach and Treatment ID

Map 4 of 7

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Reach and Treatment ID # (Map ID)	Location (River Miles) (LB or RB)	Existing Condition and Recommendations			Implementation Needs		
		Problems and Issues	**Treatment Objective**	**Treatment Type**	**Analyses**	**Design**	**Field Oversight**
Reach 7	**RM 1.74-1.97**						
7-1	1.81-1.83 (RB)	• Eroding Banks (face)	**Stabilize streambank erosion and enhance riparian corridor.** Construct Crib Structure (Typical Graphic C-3) with plantings to protect bank from continued bank erosion.	• Crib Structure (Typical Graphic C-3) Benefits Treatment 7-2 and 7-3	• Hydraulic Modeling Topographic and/or Quantity Survey • Ballasting Calculations	• Details • Specifications • Materials List/Quantities • Cost Estimate	• Staking • Construction Direction • Inspection
7-2	1.84-1.89 (LB)	• Disconnected Floodplain / Entrenched Channel • Bridge Alignment (?)	**Reconnect floodplain and enhance riparian corridor.** Reconnect historic swale to release flow onto floodplain during high flows.	• Bank Lowering with Floodplain Reconnection (Typical Graphic C-8) • LWD Relocation Required with Treatment5-7	• Hydraulic Modeling • Bank Stability Modeling	• Details • Specifications • Materials List/Quantities • Cost Estimate	• Staking • Construction Direction • Inspection
7-3	1.84-1.89 (LB)	• Compacted / Dewatered Soils • Floodplain Fill • Simplified Vegetation Structure • Low Species Diversity	**Enhance riparian corridor.** Remove dense pines; decompact soils and create microtopographic variation; plant with diversity of native floodplain species.	• Floodplain Grading and Soil Modification • LWD Relocation Benefits Treatments 5-7, 7-1, 7-2	• Visual Survey	• Specifications • LWD Maintenance Protocol	• Staking • Construction Training
7-4	1.91-1.94 (RB)	• Disconnected Floodplain / Overwide Channel • Simplified Vegetation Structure • Low Species Diversity • Minimal Vegetation Recruitment	**Promote channel narrowing and enhance riparian corridor.** Construct Lateral Bar-forming ELF (Typical Graphic C-7) to promote continued deposition. Exclude recreation access to protect riparian corridor and streambanks.	• Lateral Bar-forming ELF (Typical Graphic C-7) • Riparian Buffer Enhancement	• Visual and Quantity Survey • Ballasting Calculations	• Details • Specifications • Materials List/Quantities • Cost Estimate	• Staking • Construction Direction • Inspection
7-5	1.95-1.98 (LB)	• Disconnected Floodplain / Overwide Channel	**Stabilize streambank and enhance riparian corridor.** Incorporate standing and down large woody material.	• Reconstructed Bank (Typical Graphic C-1) • Brush Layering	• Visual and Quantity Survey • Ballasting Calculations	• Details • Specifications • Materials List/Quantities • Cost Estimate	• Staking • Construction Direction • Inspection
7-6	1.95-1.98 (RB)	• Denuded and/or Compacted Soils • Simplified Vegetation Structure • Low Species Diversity • Minimal Vegetation Recruitment	**Enhance riparian corridor.** Exclude/ redirect recreation access.	• Riparian Buffer Enhancement	• Visual Survey	-	• Staking
7-7	1.95-1.98 (LB)	• Denuded and/or Compacted Soils • Simplified Vegetation Structure • Low Species Diversity • Minimal Vegetation Recruitment	**Enhance riparian corridor.** Exclude/ redirect recreation access.	• Riparian Buffer Enhancement	• Visual Survey	-	• Staking

REACH 8

Map Features

- Bridge
- Campground
- Picnic Area
- Waterfall
- Primary Rd
- Secondary/Local Rd
- Trail
- Reach Breaks

Restoration Treatment Features

- Treament ID Number

Restoration Treatment Locations:

Yosemite Valley
Merced River Restoration Project

Reach and Treatment ID

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Reach and Treatment ID # (Map ID)	Location (River Miles) (LB or RB)	Existing Condition and Recommendations			Implementation Needs		
		Problems and Issues	**Treatment Objective**	**Treatment Type**	**Analyses**	**Design**	**Field Oversight**
Reach 8	**RM 1.97-2.18**						
8-1	1.97-2.14 (RB)	• Eroding Banks (toe) • Eroding Banks (face) • Floodplain Fill • Lateral Confinement • Denuded and/or Compacted Soils • Simplified Vegetation Structure • Minimal Vegetation Recruitment • Simplified Channel Morphology	**Stabilize streambanks and enhance riparian corridor.** Plant native vegetation and exclude/redirect recreation access.	• Brush Layering • Riparian Buffer Enhancement	• Visual Survey	• Specifications	• Staking
8-2	2.14-2.18 (RB)	• Floodplain Encroachment /Fill • Lateral Confinement • Denuded and/or Compacted Soils • Simplified Vegetation Structure • Low Species Diversity • Minimal Vegetation Recruitment	**Enhance riparian corridor.** Exclude/ redirect recreation access.	• Hardened River Access	• Visual Survey and Quantity Survey	• Specifications • Materials List/Quantities	• Staking
8-3	2.04-2.11 (LB)	• Eroding Banks (toe) • Eroding Banks (face) • Denuded and/or Compacted Soils • Simplified Vegetation Structure • Minimal Vegetation Recruitment	**Stabilize streambank and enhance riparian corridor.** Regrade soils after road removal for planting, plant native vegetation, and exclude/redirect recreation access.	• Riparian Buffer Enhancement • Bank Grading and Soil Modification • Floodplain Grading and Soil Modification	• Visual Survey	• Specifications • Materials List/Quantities	• Staking
8-4	2.16-2.18 (LB)	• Artificial Bank Protection • Denuded and/or Compacted Soils	**Stabilize streambanks.** Maintain existing riprap.	• Retain Artificial Bank Protection	-	-	-

REACH 9

Map Features

- Bridge
- Campground
- Picnic Area
- Waterfall
- Primary Rd
- Secondary/Local Rd
- Trail
- Reach Breaks

Restoration Treatment Features

- Treament ID Number

Restoration Treatment Locations:

Yosemite Valley
Merced River Restoration Project

Reach and Treatment ID

Map 6 of 7

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Reach and Treatment ID # (Map ID)	Location (River Miles) (LB or RB)	Existing Condition and Recommendations			Implementation Needs		
		Problems and Issues	Treatment Objective	Treatment Type	Analyses	Design	Field Oversight
Reach 9	**RM 2.18-2.71**						
9-1	2.18-2.21 (LB and RB)	• Artificial Bank Protection • Eroding Banks (face) • Denuded and/or Compacted Soils • Simplified Vegetation Structure • Minimal Vegetation Recruitment • Lateral Confinement	**Stabilize streambanks.** Maintain existing riprap.	• Retain Artificial Bank Protection • Bank Grading and Soil Modification	• Visual Survey	-	• Staking
9-2	2.21-2.24 (LB)	• Stormwater Drainage Infrastructure	**Enhance riparian corridor.** Restore functions to campground removal area	• Stormwater Pretreatment • Floodplain Grading and Soil Modification	• Visual Survey to identify runoff flow paths • Hydrologic Analysis	• Details • Specifications • Materials List/Quantities • Cost Estimate	• Construction Direction • Inspection
9-3	2.18-2.53 (LB)	• Eroding Banks (toe) • Eroding Banks (face) • Denuded and/or Compacted Soils • Unstable Tributary Confluence	**Enhance riparian corridor.** Regrade trail removal area for planting; plant; and exclude recreation access.	• Floodplain Grading and Soil Modification • Riparian Buffer Enhancement	• Visual Survey	• Specifications	• Staking

REACH 10

Map Features

- Bridge
- Campground
- Picnic Area
- Waterfall
- Primary Rd
- Secondary/Local Rd
- Trail
- Reach Breaks

Restoration Treatment Features

- Treament ID Number

Restoration Treatment Locations:

Yosemite Valley
Merced River Restoration Project

Reach and Treatment ID

Map 7 of 7

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Coordinate System:
UTM Zone 11, NAD 1983, meters

N W E S

0 50 100 200 Feet

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Reach and Treatment ID # (Map ID)	Location (River Miles) (LB or RB)	Existing Condition and Recommendations			Implementation Needs		
		Problems and Issues	**Treatment Objective**	**Treatment Type**	**Analyses**	**Design**	**Field Oversight**
Reach 10	**RM 2.71-2.95**						
10-1	2.73-2.77 (RB)	• Artificial Bank Protection • Denuded and/or Compacted Soils • Simplified Vegetation Structure • Minimal Vegetation Recruitment	**Stabilize streambanks and enhance riparian corridor.** Remove existing riprap and plant native vegetation.	• Selective Riprap Removal (Typical Graphic C-2)	• Visual Survey	• Specifications	• Construction Training
10-2	2.77-2.93 (RB)	• Artificial Bank Protection • Eroding Banks (face) • Simplified Vegetation Structure • Minimal Vegetation Recruitment • Disconnected Floodplain / Entrenched Channel	**Stabilize streambanks and enhance riparian corridor.** Remove existing riprap and plant native vegetation.	• Selective Riprap Removal (Typical Graphic C-2) • Floodplain Grading and Soil Modification Coordinate with Treatment 10-3 to determine boundary between riprap removal and retention	• Visual Survey	• Specifications	• Staking • Construction Training
10-3	2.93-2.95 (RB)	• Artificial Bank Protection • Eroding Banks (face) • Simplified Vegetation Structure • Minimal Vegetation Recruitment • Disconnected Floodplain / Entrenched Channel • Localized Channel Scour	**Stabilize streambanks.** Maintain existing riprap.	• Retain Artificial Bank Protection Coordinate with Treatment 10-2 to determine boundary between riprap removal and retention	• Hydraulic Modeling • Bank Stability Modeling	-	-
10-4	2.97-3.09 (LB)	• Lateral Confinement • Disconnected Floodplain / Entrenched Channel • Localized Channel Scour	**Reactivate overflow channels.** Reconnect high flow channels that connect to culverts adjacent to bridge to improve bridge conveyance.	• Bank Lowering with Overflow Channel Reactivation (Typical Graphic C-8) Required with Treatment 10-5	• Topographic and Quantity Survey • Hydraulic Modeling	• Details • Specifications • Materials List/Quantities • Cost Estimate	• Staking • Construction Direction • Inspection
10-5	2.7-2.9? (LB)	• Disconnected Floodplain / Entrenched Channel	**Accommodate reactivated overflow channel return flows.**	• Bank Lowering with Overflow Channel Reactivation (Typical Graphic C-8) Required with Treatment 10-4	• Hydraulic Modeling • Bank Stability Modeling	• Details • Specifications • Materials List/Quantities • Cost Estimate	• Staking • Construction Direction • Inspection

Appendix B

PHOTOGRAPHS OF REPRESENTATIVE CONDITIONS AND TREATMENT OPPORTUNITIES BY RIVER MILE

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Location (River Miles)	*Photos and Caption* *Describing Problems, Opportunities, or Constraints*
RM 0 – 0.19	***Reach 1 – Downstream end at Sentinel Bridge***
0-0.02 (LB and RB)	 LB facing DS: Soil compaction and vegetation trampling from recreation access (foreground); confinement by stable, vegetated artificial bank protection upstream of Sentinel Bridge (background)  RB facing DS: Confinement by stable vegetated artificial bank protection upstream of Sentinel Bridge

Location (River Miles)	*Photos and Caption* *Describing Problems, Opportunities, or Constraints*
0.02-0.04 (RB)	 RB facing DS: Artificial bank protection along overflow channel return area; bank face erosion on upper bank; toe of bank erosion under mature tree roots
0.05 (RB)	 RB view up overflow channel: Artificial bank protection along overflow channel return area; Bank face erosion on upper bank

Location (River Miles)	*Photos and Caption* *Describing Problems, Opportunities, or Constraints*
0.07-0.12 (mid channel)	 LB view DS: Overwide channel and mid channel bar; excess channel capacity
0.07-0.19 (LB)	 LB view DS: Bank toe erosion

Location (River Miles)	*Photos and Caption* *Describing Problems, Opportunities, or Constraints*
0.07-0.19 (LB)	 LB view DS: Bank toe erosion, lateral channel expansion (note old riprap), height of bank; living trees and LWM to incorporate in reconstructed bank  LB view US: High bank with active toe erosion, lateral channel expansion (note old riprap); overwide, shallow channel

Location (River Miles)	*Photos and Caption* *Describing Problems, Opportunities, or Constraints*

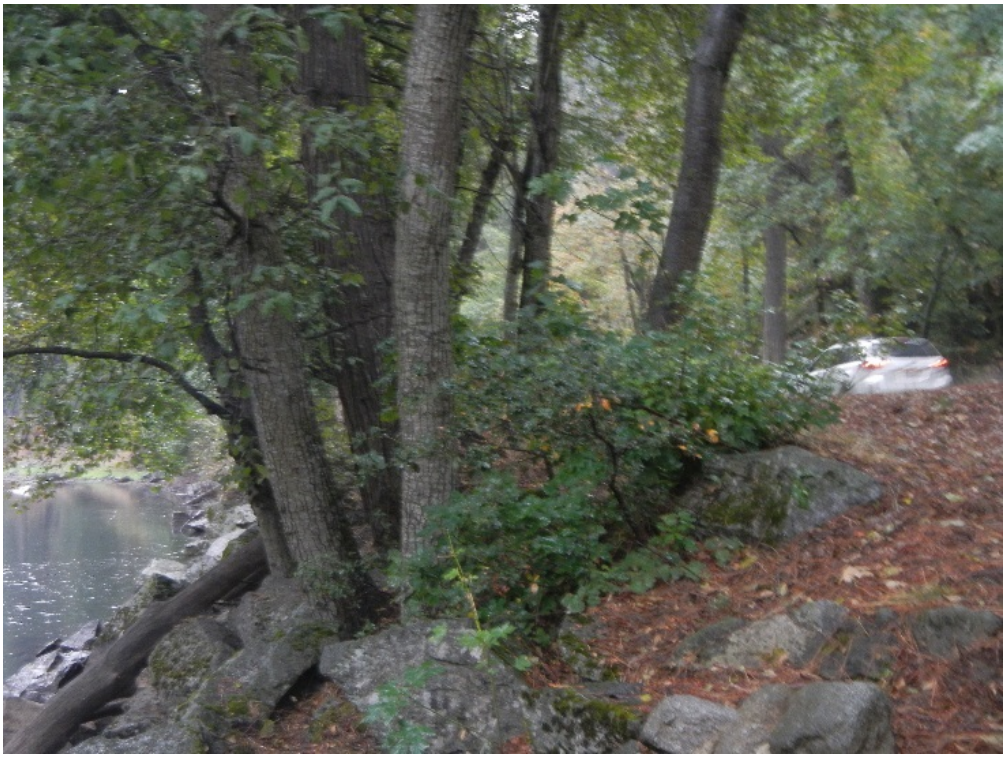
LB view up face: High, eroding bank (face and toe); simplified vegetation structure, minimal vegetation recruitment

LB view DS: Living vegetation and LWM with potential to incorporate and/or serve as model for reconstructed bank

Location (River Miles)	*Photos and Caption* *Describing Problems, Opportunities, or Constraints*
0.11-0.17 (RB)	 LB view to RB: Overwide channel, mid-channel bar and incipient floodplain development; disconnected floodplain  LB view to RB: Overwide channel, mid-channel bar and incipient floodplain development; disconnected floodplain; opportunity to reactivate

Location (River Miles)	*Photos and Caption* *Describing Problems, Opportunities, or Constraints*
0.15 (LB)	 LB view up bank face: Lack of bank vegetation, bank erosion and lateral retreat undermining bike trail
RM 0.19-0.35	***Reach 2 – RM 0.19 to RM 0.35 (the downstream extent of Housekeeping Camp)***
0.19-0.25 (LB)	 RB view DS to LB: Artificial bank protection (foreground) and lateral confinement; floodplain fill removal opportunities in the right overbank (background)

Location (River Miles)	*Photos and Caption* *Describing Problems, Opportunities, or Constraints*
0.29 (RB)	 LB view to RB: Overflow channel discharge point within disconnected floodplain
0.26-0.3 (LB)	 LB view US: Stormwater drainage outfall lacking pre-treatment

Location (River Miles)	*Photos and Caption* *Describing Problems, Opportunities, or Constraints*
	 LB view US: Lack of stormwater capture and pre-treatment, direct surface runoff paths
0.19-0.33 (LB)	 LB view US: Artificial bank protection and lateral confinement (road in background); mature vegetation on compacted soils; limited recruitment, low species diversity and simplified structure

Location (River Miles)	*Photos and Caption* *Describing Problems, Opportunities, or Constraints*
RM 0.35 – 0.85	***Reach 3 – RM 0.35 (the downstream extent of Housekeeping Camp) to Housekeeping Bridge***
0.36-0.39 (LB)	 LB view DS: High but eroding banks with racked logs and root wads suitable to integrate in reconstructed bank  LB view US: High but eroding banks with racked logs and root wads suitable to integrate in reconstructed bank

Location (River Miles)	*Photos and Caption* *Describing Problems, Opportunities, or Constraints*
0.39-0.41 (LB)	 LB view from US: Eroding banks with denuded and compacted soils and lack of vegetation; boulders suitable to integrate in reconstructed bank
0.47-0.50 (RB)	 RB viewed from point bar: Overflow swale entrance and surrounding, disconnected floodplain

Location (River Miles)	*Photos and Caption Describing Problems, Opportunities, or Constraints*
0.53-0.54 (RB)	 Bank damage from recreation access
0.67 (RB)	 DS view of planar bed channel and disconnected floodplain (RB foreground); possible channel reactivation (background)

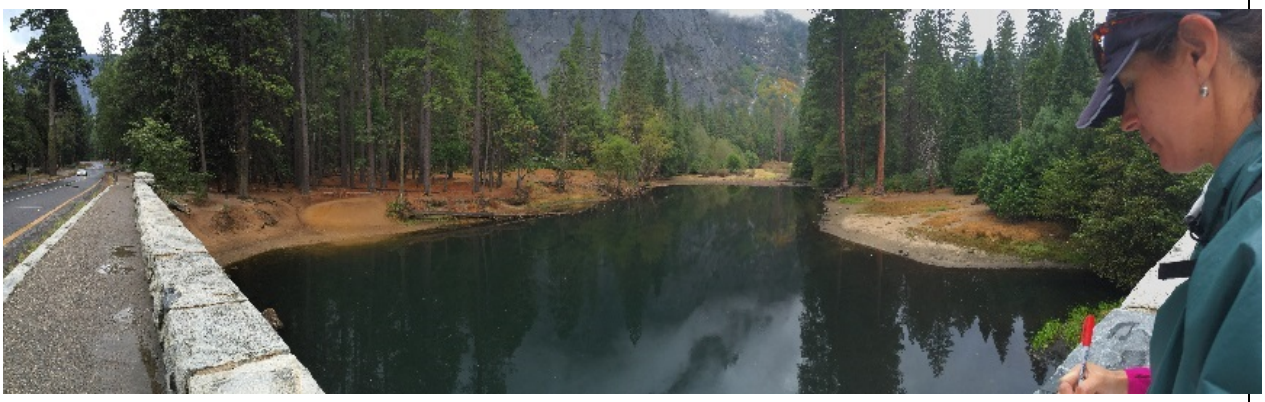
Location (River Miles)	*Photos and Caption Describing Problems, Opportunities, or Constraints*
0.83-0.85 (LB)	 LB viewed from Housekeeping Bridge: Localized scour along toe of bank, some soil compaction but vegetated overbank
RM 0.85 – 1.22	***Reach 4 – Housekeeping Bridge to Stoneman Bridge*** [1]
0.85-0.92 (LB)	 View DS from point bar to LB: Artificial toe of bank protection upstream of Housekeeping Bridge; compacted soils, denuded upper banks; bridge is not aligned with the direction of present active channel

[1] Photos not available for RM1.11-1.13 (RB) and 0.88-1.21 (RB).

Location (River Miles)	*Photos and Caption Describing Problems, Opportunities, or Constraints*
0.85-0.86 (RB)	 RB view US above Housekeeping Bridge: Damaged artificial bank protection and denuded bank with compacted soils (foreground); overflow channel/active point bar (background)
0.92-0.94 (LB)	 LB view from RB: Point bar stabilization and incipient floodplain building (foreground); artificial bank protection and denuded and compacted soils due to heavy visitor use (background)

Location (River Miles)	*Photos and Caption* *Describing Problems, Opportunities, or Constraints*
0.99-1.05 (LB)	 View US along RB towards LB: Widened channel with incipient floodplain; eroding banks with denuded and compacted soils and lack of vegetation diversity  View from RB to LB: High, eroding banks with simplified vegetation structure and low species diversity (old conifers)

Location (River Miles)	*Photos and Caption* *Describing Problems, Opportunities, or Constraints*
1.05-1.16 (LB)	 Analog for LWD at upstream end (left bank downstream of Stoneman Bridge)
1.19-1.22 (LB)	 LB viewed DS from Stoneman Bridge: High, eroding banks; localized scour downstream of bridge; denuded and compacted soils from recreation/boat access; simplified vegetation structure, low species diversity and minimal recruitment

Location (River Miles)	*Photos and Caption* *Describing Problems, Opportunities, or Constraints*
	 DS panorama from Stoneman Bridge
RM 1.22 – 1.51	**Reach 5 – *Stoneman Bridge to Ahwahnee Bridge***
1.24-1.51 (RB)	 View of RB from LB: Simplified vegetation structure, minimal vegetation recruitment, and denuded and/or compacted soils in the overbank

Location (River Miles)	*Photos and Caption* *Describing Problems, Opportunities, or Constraints*
1.22-1.24 (RB)	 US view of RB from Stoneman Bridge: Denuded and compacted soils and lack of vegetation recruitment
1.23-1.28 (LB)	 LB view DS to Stoneman Bridge: Lateral confinement by artificial bank protection with mature vegetation at top of bank

Location (River Miles)	*Photos and Caption Describing Problems, Opportunities, or Constraints*
	 LB view DS to Stoneman Bridge: Opportunities for partial riprap removal and strategically located flow deflecting ELFs
1.3-1.37 (LB)	 DS view of LB from RB: Overwide channel disconnected from floodplain, with incipient floodplain; denuded and/or compacted soils at top of bank

Location (River Miles)	*Photos and Caption* *Describing Problems, Opportunities, or Constraints*
1.37-1.41 (RB)	 View of RB from LB: Overwide channel disconnected from floodplain, with incipient floodplain; denuded and/or compacted soils at top of bank  RB view US: Incipient floodplain with analog for channel toe protection/sediment trapping

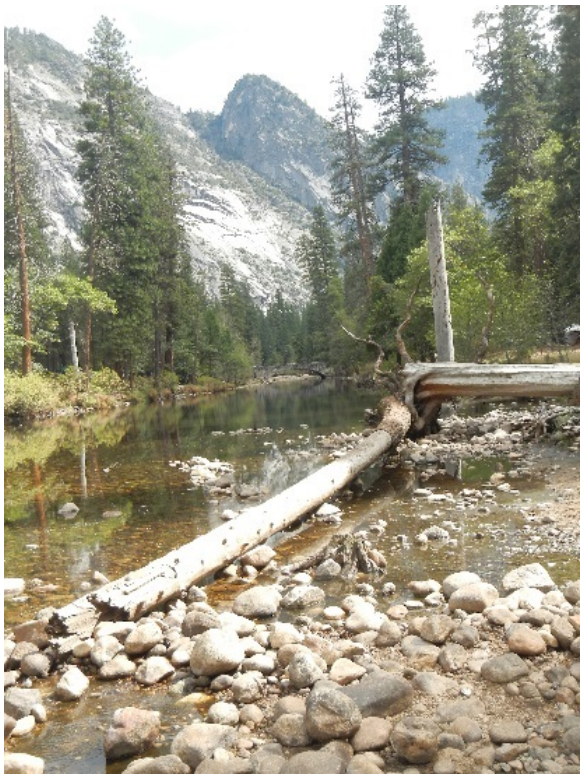
Location (River Miles)	*Photos and Caption* *Describing Problems, Opportunities, or Constraints*
1.41-1.44 (LB)	 US view: Overwide, simplified channel with no distinct bedform or profile diversity  DS view: Overwide, simplified channel lacking distinct bedform or profile diversity

Location (River Miles)	*Photos and Caption* *Describing Problems, Opportunities, or Constraints*
1.37-1.47 (LB)	 View from mid-channel to LB: Disconnected floodplain/overflow swale discharge; denuded and compacted soils from recreation access on LB  View up LB overflow swale

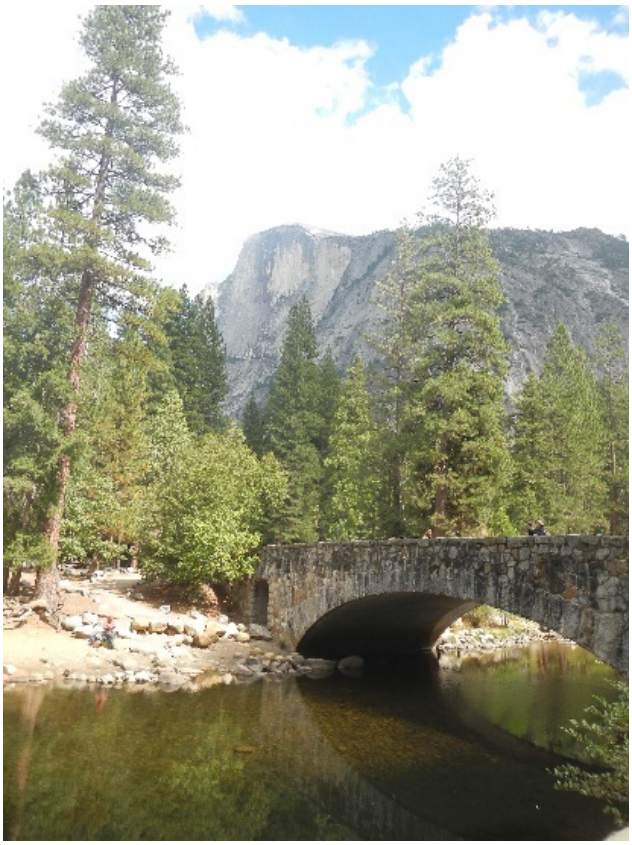
Location (River Miles)	*Photos and Caption* *Describing Problems, Opportunities, or Constraints*
1.47-1.50 (RB)	 DS view from Ahwahnee Bridge: Asymmetrical channel shape upstream of LB overflow channel outfall opposite vegetated artificial protection on RB
RM 1.51 – 1.74	***Reach 6 – Ahwahnee Bridge to Sugar Pine Bridge***
	Pending investigation of reach-specific study
RM 1.74 – 1.97	***Reach 7 – Sugar Pine Bridge to RM 1.97[2]***
1.81-1.83 (RB)	 US view to RB and Tenaya Creek from LB: Areas along RB with erosion and bank retreat between Tenaya Creek and Sugar Pine bridge

[2] Photo not available for RM 1.92-1.93 (RB).

Location (River Miles)	*Photos and Caption* *Describing Problems, Opportunities, or Constraints*
1.84-1.89 (LB)	 DS view to Sugar Pine bridge from LB; disconnected LB floodplain and entrenched channel; Racked LWD blocking overflow swale entrance on LB US of the bridge  View from LB onto floodplain: Example swale to reactivate

Location (River Miles)	*Photos and Caption* *Describing Problems, Opportunities, or Constraints*
1.95-1.98(LB)	 US view along LB: Overwide channel with remnant standing and fallen trees, limited sediment storage; opportunity for reconstructed bank
1.95-1.98 (RB)	 View RB to LB: Recreation access impacts on floodplain soils and vegetation and within channel

Location (River Miles)	*Photos and Caption* *Describing Problems, Opportunities, or Constraints*
1.95-1.98 (LB)	 View RB to LB: Recreation access impacts on floodplain soils and vegetation and within channel
RM 1.97 – 2.18	***Reach 8 – RM 1.97 to Clarks Bridge***
1.97-2.14 (RB)	 RB viewed from LB: Stabilized bank toe and plantings (foreground); denuded and compacted soils, recreation access impacts (background)

Location (River Miles)	*Photos and Caption* *Describing Problems, Opportunities, or Constraints*
	 RB viewed from LB: Denuded and compacted soils downstream of Clarks Bridge
2.14-2.18 (RB)	 View DS to RB from Clark's Bridge: Denuded and compacted soils downstream of Clarks Bridge; hardened river access needs

Location (River Miles)	*Photos and Caption* *Describing Problems, Opportunities, or Constraints*
2.04-2.11 (LB)	 View LB riparian corridor towards the Merced River from campground: Denuded and compacted soils and simplified vegetation; Continued buffer protection and soil regrading/decompaction and planting with road removal
2.16-2.18 (LB)	 DS view from Clarks Bridge: Straight, uniform and simple channel, artificial bank protection (LB); Denuded and compacted soils from recreation access (both banks); bank plantings (RB, background)

Location (River Miles)	*Photos and Caption* *Describing Problems, Opportunities, or Constraints*
RM 2.18 – 2.71	***Reach 9 – Clarks Bridge to RM 2.71***
2.18-2.21 (LB and RB)	 DS view to Clarks Bridge from LB: Retain riprap at bridge approaches on both banks
2.21-2.24 (LB)	 US view from Clarks Bridge to LB: Bank riprap to retain (foreground); denuded and compacted soils from recreation access; Dump station removal and stormwater management issues (background)

Location (River Miles)	*Photos and Caption Describing Problems, Opportunities, or Constraints*
2.18-2.53 (LB)	 US view along LB: High eroding bank with denuded and compacted soils and lack of vegetation—treatment in progress with riparian buffer fencing and top-of-bank plantings
RM 2.71 – 2.95	***Reach 10 – RM 2.71 to Happy Isle Bridge***
2.73-2.77 (RB)	 View from LB to RB: Artificial bank protection, compacted soils and minimal vegetation recruitment along trail (background)

Location (River Miles)	*Photos and Caption* *Describing Problems, Opportunities, or Constraints*
2.77-2.93 (RB)	 View from LB to RB: Artificial bank protection and bank face erosion (foreground); denuded and compacted soils, lack of vegetation recruitment and simplified vegetation structure
2.93-2.95 (RB)	 DS view of RB from Happy Isles Bridge: Entrenched channel with high, eroding banks, artificial bank protection, and minimal vegetation recruitment

Location (River Miles)	*Photos and Caption Describing Problems, Opportunities, or Constraints*
2.97-3.09	 US view to RB under Happy Isles Bridge: Scour evidence of lateral confinement (1 to 2 meters of local scour around bridge footings)  DS view of the LB: View of the overflow channel culvert presently blocked by boulder and cobble debris

Location (River Miles)	*Photos and Caption* *Describing Problems, Opportunities, or Constraints*
	 DS view of the blocked overflow channel culvert

Appendix C

TYPICAL CONCEPT GRAPHICS FOR TREATMENT TYPES

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Print Appendix C graphics 11 x 17 inch paper for best viewing

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