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Coon Creek Watershed Assessment

Final Report

Prepared for:

County of Placer

Prepared by:

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February 2017

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COON CREEK
WATERSHED ASSESSMENT

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and
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TABLE OF CONTENTS

EXECUTIVE SUMMARY 1
1 INTRODUCTION 4
2 GEOMORPHIC ASSESSMENT 5
2.1 WATERSHED AND STREAM CHANNEL OVERVIEW 5
2.2 GEOLOGY 6
2.3 SOILS 7
2.4 HISTORICAL CHANNEL ASSESSMENT 8
2.5 SPECIFIC STREAM POWER ANALYSIS 9
2.6 FLUVIAL AUDIT 10
2.7 SEDIMENT INPUT 13
2.8 SEDIMENT STORAGE 14
2.9 GEOMORPHIC PROCESS REGIME 15
3 HYDROLOGIC ASSESSMENT 18
3.1 BASIN HYDROLOGY OVERVIEW 18
3.2 CLIMATE AND PRECIPITATION 19
3.3 FLOW MANAGEMENT AND CONVEYANCE 20
3.3.1 Entities Influencing In-Stream Flows 20
3.3.2 Flow Management and Conveyance Influences on Stream Flows 21
3.4 PEAK FLOW REGIME 25
4 WATER QUALITY ASSESSMENT 31
4.1 WATER QUALITY OVERVIEW 31
4.1.1 Previous Monitoring Efforts 31
4.1.2 General Monitoring Approach 34
4.2 TEMPERATURE MONITORING 35
4.2.1 General Background 35
4.2.2 Temperature Monitoring Approach 36
4.2.3 Temperature Monitoring Findings 37
4.2.4 Temperature Suitability for Salmonids 40
4.3 DISSOLVED OXYGEN MONITORING 43
4.3.1 WY 2015 DO Monitoring 44
4.3.2 WY 2016 DO Monitoring 44
4.4 ANALYTICAL LABORATORY ANALYSIS 46
4.4.1 Sampling Methodology 46
4.4.2 Results and Discussion 47
5 RIPARIAN AND AQUATIC HABITAT ASSESSMENT 51

5.1 COARSE-SCALE ASSESSMENT 51
5.2 CRAM ASSESSMENT 52
5.2.1 Methods 52
5.2.2 Results 54
5.2.3 Conclusion 58
6 FISHERIES ASSESSMENT 59
6.1 INTRODUCTION 59
6.2 METHODS 60
6.2.1 Fish Habitat Reconnaissance Assessment–Winter 2015 60
6.2.2 Fish Distribution and Species Assemblage Surveys–Spring 2015 60
6.2.3 Chinook Salmon Emigration Timing Surveys–Spring 2016 62
6.3 RESULTS 63
6.3.1 Fish Habitat Reconnaissance Assessment–Winter 2015 63
6.3.2 Fish Distribution and Species Assemblage Surveys–Spring 2015 65
6.3.3 Chinook Salmon Emigration Timing Surveys–Spring 2016 69
6.4 DISCUSSION 71
6.5 CONSIDERATIONS REGARDING FUTURE ACTIONS 75
7 WATERSHED DISTURBANCE ASSESSMENT 77
7.1 REFERENCE STATE CONDITIONS 77
7.2 HYDROLOGIC DISTURBANCES 80
7.2.1 Land Cover Change and Hydromodification 81
7.2.2 Channel Disconnection 81
7.2.3 Flow Management Effects 81
7.3 DISTURBANCES TO PHYSICAL PROCESSES AND CONDITIONS 83
7.3.1 Disturbances to Physical Process Regime 83
7.3.2 Engineering and Land Use Pressure Index 84
7.4 WATER QUALITY DISTURBANCES 87
7.5 ECOLOGICAL DISTURBANCES 88
7.6 FUTURE DRIVERS OF CHANGE 90
8 OPPORTUNITIES AND CONSTRAINTS ANALYSIS 91
8.1 IDENTIFIED STRATEGIES AND OPPORTUNITIES 91
8.1.1 Considerations for Anadromous Fisheries Enhancement 104
8.1.2 Considerations for Flow Management 105
8.2 PRIORITIZED STRATEGIES AND PROJECTS 109
8.3 RECOMMENDED STUDIES 139
9 CONCLUSIONS AND RECOMMENDATIONS 143
10 REFERENCES 145

11 LIST OF PREPARERS 148
12 ACKNOWLEDGMENTS 149
APPENDIX A - HYDROLOGY 224
APPENDIX B - WATER QUALITY 229
APPENDIX C - CRAM 234
APPENDIX D - DISTURBANCES 245
APPENDIX E - OPPORTUNITIES 247

LIST OF TABLES

Table 1. Modeled peak flows for pre-disturbance conditions 28
Table 2. Percent increase in modeled peak flows for existing conditions 29
Table 3. Percent increase in modeled peak flow for future fully developed conditions 30
Table 4. Summary of Previous Monitoring Efforts 32
Table 5. Fall-run Chinook salmon water temperature index values by life stage 41
Table 6. Steelhead water temperature index values by life stage 41
Table 7. Summary of Discrete Sampling Efforts for Laboratory Analysis 46
Table 8. Exceedances of Aquatic Toxicity Criteria 50
Table 9. Exceedances of Human Health Criteria 50
Table 10. Qualitative Conditions of CRAM Score Ranges 53
Table 11. CRAM Attribute and Overall Scores for 19 Assessment Areas in the Coon Creek Watershed ... 55
Table 12. Average Overall CRAM Scores by Reach 56
Table 13. The Five Most Significant Stressors Affecting the Coon Creek Watershed 57
Table 14. Criteria of Pool Habitat Complexity Values 62
Table 15. Results of Winter 2015 Fish Habitat Reconnaissance Assessment 64
Table 16. Spring 2015 Fish Survey Reach Descriptions 66
Table 17. Count of Each Species Captured or Observed During Seine or Snorkel Surveys in Coon Creek and Doty Ravine in Spring 2015. 67
Table 18. Number of Fall-run Chinook Salmon and *O. mykiss*, and Proportion of Native Species by Reach in Coon Creek and Doty Ravine in Spring 2015 68
Table 19. Number of Times Each Pool Habitat Complexity Value Was Observed in Each Reach 69
Table 20. Mean Water Temperature of Survey Reaches 69
Table 21. Count of Each Species Observed During Snorkel Surveys in Coon Creek and Doty Ravine in Spring 2016 70
Table 22. Stressors to Anadromous Fish by Relevant Life Stage 74
Table 23. Summary of engineering and land use pressure feature classes and weightings 85
Table 24. Rehabilitation opportunities and constraints matrix 92

LIST OF FIGURES

Figure 1. Watershed Location 150
Figure 2. Watershed Overview and DEM 151
Figure 3. LiDAR Data Sources 152
Figure 4. Identification of Geomorphic Sub-Reaches 153
Figure 5. Geology Map 154
Figure 6. Soils Map 155
Figure 7. Historic Channel Alignments - Lower Historic Coon Creek 156
Figure 8. Historic Channel Alignments - Lower Watershed 157
Figure 9. Historic Channel Alignments - Lower to Middle Watershed 158
Figure 10. Stream Gradient 159
Figure 11. Specific Stream Power 160
Figure 12. Fluvial Audit Coverage 161
Figure 13. Example Fluvial Audit Data Mapping 162
Figure 14. Reach Type Characterization - Lower Watershed 163
Figure 15. Reach Type Characterization - Middle Watershed 164
Figure 16. Beaver Dam Density 165
Figure 17. Large Wood Occurrence Density 166
Figure 18. Relative Surface Erosion Hazard Potential 167
Figure 19. Bank Erosion Index 168
Figure 20. Sediment Storage Index 169
Figure 21. Geomorphic Process Regime - Lower Watershed 170
Figure 22. Geomorphic Process Regime - Middle Watershed 171
Figure 23. East Side Canal 172
Figure 24. Lower Coon Creek - Reach 9 173
Figure 25. Lower Coon Creek - Reaches 8 and 10 174
Figure 26. Lower Coon Creek - Reaches 11 and 12 175
Figure 27. Lower Coon Creek - Reaches 14 and 16 176
Figure 28. Coon Creek - Reaches 20 and 22 177
Figure 29. Coon Creek - Lower Canyon - Reach 23 178
Figure 30. Coon Creek - Upper Canyon Reach 179
Figure 31. Coon Creek Hydrography Overview 180
Figure 32. Hydrology Gaging and Climate Station Locations 181
Figure 33. Average Monthly Precipitation 182
Figure 34. Mean Annual Precipitation Mapping 183
Figure 35. Annual Precipitation for Auburn and Nicolaus 184
Figure 36. Average Monthly Air Temperatures 185
Figure 37. Camp Far West Diversion Dam 186
Figure 38. Doty South at Head Diversion Dam 187
Figure 39. Coon Creek Flows at SSWD in 2010 and 2013 188
Figure 40. Coon Creek Annual Flow Range at SSWD Weir 189
Figure 41. Coon Creek Monthly Flow Range at SSWD Weir 190

Figure 42. Coppin Dam and Auburn Extension Canal 191
Figure 43. Increase in 2-Year Event Discharge Between Existing and Pre-Disturbance Conditions 192
Figure 44. Increase in 2-Year Event Discharge Between Future Fully Developed and Pre-Disturbance Conditions 193
Figure 45. Water Quality Monitoring Sites 194
Figure 46. Daily Average Water Temperature at All Monitoring Sites 195
Figure 47. Daily Maximum Water Temperature at All Monitoring Sites 196
Figure 48. Daily Temperature Range at Select Sites 197
Figure 49. Effects of Temperature and Exposure Duration on Salmonids 198
Figure 50. Reach Delineation for Salmonid Thermal Suitability Assessment 199
Figure 51. Chinook Thermal Suitability - Coon Upper 2 - WY 2015 200
Figure 52. Chinook Thermal Suitability - Coon Upper 2 - WY 2016 201
Figure 53. Chinook Thermal Suitability - Doty 2 - WY 2016 202
Figure 54. Chinook Spawning and Embryo Incubation Thermal Suitability - WY 2016 203
Figure 55. Juvenile Chinook Thermal Suitability at Representative Reaches - WY 2016 204
Figure 56. Chinook Salmon Thermal Suitability by Life Stage - WY 2016 205
Figure 57. Steelhead Thermal Suitability by Life Stage - WY 2016 206
Figure 58. Dissolved Oxygen Monitoring - WY 2015 207
Figure 59. Dissolved Oxygen Monitoring - WY 2016 208
Figure 60. Analytical Laboratory Analysis - Constituents of Interest 209
Figure 61. Riparian Habitat Quality Map 210
Figure 62. CRAM Site Locations 211
Figure 63. Cumulative Average Overall CRAM Scores 212
Figure 64. Average CRAM Metric Scores 213
Figure 65. Distribution of CRAM Scores among Qualitative Categories 214
Figure 66. Comparison of Coon Creek and State-Wide CRAM Scores 215
Figure 67. Percentage of Coon Creek Sites Affected by 5 Key Stressors 216
Figure 68. Coon Creek Habitat Assessment - Winter 2015 217
Figure 69. Coon Creek Fish Survey Reaches - Spring 2015 218
Figure 70. Coon Creek Fish Surveys - Spring 2016 219
Figure 71. Doty Ravine Mining Tailings 220
Figure 72. Engineering and Land Use Pressure Index 221
Figure 73. Flow Management Alternative Concept for Upper Coon Creek 222
Figure 74. High Priority Individual Site Locations 223

GLOSSARY OF ACRONYMS

Acronym	Meaning
AR/CC ERP	Auburn Ravine / Coon Creek Ecosystem Restoration Plan
CDFW	California Department of Fish and Wildlife
COOP	Cooperative Observer Network
CVFED	Central Valley Floodplain Evaluation and Delineation
DEM	Digital Elevation Model
DWR	Department of Water Resources
eWRIMS	Electronic Water Rights Information Management System
FEMA	Federal Emergency Management Agency
LiDAR	Light Detection and Ranging
MCL	Maximum Contaminant Level
NCDC	National Climatic Data Center
NED	National Elevation Dataset
NID	Nevada Irrigation District
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
PCCP	Placer County Conservation Plan
PG&E	Pacific Gas & Electric
PNSSNS	Placer Nevada South Sutter North Sacramento Subwatershed Group
SSURGO	Soil Survey Geographic Database
SSWD	South Sutter Water District
SWRCB	State Water Resources Control Board
TMDL	Total Maximum Daily Load
USGS	United States Geological Survey
WWTP	Waste Water Treatment Plant

EXECUTIVE SUMMARY

This report documents the Coon Creek Watershed Assessment, a multidisciplinary effort to characterize environmental conditions, assess disturbances, and develop and prioritize restoration opportunities for the Coon Creek watershed. This assessment was performed by cbec inc., eco engineering with H.T. Harvey & Associates for Placer County and builds upon the Auburn Ravine / Coon Creek Ecosystem Restoration Plan developed in 2002. The findings and recommendations generated through this assessment will be used to inform the Placer County Conservation Plan (PCCP), a framework for conserving and restoring natural resources in western Placer County while coordinating and streamlining the permitting process for covered activities.

Coon Creek originates in the Sierra Nevada foothills immediately north of Auburn and flows west to the floor of the Central Valley where it is intercepted by the East Side Canal approximately 20 miles north of Sacramento. At its upper (eastern) end, the 101-square mile watershed features a moderately developed headwater plateau in the vicinity of Auburn. A short distance west, Coon Creek descends through a high-gradient canyon reach within a minimally developed portion of the watershed. When the stream exits the canyon reach upstream of McCourtney Road, it passes through a fairly dynamic, semi-confined channel corridor influenced by cattle grazing pressures. Downstream of its confluence with Doty Ravine, the largest tributary in the watershed, Coon Creek's gradient continues to decline and adjacent land use becomes increasingly agricultural with rice the dominant crop. At its present-day downstream end, Coon Creek flows into the East Side Canal which feeds the Cross Canal and eventually the Sacramento River.

Physical disturbances to the stream system are most pronounced in the middle and lower watershed. Upon exiting the canyon reach upstream of McCourtney Road, disturbances to the channel and floodplain become steadily more pronounced as the stream flows west. The channel alignment between McCourtney Road and the confluence with Doty Ravine suggests that the stream was realigned before 1910, likely for agricultural or cattle grazing purposes. This reach also happens to be the most dynamic section of the stream where it deposits cobbles, gravel and sand within the channel and the floodplain. Downstream of the Doty Ravine confluence, Coon Creek's natural pattern would have been one of increasing sinuosity and tortuous meander bends. However, the channel was extensively straightened for agricultural purposes (particularly within present-day Sutter County) and is now bordered closely by rice fields with little to no riparian corridor beyond the top of the stream bank. The most significant historic impact to Coon Creek was the construction of the East Side Canal, a linear, levee-bound drainage canal that completely disconnected Coon Creek from its downstream-most reach.

With a maximum watershed elevation of 2,205 feet, snowfall is a rare occurrence and hydrology of the catchment is driven largely by rainfall. Due to the Mediterranean climate of the region, the stream likely exhibited wet winters with rain-driven flood events and dry summers typically characterized by little to no stream flow throughout much of the watershed. However, in-stream flows of Coon Creek and its tributaries are heavily influenced today by conveyance and delivery practices during the irrigation season which typically extends from April 15th to October 15th. Water agencies operating in the basin convey imported water along a complex network of canals and stream channels to facilitate deliveries,

largely for irrigation purposes. As a result, as Coon Creek and Doty Ravine descend from east to west, they experience several cycles of flow augmentation followed by partial or complete diversion of stream flow. In addition to these spatial discontinuities in flow, irrigation deliveries and diversions can also drive high levels of temporal variability in stream flows on a daily and weekly basis during the irrigation season. Due to the limited degree of urbanization in the watershed, increases to peak flows are relatively minor (compared to other Sierra foothill watersheds) and are most notable within the headwaters draining Auburn.

Coon Creek is believed to serve as a habitat area for fall-run Chinook salmon and Central Valley steelhead, and a significant component of this project was conducting fish surveys and assessing habitat suitability for anadromous fish. Juvenile fall-run Chinook salmon were generally observed to be widespread along reaches accessible to anadromy in spring of 2015 but somewhat less so in spring of 2016. However, the limited observations of *O. mykiss* were expected to be resident rainbow trout rather than anadromous steelhead and the present-day use of Coon Creek by steelhead is unknown. Physical habitat quality along surveyed reaches in the middle watershed ranges from poor to excellent, but is generally expected to be supportive of spawning and rearing of anadromous fish. Anadromous fish are able to access all reaches of Coon Creek below Lower Hidden Falls and all reaches of Doty Ravine below the Garden Bar Road culvert during moderate or greater flows.

Temperature monitoring during water years 2015 and 2016 indicate that stream temperatures are generally suitable for fall-run Chinook salmon and Central Valley steelhead between November and April. However, by mid-May temperatures along many reaches become stressful and even lethal, particularly in the lower watershed, and may cause mortality of rearing and emigrating juveniles. Flow management practices also complicate the temperature regime of Coon Creek, both spatially and temporally. As an example, reaches used for conveyance often exhibit locally cooler water temperatures than those immediately upstream of flow releases or downstream of diversions. Dissolved oxygen levels were generally suitable for anadromous fish and most aquatic life during the winter and spring months, but became stressfully low for many aquatic organisms during the summer months at a monitoring station in the lower watershed. Other water quality concerns include historic nitrate loading from the SMD-1 waste water treatment plan before its closure in 2016 as well as occasional pesticide loading from agricultural or suburban land use.

Despite the historic and ongoing disturbances to the Coon Creek watershed, it remains one of the least developed Sierra foothill watersheds in Placer County and has the potential for significant physical and ecological uplift. This assessment identified a portfolio of basin-level rehabilitation and management strategies, site-specific restoration projects, and considerations for future management efforts and studies. Of specific emphasis are projects aimed at improving the success of salmonid rearing and emigration life stages. The installation of fish screens and passage improvements at the Doty South at Head Diversion Dam and Coppin Dam on the East Side Canal would address two major lethal entrainment points that likely affect anadromous fish populations. Retrofitting or replacing the Garden Bar Road culvert on Doty Ravine would address a prominent passage barrier for salmon and provide access to additional spawning habitat. Screening other pumps and diversions throughout the watershed is also recommended.

Channel and floodplain rehabilitation measures can be pursued to enhance physical processes and the condition of the stream and floodplain in the middle and lower watershed. Recommended strategies include floodplain grading to increase topographic complexity and to enhance or create secondary channel alignments. Degraded stream reaches can also be improved through channel form rehabilitation, reconnection of historic meander bends, channel re-profiling and placement of large woody material. These efforts would all serve to improve floodplain connectivity, and, particularly in the lower watershed, would improve the quality and availability of floodplain rearing habitat for juvenile salmonids. Another option for improving the quality, quantity and duration of availability of floodplain rearing habitat for juvenile salmonids is implementing multi-purpose floodplain management of rice fields in the lower watershed. Inundated rice fields can be used to achieve tremendous growth rates in rearing juveniles in winter and spring months while still being used for rice cultivation during the growing season.

Other high-priority rehabilitation strategies including enhancing the riparian corridor, particularly in the lower and middle watershed where there the riparian buffer width is minimal along many reaches. Efforts should aim to increase the width of the riparian buffer, improve longitudinal connectivity of the riparian corridor, increase the presence of large woody vegetation and reduce the coverage of invasive species. Cattle exclusion measures would also be significantly beneficial in reducing livestock disturbances to the stream channel along several reaches in the middle watershed. Altering current flow management practices to lessen the temporal and spatial variability of stream flows would likely benefit aquatic habitat conditions. However, this report does not recommend specific actions due to the complexity of today's flow management activities (and the resulting benefits and detriments for a broad array of species) and the lack of stream flow data. Instead, numerous considerations and concepts regarding flow management are presented that require further exploration.

As with the vast majority of environmental rehabilitation efforts, the successful implementation of the opportunities identified for the Coon Creek watershed will hinge on the effective partnership of relevant stakeholders. Many of the proposed projects are located on stream reaches flowing through large parcels of private property. Flow management practices of water resource agencies also significantly influence the conditions of the stream network. Meaningful collaboration of government agencies, land owners, non-profits, water resource agencies and other organizations can result in creative solutions that improve the health and resilience of the watershed's natural resources while also maintaining other land use objectives.

1 INTRODUCTION

Coon Creek drains a 101-square mile catchment with its headwaters in the Sierra foothills near Auburn and its outlet on the floor of the Central Valley approximately 20 miles north of Sacramento (Figure 1). Since the late 1800s, the watershed has experienced a number of disturbances due to land development and land cover change, agricultural encroachment, urbanization, channel realignment and modification, flow management, and water quality effects. Nonetheless, the catchment remains one of the least developed foothill watersheds in the area and is prioritized by Placer County for conservation and restoration strategies as part of the Placer County Conservation Plan (PCCP). This interdisciplinary assessment builds upon previous studies, particularly the Auburn Ravine / Coon Creek Ecosystem Restoration Plan developed in 2002, to further advance knowledge of the watershed's hydrology, physical processes, water quality, riparian and aquatic habitat, and fisheries. Additionally, this assessment evaluates historic and ongoing watershed disturbances and provides recommendations for basin-level rehabilitation and management strategies, site-specific restoration projects, and considerations for future management efforts and studies.

Placer County Conservation Plan

The Placer County Conservation Plan (PCCP) is a County-proposed solution to coordinate and streamline the permitting process by allowing local entities to issue state and federal permits. The proposed PCCP is a Habitat Conservation Plan (HCP) under the Federal Endangered Species Act and a Natural Community Conservation Plan (NCCP) under the California Natural Community Conservation Planning Act. As proposed, the PCCP would include the County Aquatic Resources Program (CARP) to issue permits related to the Federal Clean Water Act and the California Fish and Game Code. The CARP component would distinguish the Plan as a nationally unique model of natural resource management. In proposing this streamlined process, both costs and uncertainties would be reduced substantially, thus ensuring a more efficient use of public dollars. Furthermore, the proposed PCCP is a landscape-level plan so that each project would be issued permits based on how it contributes to the County's natural, social, and economic health now and in the future.

The PCCP designates a Reserve Acquisition Area (RAA), in which the County will purchase land in fee (or acquire conservation easements) from willing sellers and then preserve, enhance, and restore these lands to meet the PCCP's Biological Goals and Objectives (BGOs). Because the RAA is almost wholly contained in the Coon Creek Watershed, attainment of the PCCP's BGOs will depend, to a large degree, on actions implemented in the Watershed. This Watershed Assessment makes an important contribution to the success of the PCCP by both documenting the Watershed's baseline physical and ecological conditions, as a comparison to future conditions following PCCP implementation, and by identifying opportunities for the County to implement specific projects in the Watershed that would positively contribute toward attainment of the PCCP's BGOs.

2 GEOMORPHIC ASSESSMENT

The geomorphic assessment described here builds upon previous analysis performed for the Auburn Ravine / Coon Creek Ecosystem Restoration Plan (AR/CC ERP, 2002) to develop a detailed understanding of the geomorphic process regime of the Coon Creek watershed. The AR/CC ERP provided a number of basin-scale, desk-based assessment to describe trends such as surface erosion hazard potential and relative surface soil erosion susceptibility as well as field-based descriptions of reach scale geomorphology. As part of our assessment, we conducted a high-resolution geomorphic field survey (fluvial audit) of over 30 miles of stream length along Coon Creek, Doty Ravine and the East Side Canal which was complemented with desk-based analysis and synthesis. We developed a process-based conceptual model of the watershed using semi-quantitative analysis to inform sediment input, transport and storage processes. We also evaluated historic impacts, underlying geologic controls and present-day land uses to inform our understand of the physical process regime. This work focused primarily on stream reaches accessible to anadromy.

2.1 WATERSHED AND STREAM CHANNEL OVERVIEW

Coon Creek originates in the Sierra Nevada foothills immediately north of Auburn and flows west to the floor of the Central Valley where it is intercepted by the East Side Canal (Figure 2). At its upper (eastern) end, the Coon Creek watershed features a plateau with a maximum elevation of 2,205 feet. The major tributaries draining the plateau are Orr Creek and Dry Creek. At their confluence, the stream's name transitions to Coon Creek and it begins its descent through a relatively high-gradient, laterally-confined canyon reach with granitic and basalt bedrock outcrops. Between the upper and lower falls within Hidden Falls Regional Park, Coon Creek is joined by Deadman's Ravine and continues to descend through a steep canyon.

As Coon Creek nears McCourtney Road, it exits the canyon into a semi-confined channel corridor, the channel's gradient declines and the stream exhibits a greater degree of dynamic behavior. Floodplain use for pasture as well as agriculture becomes more prominent here and generally increases in the downstream direction. A short distance downstream of Gladding Road, the channel passes through one of the last significant valley constrictions and enters a more broad valley bottom where stream gradient further declines while dynamic channel behavior increases. Less than a mile upstream of Old Highway 65, Coon Creek is joined by Doty Ravine, the most significant tributary in the watershed. Immediately upstream of the Placer County boundary, the first significant distributary splits from the channel (which only carries high flows during winter storm events).

After the stream passes into Sutter County, the channel gradient further declines and the channel is generally somewhat incised. Floodplains are intensively utilized for agriculture, primarily rice production, which often extends close to the top of the bank of the stream channel. The channel generally has a meandering pattern with fairly high sinuosity. However, the stream has been straightened in many locations with historic meanders now disconnected except during high flow events or filled in completely. At its present day terminus, Coon Creek is intercepted by the East Side Canal, a

constructed flood control channel bounded by levees that drains to the Cross Canal and ultimately the Sacramento River. Along some portions of the East Side Canal, the channel has developed minor levels of sinuosity and morphological complexity as well as a vegetated riparian corridor between the levees. The historic downstream-most reach of Coon Creek (west of the East Side Canal) is entirely disconnected from the upstream system with the exception of minor irrigation flows that may pass underneath the East Side Canal's western levee via an operable gate (we were unable to determine if this gate is still operated or functional).

Digital Elevation Model

Several Light Detection and Ranging (LiDAR) datasets provided by Placer County were combined to develop a digital elevation model (DEM) for the Coon Creek watershed. Major data inputs included Central Valley Floodplain Evaluation and Delineation (CVFED) data flown in 2011 and United States Geological Survey (USGS) Federal Emergency Management Agency (FEMA) data from 2012. Minor gaps in coverage were present in a handful of locations and filled in with data from the National Elevation Dataset (NED) provided by the USGS. The coverage of these various data sets is provided in Figure 3. The resulting DEM was utilized in a number of the analyses performed during this assessment.

Identification of Geomorphic Sub-Reaches

As part of our assessment, Coon Creek, Doty Ravine and the East Side Canal were delineated into sub-reaches using geomorphically significant variables or boundaries along the reaches that were targeted by our field based assessment (Figure 4). These boundaries indicate points at which there is likely to be a change in the geomorphic process regime. The sub-reaches generated therefore represent logical sections within which to undertake subsequent geomorphic analysis and identification of disturbances. The reach boundaries were identified using all available, relevant information, including the fluvial audit data, maps, LiDAR and aerial photographs. A total of 34 sub-reaches were delineated in the focus area of the study while desk-based assessment, rapid reconnaissance and previous studies (e.g., Richard Harris' 2008 report on Hidden Falls Regional Park) informed trends in the reaches located above the 34 focus sub-reaches for this assessment.

2.2 GEOLOGY

Metamorphosed terranes, Plutonic volcanics and Quaternary fluvial deposits constitute the majority of the geologic formations present within the Coon Creek Watershed (Figure 5). The area is no longer tectonically active, but a significant amount of uplift occurred here, exposing plutonic volcanic rocks and creating a plateau at the upper end of the basin. The upper basin consists largely of metasedimentary and metavolcanic rocks. These units were originally sedimentary or volcanic islands located offshore in the Pacific Ocean. The terranes were brought into contact with present day North America by the Farallon Plate during the Jurassic period, which was moving towards, and subducting beneath, the North American Plate. This collision of offshore and onshore rocks caused extreme heat and pressure which metamorphosed the units to varying degrees. Each of these terrane units is separated by north-south trending faults. These faults are strike-slip and are no longer considered active.

There was active volcanism in the region as a result of Farallon and/or Gorda Plate subduction during the Upper Jurassic period. The resulting volcanic deposits are now observed west of the terranes in the middle of the Coon Creek watershed. In this area the primary extrusive volcanic deposits associated with this period of volcanism are the Copper Hill Volcanics. The Copper Hill Volcanics mostly consist of pyroclastic rocks, although many other types of extrusive deposits are found within this unit. Pyroclastic rocks are a result of explosive volcanics where rock fragments are erupted and fall or flow in combination with super heated gases. The Copper Hill Volcanics are mostly andesitic or basaltic in composition and do not contain quartz. This unit is abundant at the main branch of Coon Creek, is generally resistant to erosion and is unlikely to be a source of gold.

Plutonic rocks associated with this period of active volcanism are also present in the area. The plutonic rocks that exist here consist mainly of quartz diorite and granodiorite of Late Jurassic/Early Cretaceous age. This unit is present west of the terranes and south of the Copper Hill Volcanics, through a long section of the Doty Ravine. These igneous rocks are largely felsic in composition with abundant quartz present. Gold is also known to exist along many of the quartz veins. This unit is moderately to highly erosive resulting in abundant felsic minerals found in the downstream deposits.

The geologic units present at the lower end of the Coon Creek watershed are sedimentary units deposited during relatively recent fluvial events from the Lower to Upper Quaternary. The oldest, and most prevalent of these units is the Riverbank Formation. The Riverbank Formation is subdivided into three units, Upper (Qr_3), Middle (Qr_2) and Lower (Qr_1), which represent three distinct alluvial episodes separated by periods of erosion. The Riverbank Formation is largely composed of arkosic sediment derived from metamorphic and volcanic rocks of the interior Sierra Nevada. The Riverbank Formation is overlain by the Modesto Formation, which is younger and less abundant but is also found in the lower watershed. The Modesto Formation, from the Late Pleistocene, is a unit of similar origin to the Riverbank Formation. It also consists of arkosic, quartz rich sediments and was deposited during the last major series of alluvium depositional events in the San Joaquin Valley. Other sedimentary deposits found here include various types of alluvium associated with present day hydrology.

2.3 SOILS

The soils present in the Coon Creek Watershed are derived from underlying geology and subsequent fluvial activity. The area consists largely of loams of varying composition with the development of soil profiles relating primarily to parent material and proximity to flowing water.

Entisols are the least developed soil profiles, which are present in, and near, active channels. Entisols consist of fragments of parent material with no soil horizons. The soil particles are easily entrained due to lack of developed profiles and proximity to active channels. Entisols are not present in the canyon reaches of Coon Creek where steeper gradients occur. This region consists of eroding volcanic rocks (Copper Hill Volcanics) formed into canyons with little to no deposition. Ultisols are present in the uppermost region of the watershed only. These soils are the most developed, are highly weathered, moderately erodible and have a clay rich lower horizon. Alfisols are present in both the upper and lower

regions of the watershed (Figure 6). They are the predominant soil order in the lower region where they are spatially consistent with the Riverbank geologic formation (Figure 4). Alfisols are moderately developed with a clay enriched middle horizon and are moderately to highly erodible. Inceptisols are the predominant soil order in the upper and lower regions of the watershed. They are associated with metamorphic parent material, are freely draining and are slightly developed. Inceptisols are generally absent of clay and organic matter and are moderately to highly erodible. Mollisols are generally located where plutonic rocks exist with the largest spatial extent located at the Doty Ravine where there is abundant granodiorite outcropping. Mollisols are well developed, moderately erodible and high in organic matter with a dark, humus rich surface layer.

2.4 HISTORICAL CHANNEL ASSESSMENT

Assessment of historical channel alignments and changes over time provide important information regarding human impacts to and the dynamic behavior of streams and their contributing watersheds. Of particular interest is the historical alignment of stream channels and the changes to those alignments over time. Maps produced by the USGS from 1910 offer the earliest record of relatively precise stream channel alignments that we utilized in this assessment. We also leveraged the earliest available aerial imagery from 1937 with coverage roughly between Pleasant Grove Road and McCourtney Rd for Coon Creek and nearly up to Gladding Road for Doty Ravine. The earliest aerial imagery we encountered for the lowest reaches of Coon Creek within Sutter County dates 1958 which extended nearly to Dowd Road. Rapid inspection of other imagery for the middle and upper watershed did not suggest fruitful analysis given the highly confined channel alignment in steeper canyon reaches as well as heavier riparian canopy cover and decreasing size of stream channels in the middle and upper watersheds. These factors either limit the degree to which historic channel realignment would occur (either by natural or artificial means) or the degree to which it could be meaningfully detected in the imagery. Consequently, our assessment focused on the lower half of the watershed.

Historic stream lines were digitized in GIS from the 1910 USGS maps and the 1937 and 1958 aerial imagery to facilitate comparison with present day conditions (Figures 7, 8 and 9). The 1910 USGS maps pre-date the construction of the East Side Canal and show lower Coon Creek continuing further to the southwest where it terminated in a small lake feature rather than connecting to the Feather or Sacramento River. The relatively straight channel pattern along much of this historic length suggests that stream had already been substantially realigned in a number of locations. It is unclear if the lake was a constructed or natural feature. However, it is likely that during high flow events, floodwaters were largely out-of-bank in this portion of the system, and that Coon Creek's flows co-mingled with those of Auburn and Markham Ravines, the Feather River and other sloughs and distributaries.

Above the East Side Canal, we suspect that many of the differences in alignment between the 1910 maps and 1937 and 1958 aerial imagery which suggest lateral channel migration are actually due to the limited accuracy of the 1910 mapping and distortion of features through georeferencing. However, it is clear that the channel had been straightened in many areas by 1910, and that by 1937 and/or 1958, many of the original meander bends along Coon Creek were completely disconnected. Outside of these

impacts, it appears that the channel alignment has generally been quite static in these lower-most sections of Coon Creek.

While historic impacts appear to be most substantial below the present day Highway 65 Bypass, it also appears that secondary channels at and near the confluence of Coon Creek and Doty Ravine may have also been artificially disconnected. Further upstream, the comparison of 1937 and present day stream alignments suggest that lateral adjustment of Coon Creek has occurred between the confluence and Gladding Road due to natural physical processes. However, these changes appear constrained to a fairly narrow corridor. We suspect that the channel in this section was artificially realigned along the far right valley wall before 1910 to facilitate greater floodplain use for agriculture, grazing or other activities. These historic impacts are discussed in more detail in the Watershed Disturbance Assessment chapter.

2.5 SPECIFIC STREAM POWER ANALYSIS

A specific stream power analysis was performed for Coon Creek to quantitatively characterize the 'geomorphic energy regime' (i.e., the sediment transport capacity or the stream's ability to do “work”) of the system. The assessment spanned the stream network from the primary tributaries at the western headwaters near Auburn to the stream's interception point at the East Side Canal. Specific stream power was calculated using the estimated 2-year flood event discharges. Specific stream power[1] is defined as:

$$\omega = \frac{\rho g Q S}{w} \ (Watts/m^2)$$

Where:

ρ = density of water (kg/m^2)
g = gravity term (m/s^2)
Q = flow rate (m^3/s)
S = channel slope (m/m)
w = bankfull width (m)

The reaches of Coon Creek and its tributaries were broken into 300 ft segments for the analysis with discharge, slope, and width defined for each segment. Slope was derived along the stream segments using the different in elevation between the segment start point and end point divided by segment length (Figure 10). The width term was the bankfull width measured using the hillshade from the LIDAR DEM and aerial imagery. At least one width was measured for geomorphically significant sub-reach and, where necessary, multiple width measurements were made. Bankfull discharge within Coon Creek and its tributaries was estimated using the 2-year peak flow values provided by the USGS StreamStats tool (U.S Geological Survey, 2012), sampled above and below meaningful confluences and at regular intervals along longer reaches.

Specific stream power values for the analyzed reaches of the Coon Creek stream network ranged from 5.03 to 1536 Watts/m^2 (Figure 11). The specific stream power values calculated for the Coon Creek

[1] Specific stream power is presented in Watts/m^2 to facilitate meaningful comparison with relevant literature.

stream network range from low energy to high energy systems as defined by Nanson and Croke (1992). The highest specific stream power values observed in the watershed occur along Coon Creek's canyon reaches within Hidden Falls Regional Park and between Garden Bar Rd and McCourtney Rd. These high values indicate that these reaches possess the greatest capacity for sediment transport within the watershed, which is corroborated by the observed cascade and bedrock channel morphology in these parts of the stream work. The headwaters of Sailor's Ravine also posses high levels of stream power, driven largely by the steep stream gradients in these area. From these locations in the watershed, stream power generally declines as the stream descends west to the floor of the Central Valley. Along the reaches of Coon Creek in Sutter County, the low stream power values (e.g. less than 50 W/ m^2) observed along most reaches indicate that the channel has little capacity to perform significant geomorphic work or laterally migrate. This is also confirmed by field observations and aerial imagery assessment which demonstrate little naturally-induced change to stream channel alignment.

2.6 FLUVIAL AUDIT

A field-based geomorphic assessment of Coon Creek and Doty Ravine was conducted between October 2014 and November 2015 utilizing a combination of fluvial audit (higher resolution) and reconnaissance level (lower resolution) approaches. This methodology characterizes geomorphically relevant features which inform a detailed understanding of physical form and processes within a stream network. It also inventories human disturbances and river engineering measures (e.g., bank protection, grade control structures, levees, etc.) to facilitate a more nuanced understanding of the degree of impairment to physical processes and channel health. The survey is conducted on foot and utilizes a field tablet computer equipped with GIS mapping software to record observations, photos and locations using GPS. Reaches that were surveyed include the following and are also indicated in (Figure 12)[2]:

- The East Side Canal between the Cross Canal and Coon Creek (reaches 1-5)
- Coon Creek between the East Side Canal and Old Highway 65 (reaches 6-16)
- Coon Creek between Gladding Road and Salmon Run Bridge in Hidden Falls Regional Park (reaches 20-24)
- Doty Ravine between Manzanita Road and Wise Road with the exception of two minor sub-reaches (reaches 25-34)

The following is a summary of the various feature categories of interest that were observed in the study reaches and how they were characterized as part of this assessment. The fluvial audit methodology generally characterized all of these features in a high degree of detail (when they are present) while the reconnaissance level approach utilizes a less detailed inventory of bank erosion and sediment bar features but typically maintains the same level of detail for the other characteristics. Differences to this level of resolution occurred along the East Side Canal where a lesser level of detail was utilized to enable a greater distance to be covered.

[2] Despite interest, reaches 17-19 of Coon Creek and reach 25 of Doty Ravine were not surveyed due to a lack of property access. To the extent possible, desk-based assessment of remotely sensed data and past assessment were used to inform physical processes within this portion of the stream system.

An example of the fluvial data is provided in a map in Figure 13. However, the size of the watershed and resolution of the data would require an excessive number of printed maps to display findings in a visually meaningful and interpretable manner. As such, the full data set is only being provided as part of the GIS database submitted to Placer County as part of the project deliverables. These data were used to develop reach-scale analyses the results of which are presented in subsequent sections and are more meaningful to interpret at the basin scale.

Reach Type Characterization

This qualitative classification is based largely on bedforms and the stream gradient. The reach type was typically characterized over a section of channel at least 10 channel widths in length, rather than at a specific point or individual morphological unit. Observed reach types ranged from slow glide sections on the East Side Canal and lower reaches of Coon Creek to cascade reaches within the canyon between McCourtney Road and Garden Bar Road (Figure 14 and Figure 15). Reach types are generally highly correlated with stream gradient as presented in Figure 10 and also offer insights into a channel's capacity to transport or store sediment.

In some reaches bedrock controls or biological drivers such as beaver dams and large wood complicate the classification of reach types. There are numerous instances of the slow-glide reach type that occur immediately upstream of beaver dams that have ponded water for significant distances (examples include reaches 27 and 28 on Doty Ravine). In the absence of these dams, or when they are washed out during high winter flow events, the underlying reach type would likely be pool-riffle. Similarly, there are numerous instances along reaches 23 and 24 where bedrock outcrops or control points result in long glide reaches upstream with relatively minor slope during low flow conditions.

Hydraulic Control Structures

Hydraulic control structures are manmade structures that artificially control channel bed elevations or grade. Structures observed in the Coon Creek watershed include a wide range of bridges, weirs, dams (seasonal and permanent) and fords. In addition to controlling channel grade, many of these features also strongly influence local hydraulics and constrain the lateral migration of the stream channel. Some of the characteristics noted include the length and width of the feature, the elevation of the structure's invert relative to the channel bed, the materials used to armor the bed and banks (if any are present), and a visual assessment of the degree to which the structure interacts with high flows. These observations inform the degree of physical impact each structure has on the stream channel and healthy geomorphic processes. These features and their effects are discussed in greater detail in the engineering and land use pressure index within the Watershed Disturbance Assessment chapter.

Bank Erosion

The length, height and severity of erosion was recorded for observed bank erosion sites along the survey reaches. Erosion severity was classified as high, moderate-high, moderate or minor. In addition, the length and height of erosion were recorded. The most significant bank erosion sites were concentrated along Coon Creek and Doty Ravine between the Sutter-Placer County boundary and the downstream end of the canyon along Coon Creek (reaches 11 through 22) and the downstream most section of Doty

Ravine (reach 25). The bank erosion features provide an indication of local sediment inputs to the system and are utilized in the calculation of the bank erosion index discussed later in this chapter. They also provide an indication of dynamic behavior of stream channels and are used to inform an understand of the geomorphic process regime.

Bank Protection

Bank protection observed along Coon Creek and Doty Ravine consists of hard engineering measures, which refer to the use of concrete or rock (rip-rap) protection installed along stream banks. These materials resist lateral migration and erosion of a stream channel, and consequently inhibit natural geomorphic processes and lateral channel migration. The bank protection measures observed were classified as either large scale or small scale. Large scale bank protection involves armoring the majority of the stream bank such that stream flows have little interaction with the native bank material below. Small scale bank protection refers to less extensive bank armoring such that the native bank material and vegetation still partially interact with the stream, particularly during higher flows. Bank protection was surprisingly scarce along Coon Creek and Doty Ravine. Particularly in the lower reaches within Sutter County where agricultural activities often extend to the top of the stream bank, the very low density of bank protection indicates that the channel is generally quite static.

Depositional Sedimentary Features

Sediment is stored within a stream channel in depositional bar features (e.g., point bars, lateral bars) as well as distributed along the channel bed. When depositional features were observed, the feature type, sediment material (e.g., sand or gravel) and maturity of the vegetation cover, if present, were recorded. Almost all of the bar features observed had at least some amount of riparian vegetation growing on them but lacked mature vegetation, suggesting they had been activated during high flow events within the last year or two. However, several larger bar features with mature vegetation were also observed, suggesting that they had not been altered significantly in recent years. The distribution of depositional bar features was used in the development of a sediment storage index discussed later in this chapter.

Beaver Dams

Beaver dams were observed along the majority of the reaches surveyed during the fluvial audit. When observed, the location and approximate head drop of the beaver dams were typically noted. Beaver dams along Coon Creek raise the water table locally, promoting wetland and riparian vegetation, and generally improve in-stream habitat diversity. At low flows, some beaver dams may also function as fish passage barriers. They also encourage greater channel-floodplain connectivity, particularly reaches 27 and 28 on Doty Ravine. Figure 16 displays the density of beaver dams by stream length where surveys were conducted.

Large Wood

Occurrences of large in-stream wood material were mapped during the fluvial audit surveys. Where large wood is present and interacting with the low flow channel, it often generates habitat complexity and cover for aquatic species, and can also drive fluvial processes such as bed scour and bank erosion where present. Loading of large wood and the size of large logs have likely declined in many reaches due to riparian vegetation management. The density of occurrences of large wood per stream length is

mapped in Figure 17 and is intended as a helpful tool for understanding the presence and distribution of large wood in the system. However, it should be noted that this mapping does not depict the density of individual logs, but rather of large wood features (a single large log is given the same weighting in this calculation as a jam featuring several large logs).

Irrigation Features

In addition to hydraulic control structures relevant to irrigation (e.g., diversion dams), the location of pumps and field drains were also mapped. These features are used to help inform the low-flow irrigation season hydrologic analysis in the following chapter.

2.7 SEDIMENT INPUT

Sources of sediment to Coon Creek include bank and terrace erosion within the stream channel corridor, tributaries and sediment delivered directly to the creek via overland flow. The volumes and dominant size of sediment that is delivered to the active stream channel play important roles in a stream channel's behavior and morphology. Below, several quantitative assessments are described to inform the sediment input regime of the Coon Creek watershed.

Surface Erosion

The most significant surface erosion inputs are delivered to the primary stream network via tributaries and direct overland flow. Previous analysis performed for the Auburn Ravine / Coon Creek Ecosystem Restoration Plan resulted in the development of a Relative Surface Erosion Hazard Potential calculation for the full watershed (Figure 18). This calculation was based on precipitation rates and duration, hillslope gradient, soil characteristics, vegetative cover and contributing slope length for flow concentration. The results indicate that uppermost headwaters of Orr Creek and Dry Creek are subject to high rates of erosion as are the hillslopes along Coon Creek between the start of Hidden Falls Regional Park and the downstream end of the canyon (i.e. the western end of reach 23). Similarly, the headwaters of Sailor's Ravine and Doty Ravine are also prone to high rates of erosion. Consequently, we expect that the sediment delivery to Coon Creek from tributaries and direct overland flow is greatest in these middle and upper portions of the watershed. These areas also tend to have the most significant stream power or sediment transport capacity and are relatively confined. As such, little of this sediment is typically stored along these reaches and instead is transported downstream.

Bank Erosion Index

The bank erosion severity mapping conducted during the fluvial audit was used to develop an index of bank erosion to quantitatively describe the sediment contributions from bank and terrace erosion within the active stream channel along surveyed reaches. The exposed surface area of the eroding banks (length multiplied by height) was then multiplied by a weighting factor for the corresponding severity to provide a score for each erosion feature. The cumulative score of bank erosion features for each geomorphic sub-reach was then divided by the sub-reach length to develop the index scores shown in Figure 19. Because no ground-based surveys were conducted in reaches 17-19 and reach 25, vertical banks prone to erosion were delineated using LiDAR and aerial imagery along the non-surveyed reaches

as well as bounding sections of Coon Creek and Doty Ravine. Where overlap existed in both data sets, correlations were developed between field observation of bank erosion and desk-based assessment of eroding banks to calculated expected bank erosion rates along the non-surveyed reaches.

As discussed in Section 2.6, bank erosion is most significant in reaches 11 through 22 along Coon Creek and along reach 25 on Doty Ravine. In addition to serving as a local sediment supply source to these reaches, the bank erosion here is also indicative of the channel's dynamic behavior. Dynamic behavior is driven by the natural geomorphic process regime in this portion of the watershed as well as human disturbances including channel realignment and manipulation, riparian vegetation management, cattle grazing and increased peak flows due to hydromodification in the upper watershed. Trends in bank erosion and their relevance to the physical process regime are discussed in greater detail in Section 2.9 below.

2.8 SEDIMENT STORAGE

Sediment transported by fluvial processes is stored within the river corridor both within the active channel and on the floodplain. Depositional sedimentary bar features are prominent sediment storage features, often consisting of grain sizes ranging from sands to cobbles. As described in Section 2.6, depositional bar features were characterized as part of the fluvial audit survey in terms of length and vegetative cover. In order to provide a quantitative metric describing the distribution of sediment stored within the active channel, a sediment storage index was developed. The cumulative length of all recently activated depositional bar features (i.e., those not covered in mature vegetation) was summed along each geomorphic sub reach and divided by reach length to calculate the index along each sub-reach (Figure 20). Where ground-based survey access was not available (reaches 17-19 and reach 25), the index was developed using visual observation and interpretation of aerial imagery. Depositional bar features were mapped along these inaccessible reaches as well as reaches upstream and downstream. Using a correlation derived for reaches where both aerial and ground-based data were available, an appropriate index was calculated for the non-surveyed reaches as well.

Sediment storage within Coon Creek is most significant on Coon Creek between the end of the canyon and the Placer-Sutter County boundary, and for Doty Ravine between McCourtney Road and the confluence with Coon Creek. These results are interpreted in the following section. It should also be noted that this sediment storage index does not provide a complete representation of sediment storage. Specifically, sediment stored along the stream bed that does not break the low-flow water surface and sediment stored on the floodplain are not captured in this assessment. Floodplain deposition is likely a significant sediment sink in the lower reaches of Coon Creek as well areas of Doty Ravine with strong floodplain connectivity (e.g., reaches 27 and 28). This is particularly the case for fine-grained material (e.g., silts and sands) that can easily be transported large distances from the active channel. Therefore this index may be conservatively low in estimating sediment storage, particularly in lower-gradient reaches.

2.9 GEOMORPHIC PROCESS REGIME

The relationships between sediment input, sediment transport and sediment storage play a strong role in defining the geomorphic process regime of individual geomorphic sub-reaches as well as the entire basin. Assessment of the quantitative metrics discussed in the preceding sections provides indicators of the spatial distribution and the magnitude or intensity of each of these three major factors that drive the stream's geomorphic process regime. Of specific interest are specific stream power, surface erosion hazard potential, the bank erosion index and the sediment storage index. Additionally, an assessment of the underlying geology and natural geomorphic controls as well as land use and historic disturbances further informs the geomorphic process regime for the system. Rather than provide exhaustive discussion of each geomorphic sub-reach in a text format, key elements of the geomorphic process regime are provided in Figure 21 and Figure 22. Additionally, concise summaries of the geomorphic process regime along geomorphic sub-reach groupings are provided below. It should be noted that full watershed coverage is not provided by all of the indices mentioned above; however, field observations, remotely sensed data and general understandings are used as needed.

East Side Canal (Reaches 1-5)

The East Side Canal is a constructed, levee-confined stream corridor that intercepts Coon Creek, Markham Ravine and Auburn Ravine. While the levee crown to levee crown width is typically less than 350 feet, over time the channel has developed some degree of sinuosity, morphological complexity and riparian habitat within the corridor. However, where flow management infrastructure (e.g., Coppin Dam) or other grade control structures affect water surface elevations, backwater conditions often result in a highly simplified channel morphology and minimal riparian structure (Figure 23). Minor amounts of sediment deposition occurs along an inset floodplain bench, and potentially more occurs along the channel bed in backwatered reaches. Sediment input is largely limited to inflows from the three major creeks. However, the concentration of floodwaters between the levees likely drives higher stream power and sediment transport capacity compared to the unconfined channel reaches immediately upstream of the East Side Canal.

Lower Coon Creek - Sutter County (Reaches 6-10)

Between the Placer-Sutter County boundary and the East Side Canal, Coon Creek is characterized by a low gradient, meandering, slightly incised channel with frequent and extensive floodplain inundation (Figure 24). The stream channel generally appears undersized to convey typical winter flood flows. Stream power values are low and channel alignment appears to be static except where extensive riparian vegetation management has caused local bank destabilization and erosion. Channel straightening and extensive floodplain grading for widespread agricultural use have reduced stream sinuosity, increased slope and eliminated floodplain topographic complexity, affecting in-stream hydraulics and floodplain inundation patterns as well as locally increasing stream power (Figure 25). However, the dominant process regime along these reaches is likely sediment storage of fine-grained materials upon the floodplain.

Lower Coon Creek - Placer County (Reaches 11-12)

The downstream-most portion of Coon Creek within Placer County is characterized by a meandering, moderately incised stream channel and a frequently activated floodplain (Figure 26). Bank erosion and in-channel sediment storage are higher relative to the reaches downstream in Sutter County. The elevated Line 1 Canal (at the downstream end of reach 11) appears to function as a hydraulic constriction interrupting floodplain connectivity with downstream reaches and altering local floodplain hydraulics. Sediment storage, primarily on the floodplain, likely dominates the physical process regime through here while sediment transport capacity is also slightly elevated compared to downstream reaches.

Lower Coon Creek - Placer County (Reaches 13-16)

These reaches are generally higher gradient and less sinuous than the channel in Sutter County. The presence of secondary channels and moderate to high bank erosion and sediment storage indices suggest moderate levels of dynamic behavior. The channel is generally moderately incised through these reaches yet still exhibits frequent floodplain connectivity (Figure 27).

Coon Creek - Near Doty Ravine Confluence (Reaches 17-19)

While ground-based surveys were not conducted of these reaches, inspection of aerial imagery and assessment using the indicators described in the preceding sections suggests that these reaches are among the most dynamic along Coon Creek. Reaches 18 and 19 pass through what was at least historically the least confined reach between the Doty Ravine confluence and Coon Creek headwaters. Sediment deposition appears to be the dominant process here, likely a result of the less confined valley bottom and the decline in stream power relative to upstream reaches. Bank erosion also appears to be very extensive, driving local adjustments in channel alignment and providing significant sediment supply to the system.

Coon Creek - Semi-confined (Reaches 20-22)

Coon Creek exits the steep, highly confined canyon at the upstream end of reach 22 and transitions to a more dynamic, semi-confined channel with less stream power. Sediment transported through the canyon reach is deposited along these reaches, especially in extensive bar features at the inlet of reach 21 (a large secondary channel that runs parallel to reach 20). While sediment deposition likely dominates the physical process regime through these reaches, bank erosion also provides a considerable local sediment source to the system. Moderate channel incision along much of these reaches also suggests that sediment transport is considerable as well (Figure 28).

Coon Creek - Lower Canyon (Reaches 23-24) and Hidden Falls Regional Park

From the bottom of reach 23 and continuing up through Hidden Falls Regional Park are steep, highly confined sections of Coon Creek with high levels of stream power (Figure 29 and Figure 30). Although sediment transport is the dominant process through this section of Coon Creek, these reaches also likely provide the highest sediment loading rates in the watershed via tributaries and overland flow (as indicated by the Relative Surface Erosion Hazard Potential mapping in Figure 18).

Coon Creek - Upper Watershed

The headwaters of Coon Creek are located on a plateau with lesser gradient than the canyon reaches downstream. Orr Creek and Dry Creek are likely dominated by sediment supply and transport processes; however, these are generally of lower magnitude than the canyon reaches. Additionally, development around Auburn has caused hydromodification due to extensive urbanization, thereby increasing peak flows and altering stream channel morphology.

Doty Ravine - Unconfined Reaches (Reach 25)

Immediately upstream of the confluence with Coon Creek, Doty Ravine is relatively unconfined. High rates of bank erosion and sediment storage within alluvial bar features indicate a dynamic channel. Erosion also appears to be exacerbated by livestock trampling of banks. Sediment storage is likely the dominant process along this reach, both within the channel and along the floodplain.

Doty Ravine - Lower Semi-confined Reaches (Reaches 26-28)

Within the semi-confined valley bottom along reaches 27 and 28, Doty Ravine appears to have a well-connected floodplain that experiences widespread inundation, likely due to historical grading practices and a high density of beaver dams. Despite having few depositional bar features, this reach likely serves as a significant sediment storage zone for finer grained materials on the floodplain and within the stream channel in ponded areas behind beaver dams. Reaches 26 through 28 have low-elevation levees or berms on one or both sides. However, berm failures and intentional breaching for rehabilitation purposes, particularly along reaches 27 and 28, have reduced the impact of these berms on floodplain connectivity.

Doty Ravine - Upper Semi-confined Reaches (Reaches 29-34)

This section of Doty Ravine is characterized by semi-confined reaches with partially incised channels. Moderate levels of sediment storage and bank erosion are present. In the upstream to downstream direction, there appears to be a gradual transition from a sediment transport dominated to a sediment storage dominated process regime. Historic dredger mining along the northern valley bottom of reach 33 likely altered the stream channel alignment and continues to impair local floodplain connectivity to the north.

Doty Ravine Headwaters

Continuing upstream from reach 34, Doty Ravine transitions from a semi-confined system impacted in sections by historic dredger mining practices to a steep, highly confined channel. The dominant process regime is likely sediment transport, particularly in the higher reaches. Closer to reach 34 and Wise Road, sediment storage is relatively higher and sediment transport rates are relatively lower. The Relative Surface Erosion Hazard Potential assessment also indicates that the Doty Ravine and Sailor's Ravine headwaters are likely significant sources of sediment to the stream system.

3 HYDROLOGIC ASSESSMENT

The objectives of this hydrologic assessment were to characterize the general watershed hydrology with specific emphasis on (1) the effect of flow management and conveyance practices on base flows and (2) alterations to the peak flow regime due to land use change. This effort was complicated by the fact that flow gaging data for the Coon Creek watershed is sparse, particularly for peak flows but also in-stream measurement of base flows. As such, this assessment leveraged a combination of the available low-flow in-stream gage data, canal gaging data, conversations with water management agencies, field observations, hydrologic modeling, and general knowledge of watershed hydrology to characterize conditions in the Coon Creek watershed.

3.1 BASIN HYDROLOGY OVERVIEW

As Coon Creek descends from the Sierra Nevada foothills to the floor of the Central Valley, it drains a watershed approximately 101 square miles in size[3] (Figure 31). The basin's hydrology is driven both by its natural characteristics and by flow management and conveyance practices. Typical of northern California streams, Coon Creek experiences a Mediterranean climate characterized by wet winters and dry summers. With its headwaters in the Sierra Nevada foothills at an elevation just about 2,000 feet, temperatures are too warm to support the development of snow pack, and snowfall in the Auburn area is a rare occurrence. Consequently, Coon Creek's hydrology is driven by rainfall and the basin does not exhibit spring snowmelt flows. Following the cessation of rain events in the late spring, Coon Creek's historical in-stream flows would have gradually declined through the summer, likely ceasing altogether along much of its channel length. However, today much of Coon Creek and its tributaries are perennial, due to the conveyance of flows along stream channels by the Nevada Irrigation District (NID) and South Sutter Water District (SSWD), the two major water management agencies operating in the watershed. Water management and conveyance practices along Coon Creek and its tributaries results in a complex series of additions, withdrawals and diversions, particularly during the irrigation season which typically occurs each year between April 15th and October 15th. Land use change and development, particularly in the upper watershed near Auburn where urbanization has occurred, has also altered the peak flow regime by increasing the volume of flows delivered to stream channels during rain events.

[3] The Coon Creek watershed size of 101.4 square miles is based on an ArcGIS-automated delineation performed using the DEM developed with the LiDAR data described in Section 2. The calculation includes all land draining to the Coon Creek interception point at the East Side Canal but does not include areas drained by the Bunkham Slough distributary. Additionally, this calculation does not account for management of drainage by small levees and other drainage control features on farmland in the lower portion of the watershed, which may direct flows toward or away from the stream channel depending on management. As a point of comparison, the delineation of the watershed using the USGS Stream Stats tool (which relies on a coarser resolution DEM) shows a drainage area of approximately 102 square miles for a similar outlet but provides a slightly different boundary delineation in the lowland areas.

Data Sources

Climate and flow data from a number of sources were leveraged in this assessment, including the locations indicated in Figure 32. Long term precipitation and air temperature data were obtained from the National Climatic Data Center (NCDC) Cooperative Observer Network (COOP) data records. Flow and stage gaging was obtained from several sources. The South Sutter Water District maintains the only long-term flow gage on Coon Creek, but it only records low flows during the irrigation season. Limited flow gaging of Coon Creek has also been conducted on private property near Highway 65. Placer County's flood control system maintains three stage and precipitation gages on stream channels in the watershed but does not have a stage-discharge rating curve for these sites. The Nevada Irrigation District gages the flows released from and diverted into a number of their canals in the watershed, but does not directly measure in-stream flows. A HEC-1 hydrologic model previously developed by Civil Engineering Solutions, Inc. was also updated for this assessment to assist in estimating changes to the peak flow regime.

3.2 CLIMATE AND PRECIPITATION

Northern California has a Mediterranean climate characterized by cool and wet winters and hot, dry summers. The majority of precipitation in the Coon Creek watershed falls as rain between November and April, with minor amounts sometimes falling in May, June, September and October (Figure 33). Rain in July and August is rare. Figure 33 provides average monthly precipitation for gaging stations near Auburn and Nicolaus, which are located at the eastern headwaters and the western terminus of the watershed, respectively. In addition to winter-dominated rainfall patterns for the watershed, this figure also shows the strong decreasing trend in the amount of annual rainfall that occurs from east to west in the Coon Creek watershed. On average, Auburn typically sees 80% more rainfall than Nicolaus over a year. This trend, which is even more visible in Figure 34, is driven largely by the orographic effect of the Sierra Nevadas, which causes greater amounts of precipitation at higher elevations.

Another characteristic of northern California's climate is that while there is an average annual precipitation amount for every river basin, it is relatively uncommon to see the average amount of precipitation actually occur in a given year. Instead, California is characterized by significant interannual variability in precipitation, and droughts and floods are fairly common occurrences. This high level of variability in rainfall occurs in the Coon Creek watershed as is evident at both the Auburn and Nicolaus gaging locations (Figure 35). This high level of variability in precipitation has important consequences for both physical processes and riverine ecology.

Air temperatures in the summer are typically hottest in July and August with average daily highs and lows in the low 90s and low 60s (degrees Fahrenheit) in Auburn, respectively (Figure 36). Summertime highs are slightly higher in Marysville, reaching the mid 90s, but summertime lows are slightly cooler than those in Auburn. This is likely driven by the approximately 2,000 foot elevation difference between Auburn and Marysville and, potentially, by overnight inversions as cooler air sinks to the floor of the Central Valley. Winters in the Coon Creek watershed are generally mild, with December and January generally exhibiting the coldest temperatures. Average daily highs and lows for Auburn and Marysville

are typically in the mid 50s and upper 30s, respectively, and differences between the two sites are minimal. Air temperatures rarely dip below freezing and snowfall in the headwaters is rare. When snow (or sleet) does occur, it melts quickly and no sustained snowpack is formed.

3.3 FLOW MANAGEMENT AND CONVEYANCE

The in-stream flows of Coon Creek and its tributaries are strongly influenced by flow management and conveyance practices of the water agencies operating in the watershed, particularly during the irrigation season which runs April 15th to October 15th. These agencies use a combination of canals and natural stream channels to convey flows. The movement of water is driven largely by irrigation demand but smaller deliveries for domestic water use also occur. Along the flow paths of Coon Creek and Doty Ravine from their headwaters to the East Side Canal, in-stream flows experience several pronounced cycles of flow additions followed by complete diversions and/or significant levels of flow abstraction for irrigation purposes. The following sub-sections describe the different entities that influence stream flows as well as the resulting impacts to base flows during the irrigation season.

3.3.1 Entities Influencing In-Stream Flows

Several different agencies as well as a large number of individual landowners are responsible for altering the in-stream flows within the Coon Creek watershed. Each of these entities is described below, along with their objectives and a brief overview of their operations.

Pacific Gas & Electric

Pacific Gas & Electric (PG&E) is a company mostly focused on power generation that also occasionally provides water wholesales. PG&E maintains several small reservoirs at the far eastern end of the Coon Creek watershed. These reservoirs include Halsey Forebay, Halsey Afterbay, Lake Arthur, Lake Theodore and Rock Creek Lake, which are located in the headwaters of Dry Creek. It is our understanding that PG&E does not release flows for conveyance purposes along Dry Creek as part of its normal operations and does not have any individual water customers within the watershed. There may be instances, however, where PG&E performs one-time releases of flows for purchase by other water agencies or for flood prevention purposes.

Nevada Irrigation District

The Nevada Irrigation District (NID) is the primary water supply agency for domestic and agricultural uses in the Placer County portion of the Coon Creek watershed. NID was formed in 1921 within Nevada County and expanded into Placer County in 1926. Today the agency has over 25,000 customers and operates a complex water storage and conveyance system that includes 10 reservoirs and a vast network of canals. Many of NID's canals within the Coon Creek watershed were originally developed during the gold mining era in California in the late 1800s and very early 1900s. These canals navigate the often steep foothill topography and many of them are fairly limited in size. In addition to using canals, NID relies on the natural stream channels of Coon Creek and its tributaries to convey and deliver flows.

Much of the water NID supplies to customers in the Coon Creek watershed is imported from Lake Combie, a reservoir on the Bear River.

SMD-1 Wastewater Treatment Plant

Up until May 2016, Placer County operated a wastewater treatment plant located north of Joeger Road and a short distance west of Highway 49. The plant is situated immediately southeast of the confluence of Dry Creek and Rock Creek, and borders both stream channels. The SMD-1 plant discharged treated effluent into Rock Creek and was also required to purchase dilution flows from NID further upstream on Rock Creek. However, as of May 23rd, 2016, the treatment plant has been shut down and all wastewater is now conveyed to a treatment plant in the City of Lincoln.

South Sutter Water District

The South Sutter Water District (SSWD) was established between the mid 1950s and early 1960s by local landowners and farmers to provide surface water for irrigation needs and to address declining groundwater levels. The district operates primarily in southern Sutter County as well as small portions of western Placer County. The majority of SSWD's customers are rice farmers while a smaller percentage of customer demand is for irrigated pasture, orchards, and row crops. SSWD's customers generally obtain the majority (roughly two thirds) of their water from groundwater pumping while approximately one third comes from surface water deliveries. In addition to serving irrigation water needs, SSWD's conveyance of surface water along its canal network is also intended to replenish the groundwater table. As much as 30 to 40% of the water conveyed along SSWD's unlined canals can be lost to groundwater recharge, particularly when groundwater levels are low. The water that SSWD provides in the Coon Creek watershed comes from the Camp Far West Reservoir on the Bear River delivered to Coon Creek via the Line 1 Canal (Brad Arnold, personal communication).

Individual Landowners

In addition to the agencies described above, individual land owners also significantly influence in-stream flows. Both individual water rights holders as well as NID and SSWD customers can abstract flows from Coon Creek and its tributaries. The greatest demand for water in the Coon Creek watershed is driven by agricultural uses, primarily rice farming as well as irrigated pasture. Landowners living adjacent to stream channels can pump directly from streams using either permanently situated pumps or portable irrigation pumps. Additionally, some landowners are able to pump from short canals backwatered by seasonal grade control structures on the main channel. Also of consideration are low levels of illegal pumping of water that may occur, especially along less accessible stream reaches. While the greatest influence of individual landowners on in-stream flows is typically abstraction, return flows from draining rice fields, stock ponds and other sources can also increase in-stream flows at various times of the year.

3.3.2 Flow Management and Conveyance Influences on Stream Flows

A key objective of this hydrology assessment was to characterize the influence of conveyance and management practices on in-stream flows during the irrigation season, and to present this information in a manner that was easy to understand. We sought to distill the complex movement of water through flow additions, withdrawals and diversions into a set of the most significant and relevant actions that

occur in the watershed. This synthesis of flow management activities is summarized in a single map (Figure A-1). This map depicts out-of-basin transfers of water into the Coon Creek watershed, the addition of flows into natural stream channels for conveyance and larger-scale deliveries, and the diversion of flows out of natural channels. It also shows pump locations observed during our field assessment and the location of active points of diversion within the State Water Resources Control Board's Electronic Water Rights Information Management System (eWRIMS) database. These points likely represent a significant portion, but not the entirety, of water abstraction locations along the watershed's stream network.

Approximation of In-Stream Flows

Due to the very limited amount of flow gaging in the watershed, longer-term time series data were not available to characterize in-stream flows with accuracy except at the SSWD weir on Coon Creek immediately upstream of the Placer-Sutter County boundary, and by inference from NID's canal gages where NID attempts to divert all flow from Coon Creek and Doty Ravine. However, between these data sources, observations during the window of field studies in the watershed (September 2014 to October 2016), and conversations with NID and SSWD personnel, we developed a highly approximate qualitative estimate of in-stream flows indicated by the variable-width blue overlay in Figure A-1 that covers the stream network. The width of this line is correlated to the average expected flows during the earlier portion of the irrigation season (i.e. May and June). However, it should be noted that actual in-stream flows and conveyance activities vary widely year-to-year and day-to-day based on regional water supply levels in reservoir and snowpack, late spring and early summer precipitation events, customer demand for water, and a large array of other factors.

Drivers of Hydrologic Complexity

Today, human uses and disturbances as well as natural processes drive a complexity in Coon Creek's watershed hydrology that is beyond what can be characterized in this assessment. In addition to the major flow conveyance activities depicted in Figure A-1 are a large number of smaller scale water deliveries via the stream network and canal system. Additionally, there are countless return flows that drain to the stream network from both domestic and irrigation uses that cannot be quantified. Groundwater and surface-water interactions also play a large role in driving in-stream flows. The great level of variability at both the daily, seasonal and annual time scales of in-stream flows and conveyance activities also makes characterizing "typical" conditions difficult.

Finally, it is important to consider that the water agencies operating in the Coon Creek watershed are generally as judicious as possible in their use of water. However, the movement and gaging of flows is ultimately an imperfect science and requires excess water to be conveyed through the system to avoid leaving customers short of water. Losses due to leakage from canals and other infrastructure, groundwater and surface water interactions, evapotranspiration, illegal consumption and diversions (e.g., small-scale marijuana cultivation), unquantifiable return flows, and wide range of other variables make it challenging for water agencies to predict the exact amount of flow necessary to be added at the upstream end of a canal or stream channel. Additionally, water agencies must account for the significant travel times between reservoirs and receiving customers. For example, SSWD makes adjustments to releases from the Camp Far West Reservoir at 4 AM to meet adjustments in water orders for late

morning through late afternoon on Coon Creek and other locations. Water travel times are also heavily dependent on the volume of water being conveyed along canals and stream channels (Brad Arnold, personal communication).

Discussion of Irrigation-Season Flow Management by Watershed Zones

As discussed above, the most significant conveyance and flow management activities are summarized in Figure A-1. The following sections of this chapter describe these specific activities in the Coon Creek watershed by major zones in greater detail and provide appropriate explanation as needed.

Coon Creek Headwaters (Orr Creek and Dry Creek)

The upper headwaters of Coon Creek consist of Orr Creek and Dry Creek, two intermittent stream channels that have been transformed into perennial streams along portions of their length by flow management and conveyance activities. At the upstream end of one of one Orr Creek's northern forks, NID typically releases between 30 and 40 cfs. Approximately 3 miles downstream, NID typically diverts 7 cfs out of the Orr Creek reservoir into the Gold Hill Canal while the rest of the added flows continue downstream to Coon Creek.

At the upper end of Dry Creek, PG&E maintains several small reservoirs including Halsey Forebay, Halsey Afterbay, Lake Arthur, Lake Theodore and Rock Creek Lake. As mentioned earlier, it is our understanding that PG&E does not release flows for conveyance purposes along Dry Creek as part of its normal operations. As such, Dry Creek typically lives up to its name until its confluence with Rock Creek, just downstream of Highway 49. Up until May 2016, Placer County's wastewater treatment plan (SMD-1) discharged treated effluent to Rock Creek immediately upstream of its confluence with Dry Creek. However, the plant was shut down on May 23rd, 2016, SMD-1 and all wastewater is now piped to the City of Lincoln.

While SMD-1 was in operation, Placer County was required to purchase flows for Rock Creek to dilute the discharged effluent in order to meet water quality requirements. Up until fall of 2016, these flows were typically 5 cfs during the summer and 3 cfs in the winter, which were released upstream to Rock Creek by NID at the Rock Creek Canal. Per an agreement with the California Department of Fish & Wildlife (CDFW), Placer County will continue to purchase at least 0.5 cfs for the foreseeable future to enable Rock Creek to more gradually adjust back to an intermittent stream (Dave Atkinson, personal communication). The combined Dry Creek and Rock Creek flows continue downstream until the Dry Creek confluence with Orr Creek, at which point the stream's name transitions to Coon Creek.

Upper Coon Creek and Deadman's Ravine

At its upstream end, Coon Creek's irrigation season flows are typically dominated by flows coming from Orr Creek. Less than 1 mile downstream, as Coon Creek descends into the canyon, the stream reaches NID's Camp Far West Diversion Dam (Figure 37). At this dam, NID has an appropriative water right to all natural stream flows. These natural flows as well as NID's released flows (from upstream) and the water purchased by Placer County for effluent dilution are typically diverted into NID's Camp Far West Canal. The only water that continues downstream is that which seeps through cracks in the dam, travels

through the hyporheic zone or is released by NID at a spill gate at the head of the Camp Far West Canal back into Coon Creek. Coon Creek then continues its descent into the canyon where it is joined by Deadman's Ravine.

Deadman's Ravine is also used by NID to convey flows. At its upstream end, NID typically releases 15-17 cfs into Deadman's Ravine from one of its canals. A significant portion of that water (typically 12-13 cfs) is then diverted into the Gold Hill II Canal a short distance downstream. Continuing downstream, an additional 2-7 cfs is often released into Deadman's Ravine from the Gold Hill Canal. As Deadman's Ravine nears its confluence with Coon Creek, NID typically diverts all of the remaining flow in Deadman's Ravine (often 5-6 cfs) into the Whisky Diggins Canal. Any flow that is not captured at this diversion passes on to Coon Creek. Coon Creek then continues down the canyon without further management.

Once Coon Creek exits the highly confined canyon, it typically gains an additional 5-7 cfs that is released by NID into its #10 spill from the Camp Far West Canal. The majority of these flows are typically abstracted by NID customers before Coon Creek reaches its confluence with Doty Ravine a short distance upstream of Highway 65.

Doty Ravine and Sailor's Ravine

Near its headwaters, Sailor's Ravine experiences an addition of approximately 2-3 cfs which is then diverted a very short distance downstream. Doty Ravine can also pick up very minor flows at the end of the Gold Hill Canal and from other return flows. However, the first significant addition of flows along Doty Ravine occurs a short distance downstream of the confluence with Sailor's Ravine where NID typically adds 5-7 cfs to the stream. Approximately 4 miles downstream, all flows in Doty Ravine are generally diverted by NID at the Doty South Diversion Dam (Figure 38) into the Doty South Canal. This dam is a permanent dam with an adjustable riser that diverts flows into the Doty South Canal via an unscreened opening (there is a debris screen, but this screen does not screen for fish).

Lower Coon Creek

Downstream of its confluence with Doty Ravine, flows in Coon Creek can decrease as the stream continues west due to irrigation withdrawals. Shortly upstream of the Placer-Sutter County boundary (and a significant canal release point into Coon Creek operated by SSWD), Coon Creek passes over SSWD's seasonal, low-flow weir. SSWD carries an appropriative water right for all flows on Coon Creek entering Sutter County and adds additional irrigation flows to meet downstream demand. Flows are measured at this location each year between April 15 and October 15th, but the actual start and end dates of measurements are driven by SSWD's operations in that given year.

The daily flow measurements often show large day to day fluctuations in flows at this location of Coon Creek (see Figure 39 for daily flows in 2010 and 2013). The large range in flow values is also summarized in Figure 40 which shows the large range of flows that occurred between 2006 and 2015. It is also not uncommon in some years for periods of zero flow to occur during the summer at this location, as was the case in 2007, 2008, and 2012-2015. These periods of zero flow usually occur in July and August, while irrigation season flows are typically greatest during April and October, which can also be driven by precipitation (Figure 41).

Shortly downstream of this weir, SSWD releases flows into Coon Creek from the Line 1 Canal which runs north to south in this area along the Placer-Sutter County boundary. These flow additions are often in the range of 25 to 30 cfs during the periods of greatest demand (typically June through August). However, the actual amount is often determined in large part by incoming flows from Placer County and irrigation demand by farmers in Sutter County. As Coon Creek continues downstream, the majority of these flows are abstracted by downstream pumps for rice farming. By the time Coon Creek reaches the East Side Canal, it is not uncommon for 90 to 95% of the flow present downstream of the Line 1 Canal release to be abstracted (Brad Arnold, personal communication). However, towards the end of the irrigation season (roughly mid-September onward), it is common for this pattern to actually reverse as rice farmers reduce or cease their demand altogether and instead release flows back into the stream as they drain their fields.

East Side Canal

Coon Creek is intercepted by the East Side Canal a short distance downstream of Nicolaus Avenue. The downstream-most reaches of Coon Creek are now entirely hydrologically disconnected from the upper watershed except for any flows passing through an operable gate under the East Side Canal's western levee. Further downstream, the East Side Canal also intercepts flows from Markham and Auburn Ravine. Immediately downstream of Auburn Ravine, SSWD operates a seasonal flashboard dam called Coppin Dam (Figure 42). Boards on this dam can technically be installed as early as April 5th and removed as late as October 25th (10 days before the start and after the completion of the irrigation season, respectively). Backwater effects driven by Coppin Dam enable SSWD to "push" flows down Auburn Extension, a canal that runs directly west, by gravity alone. During periods of peak demand, up to 25 cfs can be diverted into Auburn Extension while typically less than 1.3 cfs passes over, through or under Coppin Dam (via subsurface flow). Similar to Coon Creek, the East Side Canal also typically experiences higher flow volumes toward the end of the irrigation season due to return flows from draining fields. During these times, it is common that far more than 1.3 cfs passes Coppin Dam as the East Side Canal continues down to the Cross Canal and ultimately the Sacramento River.

3.4 PEAK FLOW REGIME

Peak flows were estimated using a hydrologic model to facilitate comparison of three land cover scenarios: (1) existing conditions, (2) pre-disturbance conditions, and (3) future fully-developed conditions. This effort relied on an existing hydrologic model developed by Civil Engineering Solutions, Inc (CESI) to compute peak flows. The model domain includes the Coon Creek watershed down to its outlet at the East Side Canal (Figure A-3). It should also be noted that the model does not account for flows discharged into Bunkham Slough (a distributary of Coon Creek that splits off the main stem downstream of the confluence with Doty Ravine) or interactions between Coon Creek and adjacent streams (e.g., Markham and Auburn Ravines). The existing conditions scenario relies on the existing model setup and is representative of 2007 land cover. To assess changes to peak flows resulting from

present day land use and land development, CESI revised this hydrologic model to reflect pre-disturbance land cover conditions.

To assess peak flows in the future fully developed conditions scenario, CESI updated the model using land cover information from Placer County's general plan. Inspection of the City of Lincoln's general plan did not show future development within the Coon Creek watershed (Thomas Plummer, personal communication). Additionally, the City of Auburn was unable to provide their general plan data in a GIS format (Edgar Medina, personal communication) and the data provided was not suitable for use within the model. As such, the future conditions scenario model relies on 2007 land cover conditions within Auburn's city limits. While additional development has occurred and will likely continue to occur in Auburn in the coming decades, the net impact to peak flows in Coon Creek should be limited by on-site stormwater detention. It should also be noted that while on-site stormwater detention will also be required for urban development occurring within Placer County (but outside Auburn's city limits), this detention is not accounted for in the model. As such, the model likely overestimates future stormwater contributions from urban development within unincorporated portions of Placer County, but underestimates future flow contributions from the City of Auburn. The composite future land use mapping used in the model is depicted in Figure A-2 in the Appendix. Additionally, the future fully developed conditions model does not consider any effects resulting from climate change.

Model Results and Discussion

The model was run for the three different land cover scenarios for a suite of 24-hour duration storms for the 2-, 5-, 10-, 25-, 50-, 100-, 200- and 500-year events. Peak flows were extracted from the model at 18 locations to characterize the peak flow regime of the watershed and to facilitate comparison across the three land cover scenarios (these locations are depicted in Figure 43 and Figure 44). A subset of these flow values are provided for the pre-development land cover scenario in Table 1, while the complete set of flow values for all three scenarios is provided in Appendix A. Considering only the 18 monitoring locations, the peak flows for Coon Creek for the existing conditions land cover scenario are 5,499, 13,753, 31,217 and 37,407 cfs for the 2-, 10-, 100- and 200-year events, respectively (as observed at point number 3, or model node CO12+, in Figure 43).

Basin-wide peak flows for 24-hour events occur on Coon Creek downstream of the Doty Ravine confluence but upstream of the Placer-Sutter County boundary. The reason that these peak flows occur upstream of the stream's outlet is due to the physical shape, hydrography and topography of the Coon Creek watershed and the routing of flood flows. As Coon Creek approaches its outlet, the width and slope of the watershed decline, resulting in lesser contribution of flood water per unit length of stream channel compared to reaches further upstream. Additionally, the localized storage of floodwater in the channel and the floodplain as the flood wave passes downstream results in smaller peak flows at the downstream end due to floodplain attenuation.

Table 2 and Table 3 provide the percent increase in peak flows (relative to the pre-disturbance condition) due to changes in land cover for the existing conditions and future development scenarios. These same values were also used to visually depict increases in flows along the major stream reaches of

the Coon Creek watershed Figure 43 and Figure 44 for the 2-year event. The model results show that the greatest percent increase in flows occurs along Dry Creek, a tributary of Coon Creek that drains portions of Auburn. The model shows no change to the peak flows of Doty Ravine and Deadman's Ravine. While in reality peak flows have likely increased somewhat due to the land use changes (e.g., grazing pressures, limited road development, etc.) in these sub-watersheds, it is likely relatively minor compared to the changes driven by urbanization around Auburn. Overall, the magnitude of these percent increases in peak flows is relatively minor, which suggests that with the exception of Dry Creek, changes to peak flow hydrology caused by land use change and hydromodification in the Coon Creek watershed are fairly limited.

Table 1. Modeled peak flows for pre-disturbance conditions

Point Number	Model Node	Stream	Description	Peak Flow (cfs)					
				2-Year	10-Year	50-Year	100-Year	200-Year	500-Year
1	CO16D+	Coon Creek	Downstream-most point	3,985	9,223	17,156	21,121	25,242	33,970
2	RCO14B	Coon Creek	Placer-Sutter Boundary	4,418	11,351	21,203	26,471	31,998	44,677
3	CO12+	Coon Creek	Dstm of Doty Ravine Confluence	5,378	13,649	25,034	31,124	37,299	51,012
4	CO9+	Coon Creek	Ustm of Doty Ravine Confluence	4,012	10,407	19,784	24,502	29,219	38,567
5	CO11+	Doty Ravine	Immediately Ustm of Confluence	1,806	4,829	7,512	8,745	10,015	11,961
6	CO8+	Coon Creek	McCourtney Rd Bridge	4,015	10,402	20,024	24,782	29,452	38,599
7	CO7+	Coon Creek	Garden Bar Rd Bridge	3,486	9,263	17,980	22,199	26,330	33,813
8	CO5++	Coon Creek	Dstm of Deadman's Confluence	3,318	8,798	16,928	20,821	24,722	31,649
9	CO6B+	Deadman's	Immediately Ustm of Confluence	352	1,010	1,834	2,254	2,668	3,235
10	CO5+	Coon Creek	Ustm of Deadman's Confluence	3,085	8,341	15,269	18,841	22,363	28,711
11	CO4@D+	Coon Creek	Below Orr-Dry Ck Confluence	2,639	7,496	13,394	16,366	19,259	24,274
12	CO4+	Orr Creek	Immediately Ustm of Confluence	1,457	3,726	6,446	7,652	8,754	10,422
13	CO2C+	Dry Creek	Immediatley Ustm of Confluence	1,634	4,744	8,346	10,058	11,673	14,055
14	CO10E+	Doty Ravine	McCourtney Rd Bridge	1,710	4,824	7,450	8,712	9,985	11,956
15	CO10D+	Doty Ravine	Garden Bar Rd Bridge	1,531	4,086	6,489	7,724	8,941	10,774
16	CO10C+	Doty Ravine	Downstream of Sailor's Ravine	896	2,503	4,178	4,971	5,768	6,917
17	CO10B+	Doty Ravine	Immediately Ustm of Sailor's	573	1,486	2,418	2,847	3,262	3,903
18	CO10C	Sailor's Ravine	Immediately Ustm of Confluence	528	1,226	1,959	2,305	2,638	3,183

Table 2. Percent increase in modeled peak flows for existing conditions

Point Number	Model Node	Stream	Description	Percent Increase in Peak Flow					
				2-Year	10-Year	50-Year	100-Year	200-Year	500-Year
1	CO16D+	Coon Creek	Downstream-most point	2.38%	1.43%	0.80%	0.68%	0.58%	0.45%
2	RCO14B	Coon Creek	Placer-Sutter Boundary	3.40%	1.13%	0.64%	0.52%	0.43%	0.33%
3	CO12+	Coon Creek	Dstm of Doty Ravine Confluence	2.25%	0.76%	0.42%	0.30%	0.29%	0.25%
4	CO9+	Coon Creek	Ustm of Doty Ravine Confluence	2.42%	0.82%	0.47%	0.43%	0.31%	0.25%
5	CO11+	Doty Ravine	Immediately Ustm of Confluence	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
6	CO8+	Coon Creek	McCourtney Rd Bridge	2.32%	0.82%	0.48%	0.43%	0.32%	0.26%
7	CO7+	Coon Creek	Garden Bar Rd Bridge	2.58%	0.91%	0.51%	0.44%	0.34%	0.28%
8	CO5++	Coon Creek	Dstm of Deadman's Confluence	2.74%	0.90%	0.54%	0.51%	0.35%	0.29%
9	CO6B+	Deadman's	Immediately Ustm of Confluence	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
10	CO5+	Coon Creek	Ustm of Deadman's Confluence	2.98%	0.95%	0.60%	0.45%	0.38%	0.32%
11	CO4@D+	Coon Creek	Below Orr-Dry Ck Confluence	3.41%	1.08%	0.49%	0.39%	0.43%	0.30%
12	CO4+	Orr Creek	Immediately Ustm of Confluence	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
13	CO2C+	Dry Creek	Immediatley Ustm of Confluence	5.63%	1.71%	0.80%	0.72%	0.65%	0.51%
14	CO10E+	Doty Ravine	McCourtney Rd Bridge	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
15	CO10D+	Doty Ravine	Garden Bar Rd Bridge	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
16	CO10C+	Doty Ravine	Downstream of Sailor's Ravine	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
17	CO10B+	Doty Ravine	Immediately Ustm of Sailor's	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
18	CO10C	Sailor's Ravine	Immediately Ustm of Confluence	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Note: percent increase is relative to pre-disturbance peak flows

Table 3. Percent increase in modeled peak flow for future fully developed conditions

Point Number	Model Node	Stream	Description	Percent Increase in Peak Flow					
				2-Year	10-Year	50-Year	100-Year	200-Year	500-Year
1	CO16D+	Coon Creek	Downstream-most point	4.62%	2.60%	1.47%	1.31%	1.16%	0.97%
2	RCO14B	Coon Creek	Placer-Sutter Boundary	6.16%	2.21%	1.25%	1.11%	0.95%	0.98%
3	CO12+	Coon Creek	Dstm of Doty Ravine Confluence	4.70%	1.73%	1.26%	1.23%	1.12%	1.28%
4	CO9+	Coon Creek	Ustm of Doty Ravine Confluence	6.03%	2.33%	1.97%	1.82%	1.86%	2.33%
5	CO11+	Doty Ravine	Immediately Ustm of Confluence	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
6	CO8+	Coon Creek	McCourtney Rd Bridge	6.08%	2.49%	2.22%	2.14%	2.22%	2.10%
7	CO7+	Coon Creek	Garden Bar Rd Bridge	6.68%	2.61%	2.44%	2.52%	2.09%	2.14%
8	CO5++	Coon Creek	Dstm of Deadman's Confluence	6.99%	3.38%	2.17%	2.33%	1.93%	1.77%
9	CO6B+	Deadman's	Immediately Ustm of Confluence	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
10	CO5+	Coon Creek	Ustm of Deadman's Confluence	7.71%	3.56%	2.22%	2.22%	1.82%	1.95%
11	CO4@D+	Coon Creek	Below Orr-Dry Ck Confluence	8.90%	4.03%	2.99%	2.28%	2.08%	2.34%
12	CO4+	Orr Creek	Immediately Ustm of Confluence	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
13	CO2C+	Dry Creek	Immediatley Ustm of Confluence	16.28%	6.43%	3.88%	3.52%	3.03%	2.60%
14	CO10E+	Doty Ravine	McCourtney Rd Bridge	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
15	CO10D+	Doty Ravine	Garden Bar Rd Bridge	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
16	CO10C+	Doty Ravine	Downstream of Sailor's Ravine	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
17	CO10B+	Doty Ravine	Immediately Ustm of Sailor's	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
18	CO10C	Sailor's Ravine	Immediately Ustm of Confluence	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Note: percent increase is relative to pre-disturbance peak flows

4 WATER QUALITY ASSESSMENT

The objective of this water quality assessment was to build off past monitoring efforts to further characterize water quality health, sources of water quality impairment, and habitat suitability for salmonids within the Coon Creek watershed. This section of the report begins with a review of previous water quality monitoring data and findings. It then summarizes and discusses findings from the temperature monitoring, dissolved oxygen monitoring and analytical laboratory analysis conducted as part of this assessment.

4.1 WATER QUALITY OVERVIEW

Water quality is a key component of overall watershed health. The interplay between temperature, dissolved oxygen, nutrients, and contaminants affects a stream's biodiversity, its resilience to invasive species, its suitability for healthy populations of native species, and the health of humans who rely on it (Ecological Society of America, 2003). For instance, anadramous fish thrive in streams that are clear, cool, rich in oxygen, and free of contaminants that can interfere with vital life processes such as organ development and navigation. Contaminants stored in streambed sediments can make their way up the food chain and pose risks to humans who consume contaminated fish. Benthic macroinvertebrate species, which serve as an important food source for fish, are also highly sensitive to changes in water quality because of their relatively immobility. Coon Creek's water quality is a function of numerous factors, including climate, geology, flow regime and management for irrigation, and past and present land use in the watershed. This assessment of water quality conditions in the Coon Creek watershed draws on insights gained from a review of existing water quality monitoring data, as well as new data generated as part of this project.

4.1.1 Previous Monitoring Efforts

Data Sources

A number of water quality-monitoring efforts have been conducted on Coon Creek in the past. Prior monitoring programs identified as part of this assessment are summarized in

Table 4. Existing data reviewed as part of this assessment spans the period from 1994 to the present. These previous monitoring efforts were carried out for a variety of different purposes, and their duration and scope varied considerably. Geographically, prior monitoring data exists for most reaches of Coon Creek from its confluence with the East Side Canal up to its headwaters in North Auburn, near State Highway 49. However, the richest chemical water quality data exists for two sites at the extreme upstream and downstream reaches associated with the former the Placer County SMD-1 wastewater treatment plant in Auburn and the Placer Nevada South Sutter North Sacramento Subwatershed Group (PNSSNS) in Sutter County, respectively. Monitoring was conducted at several points near SMD-1 to comply with the facility's NPDES permit. Water quality data is collected at the PNSSNS Representative site for reporting to the Irrigated Lands Regulatory Program of the Central Valley Water Quality Control

Board. Continuous temperature monitoring was also conducted by Bailey Environmental at five locations spread along Coon Creek and its headwaters.

Table 4. Summary of Previous Monitoring Efforts

Organization	Location	Frequency and Years Covered	Parameters Measured	Source
Department of Water Resources (DWR)	1 mile downstream of Trowbridge, near confluence with Eastside Canal	Monthly, 2001-2002	• General water quality • Metals • Nutrients • Pathogen indicators • Pesticides	Cited in Auburn Ravine / Coon Creek Ecosystem Restoration Plan
Placer Nevada South Sutter North Sacramento Subwatershed Group (PNSSNS)	Brewer Road	Seven times annually, 2007 - present	• General water quality • Metals • Nutrients • Pathogen indicators • Pesticides *(frequency varies)*	PNSSNS Reduced Monitoring and Management Practices Verification Plan, May 2015; California Environmental Data Exchange Network, Water Board Irrigated Lands Program
Bailey Environmental	5 locations: Coon Creek at sites (1) just upstream of Garden Bar Rd, (2) just upstream of Gladding Rd, (3) at Placer-Sutter Boundary, and (4) at Nicolaus Rd; (5) Dry Creek downstream of SMD-1	Continuous monitoring from Sept. 2001 to Aug. 2003 at Garden Bar and Gladding Rd sites and for summer 2003 at the other 3 sites	• Temperature	Streams of W. Placer Co.: Aquatic Habitat and Biological Resources Literature Review, Bailey Environmental, 2003
Teichert Construction	Unclear, but likely between Gladding Road and Old Hwy 65	Once, 1994	• General water quality • Metals • Nutrients • Oil and grease • Pathogen indicators • Pesticides	Draft EIR for Teichert Aggregate Facility
Lincoln High School	• Teichert Property (upstream of Gladding Rd.) • Fleming Property (downstream of Garden Bar Rd.)	Once, 2002	• General water quality • Nutrients • Pathogen indicators	Streams of W. Placer Co.: Aquatic Habitat and Biological Resources Literature Review, Bailey Environmental, 2003
Dry Creek Conservancy	• Upstream of Gladding Rd. • Lower Spears • Upper Spears	Once, 2005	• General water quality	Excel spreadsheet provided by Dry Creek Conservancy
Placer County	SMD-1 WWTP • Rock Creek Upstream • Dry Creek Upstream • Dry Creek Downstream	Monthly, 2011-2016 (monitoring also occurred before 2011 but data was not available)	• General water quality • Aluminum • Chloroform	NPDES Data from California Integrated Water Quality System

Key Findings

Previous water quality assessments of the Coon Creek watershed identify five primary water quality issues of concern: temperature, dissolved oxygen (DO), eutrophication caused by nutrient enrichment, metals, and pesticides.

Temperature

Water temperature is a critical component of habitat suitability, particularly for salmonids. The most significant temperature monitoring effort previously conducted along Coon Creek was performed between 2001 and 2003 by Bailey Environmental at two locations in the watershed, and at an additional three locations for the summer of 2003 (Table 4)(Bailey, 2003). Of these five locations, four were accessible by anadromous fish. This data collection effort indicates that during the period of monitoring, temperature would have affected some stages of Chinook salmon and steelhead life history. For Chinook salmon, warm water temperatures may have resulted in egg mortality up until early to mid-November. Between mid-November and March, temperatures were generally suitable for spawning, embryo incubation and juvenile rearing. However, from April through June, water temperature likely caused stress and/or mortality in juvenile Chinook salmon that had not yet emigrated from the watershed. For steelhead, temperatures were generally suitable for spawning and embryo-incubation until early to late March. Afterwards, temperature would have likely limited successful embryo development. Warm temperatures would have also likely limited the success of juvenile steelhead rearing between May and September. Review of this data and aerial photography of stream reaches by Jones & Stokes also indicates that low to moderate shading may drive warmer stream temperatures along Coon Creek (Jones & Stokes, 2005).

DO

The Central Valley Regional Water Quality Control Board criterion for minimum dissolved oxygen in cold water streams is 7 mg/L (CVRWQCB, 2016). In general, dissolved oxygen concentrations higher than 7 mg/L allow cold water fish species to thrive. Approximately 99% of DO measurements made in Coon Creek during previous studies were greater than or equal to 7 mg/L. These results indicate that low DO levels are not likely to be a major impediment to the survival of anadramous species in the Coon Creek watershed. In general, DO levels were higher in winter months and lower in summer months, as expected based on temperature-dependent solubility of oxygen in water. No long-term temporal or geographic trends were apparent with respect to available DO measurements.

Nutrients

Eutrophication is the process in which excessive growth of plant life caused by high levels of nutrients leads to low levels of dissolved oxygen. The concentrations of nitrogen and phosphorus necessary to cause eutrophication are highly watershed-specific, but a general rule of thumb is that the ratio of nitrate to orthophosphate should be limited to 10 or less (Bailey, 2003). Data from the PNSSNS monitoring program show that nitrate levels and the nitrate to orthophosphate ratio in Coon Creek are highest in February or March. However, dissolved oxygen levels in Coon Creek do not decrease to levels of concern until the late summer months, when nitrate concentrations in the creek are low. This

suggests that the higher ambient temperatures and potentially low-flow conditions that exist during the late summer are the main driver of decreased oxygen concentrations, rather than nutrient enrichment. The Placer County SMD-1 wastewater treatment plant was a major historical source of nitrogen loading to the watershed, and its closure in 2016 should reduce the likelihood of eutrophication events in the Coon Creek watershed.

Metals

Heavy metals such as copper and aluminum can have toxic effects on aquatic life, even at low concentrations. Copper was monitored during the DWR study in 2001, as well as by PNSSNS in 2007 and 2011. Aluminum was monitored in Coon Creek during the DWR study in 2001 and by PNSSNS on two occasions in 2007, as well as in Rock Creek above the SMD-1 discharge on a monthly basis from 2011 to 2016. Data from these efforts show that concentrations of copper and aluminum exceed the chronic toxicity criteria for protection of aquatic life specified by the California Toxics Rule (SWRCB, 2016) in 35% and 47% of instances, respectively. A prior assessment of aquatic habitat in Coon Creek concluded that high copper concentrations were likely due to background sources and that aquatic life has adapted to these levels (Bailey, 2003). However, no justification was provided for either of these conclusions, and they are best regarded as speculative. Interpretation of the existing metals data is difficult because the monitoring record is quite discontinuous and there is uncertainty regarding the analytical methods used (i.e. total recoverable metal vs. dissolved metal). Taken as a whole, the existing data suggests that metals toxicity is an issue that should be investigated further.

Pesticides

Pesticides were monitored in Coon Creek during the DWR study in 2001 and by PNSSNS on a monthly basis in 2007 and 2011. The majority of pesticide analyses resulted in non-detects. The DWR study detected diazinon twice, while the PNSSNS program detected chlorpyrifos, diuron, and simazine twice, and thiobencarb once. One sample each for chlorpyrifos and diuron were at concentrations exceeding water quality criteria. Nine out of eleven of the positive pesticide detections occurred between the months of February and May. The two chlorpyrifos detections both occurred in August. The existing data indicates that pesticide effects could be seasonally significant and should be investigated further.

4.1.2 General Monitoring Approach

Building upon the existing datasets described above, cbec developed and implemented a water quality monitoring program using various instrumentation platforms and sampling frequencies for a range of constituents. The monitoring approach was intended to further understanding of the basin's water quality health, sources of pollution, degrees of impairment, and habitat suitability for salmonids across seasonal and spatial time scales. The design of the water quality monitoring study leveraged preliminary findings from the watershed assessment, particularly stream channel characteristics (e.g., gradient and reach type), flow management practices for irrigation, and land use. Temperature monitoring was a major focus of this assessment, and, along with dissolved oxygen monitoring, helped inform water quality conditions for salmonids and other aquatic organisms. Analytical laboratory analysis was used to investigate other constituents (e.g., nutrients, metals, pesticides, and coliform) to more directly inform

water quality impairment and toxicity due to land use in the watershed.

4.2 TEMPERATURE MONITORING

4.2.1 General Background

Water temperatures are an important component of water quality, both as a driver of other water quality parameters and habitat suitability for aquatic organisms. Water temperatures determine the solubility of oxygen within water and the likelihood of hypoxic conditions in a water body. Water temperatures also drive the rates of many chemical reactions and in turn other water quality conditions. Aquatic organisms are also highly sensitive to water temperatures. Cold-water fish species, particularly Chinook salmon and steelhead in Coon Creek, depend on cooler temperatures to maintain healthy physiological conditions. By contrast, other organisms (e.g., amphibians, certain reptiles, etc.) can thrive in warmer waters.

Key Drivers of Water Temperatures in Coon Creek

A large range of natural and human factors influence water temperatures in any watershed. These drivers include but are not limited to climate conditions, channel structure, interactions between groundwater and surface water, riparian canopy cover and flow management. The following is a description of a number of the key drivers of water temperatures within the Coon Creek watershed. It should be noted that this list is not exhaustive, and that water temperatures are determined by the complex interaction of a large number of factors.

<u>Groundwater - Surface Water Interactions</u>
One of the strongest drivers of water temperatures, particularly in smaller systems, is the exchange of water between the active stream channel and adjacent groundwater. Groundwater discharge to a stream channel can make up a significant portion of in-channel flow, particularly outside of precipitation events. Depending on the geology, bed material, channel complexity and other factors, there can also be considerable movement of water between the channel and the groundwater table. Consequently, baseline stream temperatures are generally determined by the temperature of adjacent groundwater. A stream's temperature typically deviates from this baseline groundwater table temperature with increasing distance downstream and influence of other factors such as atmospheric conditions and human influences (Poole and Berman, 2001).

<u>Climate and Atmospheric Conditions</u>
Ambient air temperature is one of the strongest drivers of water temperatures in the Coon Creek watershed. The exchange of heat between stream flow and the atmosphere increases as the difference in water and air temperatures increases. Precipitation events and the general precipitation regime of the watershed is also important. Additionally, relative humidity, solar radiation, wind and other atmospheric conditions drive water temperatures.

Channel Geometry and Structure

The geometry and structure of the stream channel itself also has a significant influence on the stream's natural capacity to insulate or buffer changes in temperatures. As an example, the substrate or bed material influences the rate of exchange of groundwater. The width of the stream controls the surface area exposure of the stream to the atmosphere. Channel slope also influences travel times and groundwater exchange (Poole and Berman, 2001).

Riparian Vegetation

The riparian canopy can block solar radiation from reaching the water surface. Additionally, riparian vegetation can influence local wind-speed and thereby influence the exchange of heat between the stream and the atmosphere. As the size (particularly the width) of a river increases, the capacity for riparian vegetation to shade the stream and limit wind-speed often declines (Poole and Berman, 2001). Management of riparian vegetation, especially the removal of the riparian canopy, greatly increases the solar radiation reaching Coon Creek and its tributaries along many reaches.

Flow Rate

The amount of flow in a stream, typically measured in cubic feet per second, has a large effect on the stream's temperature and its capacity to buffer itself from atmospheric conditions. Higher flow rates indicate more water in the stream channel and therefore greater thermal mass. Greater amounts of flow usually reduce the ratio of surface area exposure to water volume, making the stream less susceptible to temperature changes driven by heat exchange with the atmosphere. Increased flow rates also increase water velocities and thereby reduce the transit time of a parcel of water between one point and the next, which further buffers the stream from atmosphere-driven temperature changes.

Flow Management

Human management of stream flows appears to be a considerable driver of water temperatures within the Coon Creek watershed. Augmentation of stream flows with water imported from outside basins introduces water of different temperatures and increases flow rates. By contrast, diversions remove water from the stream channel and reduce stream flows. Conveyance, delivery and diversion of irrigation water along stream channels thereby influences water temperatures along many reaches of Coon Creek, particularly during the irrigation season (April 15 through October 15).

4.2.2 Temperature Monitoring Approach

As part of this assessment, a network of 20 continuous temperature monitoring stations were established along Coon Creek and its tributaries as well as one site along the East Side Canal (Figure 45). Monitoring locations were selected to inform longitudinal and temporal trends in water temperatures along Coon Creek, Doty Ravine and other tributaries as well as the influence of tributaries and flow augmentation from major canal inputs[4]. Another major objective of this temperature monitoring effort

[4] A second map of temperature monitoring locations relative to irrigation season flow management is provided in Appendix A (Figure A-2).

was to assess thermal suitability of the stream network for various life stages of Chinook salmon and steelhead.

Temperature monitoring began in November 2014 at a total of 8 sites in the middle and upper watershed. An additional 12 monitoring locations were established in the spring of 2015. Monitoring was conducted with Onset HOBO temperature sensors and ceased in September of 2016. Installations depended on site conditions and included stilling wells driven into the stream bed, sensors fixed to infrastructure (e.g., bridge piers) and sensors secured to stable submerged wood features. Sensors were generally deployed within well developed pool features along shaded sections of the stream channel. However, channel conditions and access constraints resulted in some deployments being partially exposed to solar radiation or installed in shallow pool features. During the monitoring period, data from several sensors was lost (due to theft or loss during flood flows) or considered non-representative of surface water temperatures (due to pools filling in during winter storm events or air exposure during times of exceptionally low flows).

4.2.3 Temperature Monitoring Findings

The period of data collection provides partial coverage for water year (WY) 2015 and fairly complete coverage for WY 2016. It should be noted that WYs 2015 and 2016 were designated as a critically dry year and a below normal year, respectively, by the Sacramento River Water Supply Index (CDWR, 2016). These designations are made each year by the California Department of Water Resources and are based upon estimates of unimpaired runoff for the Sacramento River Valley. While hydrologic conditions within the Coon Creek watershed are governed by many local factors and the basin does not have a snowmelt component, this index is useful for providing an indication of the amount of water in the basin each year which in turn can influence stream temperatures. In general, temperatures in WY 2015 were slightly warmer than those in WY 2016 which may have been partly due to the lesser water supply in WY 2015. It should also be noted that the data provided in this monitoring effort is likely not representative of the full range of water temperatures and seasonal variability that occurs across longer time scales, or that which may occur during wetter years.

The range of observed water temperatures generally spans from lows in the upper 30s during the winter to highs between the mid 70s and mid 80s during the summer months (depending on the site) (Figure 46 and Figure 47). Late November through February demonstrates the coldest water temperatures while the warmest temperatures were observed from May to August. Several trends observed in the watershed are described below while more comprehensive discussion by watershed zones follows in a later section.

Daily Temperature Range Greatest During Summer Months

The daily range in water temperatures at any given site is generally greatest during summer months and smallest during winter months (Figure 48). This is likely due to a combination of factors, including the greater difference between air and water temperatures during the summer (which drives greater rates of heat exchange) and the relatively higher flow volumes that generally occur during the winter months (which reduces travels times and duration of sun exposure and heat exchange with the atmosphere).

Inter-Site Temperature Variability Greatest During Summer Months

The variability in temperature among sites is also generally greater during the summer months than the winter months. As an example, Figure 48 shows greater levels of variability among sites during the summer months compared to the winter months. This seasonal trend in inter-site temperature variability is likely driven by a wide range of drivers that include anthropogenic influences and natural factors. During the summer months, heat exchange rates are generally greatest due to large differences between air and water temperatures, the strength and duration of sun exposure and relatively lower amount of flows in the stream (except where irrigation season flow management occurs). Variability in the intensity of these drivers (e.g., full sun exposure along some reaches and complete shading along others) is thereby magnified during the summer months. Additionally, inter-site variability in stream temperatures is also likely driven by the conveyance of irrigation flows along some reaches but not others.

Cooler Temperatures Generally Observed Along Steep, Shaded Reaches

Observed temperatures along steeper, shaded reaches of Coon Creek and Doty Ravine are generally cooler than those along lower-gradient reaches with significant sun exposure (Figure 46; also see Figures B-1 through B-4 in Appendix B for temperature data organized by reach). For example, the canyon reaches along upper Coon Creek (e.g., sites Coon Upper 3, Coon Upper 4 and Coon Upper 5) and the moderate to high gradient reaches along Doty Ravine (e.g. sites Doty 2 and Doty 3) generally exhibit lower temperatures than the reaches of Coon Creek downstream of the Doty Ravine confluence (Coon Lower 1 through Coon Lower 5) as well as lower portions of Doty Ravine that lack consistent riparian canopy (e.g., Doty 1). This temperature trend is most consistent before the start of the irrigation season when additional flows for conveyance and delivery purposes alter the temperature regime along certain reaches.

Reaches Utilized for Flow Conveyance Generally Exhibit Cooler Temperatures During Irrigation Season

During the irrigation season, stream reaches utilized by NID and SSWD for flow conveyance and delivery purposes generally demonstrate cooler temperatures than reaches immediately upstream and downstream. This trend is particularly pronounced along the following three reaches which coincide with relatively higher flow amounts during the irrigation season as indicated by the relative flow overlay in Figure A-1 and temperatures in Figure 46 (also see Appendix B for temperature figures organized by reach):

1. Coon Creek between SSWD's Line 1 Canal and the East Side Canal (temperatures summarized by Coon Lower 2 which are generally cooler than Coon Lower 4)
2. Doty Ravine between an NID release just downstream of the Sailor's Ravine confluence and the Doty South Canal Diversion Dam (temperatures summarized by Doty 2 which are generally cooler than Doty 1 and Doty 3)
3. Orr Creek and upper Coon Creek between NID's Orr Creek release from the Combie-Ophir Canal and the Camp Far West Diversion Dam (temperatures summarized by Coon Upper 5 which are generally cooler than Coon Upper 3 and 4)

While direct monitoring of canal temperatures was not conducted as part of this study, we suspect that flows delivered from canals during the summer months are generally cooler than in-stream water along

most reaches (based on temperatures observed at sites above and below release points). Additionally, the increased flows along conveyance reaches increases flow velocity and reduces travel times for water, thereby decreasing the duration of sun exposure and heat exchange with the atmosphere. The increased flow volumes also increase thermal mass, thereby providing the stream with greater buffering against temperature increases.

Temperature Findings by Watershed Zones

East Side Canal

Monitoring was conducted at a location below Coppin Dam and the confluence with Auburn Ravine, and data was only available between March and early September. Summer time highs generally reached the low to mid 80s between June and August, and daily temperature ranges occasionally exceeded 15 degrees (Figure 47). These large daily temperature ranges are likely driven in part by the low amounts of flow downstream of Coppin Dam during most of the irrigation season.

Lower Coon

Summertime temperatures generally fluctuate between the mid 60s and the mid 80s along this reach, with daily averages typically between the upper 60s and 80 (Figure 46; also see Figure B-1 in Appendix B). As discussed above, it appears that flow releases from the Line 1 Canal (which occur between Lower Coon 3 and Lower Coon 4) drive cooler temperatures downstream during the irrigation season. Temperatures along Lower Coon 1-3 are typically cooler than those observed at Lower Coon 4 and 5 during the irrigation season.

Upper Coon and Deadman's Ravine

During the spring and summer, temperatures are generally cooler within the canyon reaches (e.g., Coon Upper 3 and 4) than they are along the lower gradient, semi-confined reaches further downstream (e.g., Coon Upper 1 and 2) (Figure 46; also see Figure B-2 in Appendix B). Above the Camp Far West Diversion Dam, Coon Creek exhibits even cooler temperatures during the irrigation season due to conveyance of NID flows (as occurs at Coon Upper 5). Deadman's Ravine similarly exhibits cool temperatures, which is likely due to conveyance of irrigation flows that pass by the Whiskey Diggins Canal diversion as well as the channel's steep gradient and fairly dense riparian canopy.

Orr Creek, Dry Creek and Rock Creek

During the irrigation season, Orr Creek exhibits significantly cooler temperatures than Dry Creek which appears to be driven the flow conveyance along Orr Creek (see Appendix B). During the spring and summer months, Rock Creek is generally cooler than Dry Creek but warmer than Orr Creek, which was likely driven at least in part by flows purchased to dilute effluent from SMD-1. However, during the winter months of WY 2016, the water temperatures in Rock Creek were notably warmer than those in Dry Creek and Orr Creek.

Doty Ravine

Temperatures along the middle section of Doty Ravine (observed at Doty 2) are generally cooler than those in the lower and upper reaches during the irrigation season (see Appendix B). This is likely due to

NID's conveyance of flows along Doty Ravine from just downstream of the confluence with Sailor's Ravine to the Doty Canal South Diversion Dam. The lower reach of Doty Ravine (represented by Doty 1) tends to exhibit the highest temperatures along Doty Ravine, particularly during the spring and summer months. This lower reach is fairly low gradient, lacks canopy cover in many areas, and has a high density of beaver dams that likely increase the surface area of the wetted channel, and increase the travel time through this reach.

4.2.4 Temperature Suitability for Salmonids

Water temperature is among the most important factors controlling aquatic habitat suitability for salmonids at the southern end of their geographic range. Chinook salmon and steelhead are both cold-blooded organisms that depend on water temperatures within a certain range to maintain necessary physiologic functions. While exceptionally cold temperatures can slow their metabolism and growth rates, overly warm temperatures result in thermal stress and ultimately cause mortality in salmonids. Warm temperatures also increase the susceptibility of salmonids to parasites and bacterial infections, which can drive increased levels of stress and mortality. Furthermore, warmer water temperatures support warmwater fish species (e.g., bass, sunfish, bluegill, Sacramento pikeminnow) that often prey on juvenile salmonids. This section of the report explores the thermal suitability of the Coon Creek watershed for Chinook salmon and steelhead by life stage.

Temperature Suitability Thresholds by Life Stage

Each life stage in Chinook salmon and steelhead life histories has specific temperature requirements and sensitivities. The effect of temperature on each life cycle stage has been studied extensively (in both field and laboratory settings) and includes identification of optimal, tolerable and lethal temperature ranges with respect to the maintenance of various physiological functions such as growth and heart performance (USEPA 2003, Bratovich et al. 2012). The following tables summarize the water temperature index values for fall-run Chinook salmon and steelhead by life stage, as well as the potential seasonal ranges for each life stage that were determined for the lower American River[5].

[5] Water temperature index (WTI) values and life stage seasonal ranges from the lower American River were adopted for Coon Creek given the similarity in geographic context (Sierra foothills to floor of the Central Valley), proximity to Coon Creek, and the scientifically robust nature of the data set. However, salmonids in Coon Creek may have differences in life history timing and response to temperature thresholds, and will experience significantly different channel sizes and flow regimes than those present along the lower American River.

Table 5. Fall-run Chinook salmon water temperature index values by life stage

Life Stage	Water Temperature Index (°F)			Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	Upper Optimum	Upper Tolerance	Lethal												
Adult Immigration	64	68	72												
Adult Staging	61	65	72												
Spawning	56	58	63												
Embryo Incubation	56	58	63												
Juvenile Rearing	61	65	75												

*WTI values from Addley et al. 2013 and Bratovich et al. 2012.

Table 6. Steelhead water temperature index values by life stage

Life Stage	Water Temperature Index (°F)			Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	Upper Optimum	Upper Tolerance	Lethal												
Adult Immigration	64	68	70												
Adult Staging	61	65	70												
Spawning	54	57	63												
Embryo Incubation	54	57	63												
Juvenile Rearing	65	68	75												
Smolt Emigration	52	55	74												

*WTI values from Addley et al. 2013 and Bratovich et al. 2012.

It should also be noted that there is a significant degree of variability in physiological response in fish to these temperature thresholds and that the duration of exposure is also highly important in determining the response. The habitat range of Pacific salmon spans from Alaska to California, and fish in warmer climates have evolved to tolerate warmer temperatures. Additionally, each individual fish will respond to temperature-induced stress and mortality at different rates given its size, fitness, food supply, genetics and other factors. Salmonids also have the capacity to acclimate to warmer waters; if given time to adjust to warmer temperatures, their susceptibility to thermally-induced physiological stress and mortality can lessen. Finally, the duration of exposure that a fish experiences to a certain temperature

plays a huge role in determining the degree of the physiological response. As water temperature increases, the permissible duration of exposure that a salmonid can withstand before dying decreases. Salmonids can also persist at sub-lethal temperature ranges but their physiological health can be compromised over time and their growth can cease or reverse altogether. Figure 49 provides a helpful visual representation of the relationship between duration of exposure and physiological response (EPA 2003, Bratovich et al. 2012).

Coon Creek Thermal Suitability in WYs 2015 and 2016

Observed temperatures within the Coon Creek watershed were assessed with respect to species and life stage-specific water temperature index values to determine the suitability of anadromous reaches to Chinook salmon and steelhead life histories. To facilitate this analysis, the length of Coon Creek and Doty Ravine accessible by salmonids was delineated into six sub-reaches that experience similar hydrologic conditions (particularly with respect to flow management) and that would be expected to exhibit similar temperature patterns (Figure 50). A seventh reach (Coon Upper - Headwaters) was added to describe conditions above natural and artificial barriers to anadromy to inform discussion of thermal suitability of this portion of the watershed. Data that was considered representative of the temperature conditions along these reaches was compiled, generally using one monitoring location but occasionally integrating a second site's data when the data quality during a specific monitoring period was uncertain. The primary monitoring location used to characterize temperature conditions along the reach is also indicated in Figure 50.

The hourly and daily average temperature values from these representative sites were plotted by water year for each species and life stage. Figure 51 through Figure 53 depict examples of this data for Chinook salmon at several individual sites along lower and upper sections of Coon Creek and along Doty Ravine. The horizontal lines on these figures represent the water temperature index values by life stage that indicate thresholds between optimal, tolerable and lethal conditions. The shaded zones on each graphic represent temperature suitability zones for each life stage season. To facilitate comparison across sites as well as assessment of watershed-wide conditions, the daily average temperature data for these reaches are combined in Figure 54 and Figure 55 for Chinook salmon in WY 2016.

To provide a more comprehensive and spatially distributed understanding of thermal suitability for Chinook salmon and steelhead throughout the Coon Creek watershed, composite summary graphics were generated (Figure 56 and Figure 57). These graphics depict thermal suitability for each life stage and each reach within the seasonal color bands on the right panel. It should be noted that Figure 56 and Figure 57 are based on daily average temperature data rather than instantaneous data, and that daily maximum temperatures exceed the thermal suitability thresholds more frequently. Also, assessment of thermal suitability focused on WY 2016 because the data record was more spatially and temporally robust for this year, and because WY 2016 had somewhat closer to average precipitation conditions according to the Sacramento River Water Supply Index.

<u>Discussion of Thermal Suitability for Chinook Salmon Life History</u>

In WY 2016, temperatures became suitable for Chinook salmon spawning and embryo incubation in early November throughout the anadromous reaches of the watershed (Figure 56). Depending on

location, temperatures generally remained optimal for embryo incubation through late February or mid-March. Between late April or early May, temperatures became consistently stressful for rearing Chinook salmon juveniles (depending on location). The upper reaches of Coon Creek (Coon Upper - Headwaters and Coon Upper - Canyon) and the middle reach of Doty Ravine generally remain cooler later into the season than the other downstream reaches. The conveyance of flows along the Coon Upper - Headwaters and Doty Middle reaches appears to extend the thermal suitability of these reaches, and may also assist in keeping the Coon Lower - Sutter County reach cooler longer.

Juvenile Chinook salmon remaining in the watershed beyond mid-April will likely seek out coldwater refugia (e.g., deep, shaded pools with groundwater discharge that would be cooler than the temperatures recorded at monitoring stations) and/or migrate to these upper reaches as possible. However, the Coon Upper - Headwaters and Doty Middle reaches are completely or partially inaccessible to salmonids due to passage barriers, respectively. Juvenile Chinook salmon that remained in the watershed beyond early May 2016 may have been able to persist for some time, but would have likely seen diminished or reversed growth or perished. Additionally, successful juvenile emigration likely became thermally inhibited by late May or early June except during short periods of relatively cool temperatures across the watershed. The Coon Lower - Placer County reach appears to be the most thermally limiting section of Coon Creek for successful late-season juvenile emigration (although the East Side Canal and Cross Canal also likely pose thermal challenges).

Discussion of Thermal Suitability for Steelhead Life History

The spawning and embryo incubation seasons for steelhead generally occur later in the winter than those of Chinook salmon (Table 5 and Table 6). In WY 2016, temperatures were generally optimal for these life stages until mid to late February (depending on location) (Figure 57). By early to mid-March, temperatures likely precluded successful spawning and embryo incubation of steelhead. Provided any juvenile steelhead had emerged from the gravel by early March, temperatures would have remained suitable for rearing through early or late May (depending on location). Over-summer rearing generally appeared stressful or lethal throughout the watershed, although the Doty Middle reach or isolated thermal refugia may be able to support an over-summering life history strategy. Juvenile or yearling emigration from the watershed would likely be most successful before mid-April. Overall, the temperature data of WY 2016 suggests that the watershed offers limited habitat suitability, at best, for steelhead that choose an over-summering life history.

4.3 DISSOLVED OXYGEN MONITORING

Dissolved oxygen (DO) is a measure of the amount of non-compound gaseous oxygen present in the water column. Oxygen dissolves into streams via diffusion from the atmosphere, through aeration along locally turbulent sections of a stream (e.g., cascades, riffles, etc.) and as a byproduct of photosynthesis. Almost all aquatic organisms consume dissolved oxygen for respiration. Consequently, adequate dissolved oxygen levels are critical for the survival of most aquatic life. The concentration of dissolved oxygen within the water column is strongly dependent on water temperature and salinity. As water temperature or salinity increase, the solubility of oxygen in the water column decreases. Depending on

temperature, fully saturated dissolved oxygen levels in Coon Creek likely span 14 mg/L during the coldest winter temperatures to 7.5 mg/L during peak summer temperatures (SWRCB, 2016). However, it is not uncommon for dissolved oxygen concentrations to drop well below fully saturated conditions along stagnant reaches of a stream or where excess nutrient levels or organic matter fuel algae blooms or significant bacteria growth followed by intense oxygen demand for decomposition.

4.3.1 WY 2015 DO Monitoring

Continuous monitoring of dissolved oxygen concentrations was performed in two phases at a total of three locations along Coon Creek (Figure 45). The first phase of DO monitoring consisted of short-term deployments at two locations (SONDE-1 and SONDE-2, also identified as Coon Lower 4 and Coon Upper 1 monitoring sites, respectively) between late February and early March of 2015. Water quality sondes[6] were deployed for a period of two weeks at both locations. However, due to equipment malfunction, the sonde at Coon Upper 1 only collected usable DO data over a period of three days.

During the two-week deployment, dissolved oxygen values at Coon Lower 4 fluctuated between 9.5 and 13 mg/L (Figure 58). For the period of data collection at Coon Upper 1, DO fluctuated between 10 and 12.5 mg/L. Given that water temperatures during this monitoring period ranged between the mid 40s and upper 50s, these results indicate that dissolved oxygen levels at these locations at this time of year are generally healthy for aquatic life, including salmonids. At no point did DO concentrations fall below the minimum criteria of 7 mg/L specified by the Basin Plan (CVRWQCB, 2016). Both of these data sets collected during the first phase of DO monitoring represent conditions in the upper portion of Coon Creek during winter months when low DO levels were not expected to be problematic.

It should also be noted that DO levels at both locations exhibited regular diurnal fluctuations, with local maxima during the afternoon and local minimum at night. This pattern is typical for surface waters and is caused by the competing processes of photosynthesis, which produces oxygen during the daylight hours, and respiration, which decreases oxygen levels overnight.

4.3.2 WY 2016 DO Monitoring

A second phase of DO monitoring was conducted during WY 2016 and consisted of two longer-term deployments of dissolved oxygen sensors[7]. The first deployment was conducted between December 8th, 2015 and April 5th, 2016 at Coon Upper 1 only. This deployment was intended to characterize a

[6] WY 2015 DO monitoring was conducted with YSI 6920 V2-2 multi-parameter water quality sondes rented from Geotech Environmental Equipment, Inc. based in Sacramento, California.

[7] WY 2016 DO monitoring was conducted with the HOBO U26 Dissolved Oxygen Data Logger manufactured by Onset. These sensors are designed for extended duration deployments with minimal servicing needs. The manufacturer does recommend servicing on a monthly basis, particularly during warmer weather conditions. However, given the limited resources available for DO monitoring, we opted to conduct longer deployments between sonde servicing to ultimately collect more data. We did this recognizing that data quality may be affected by biofouling, sensor drift or instrumentation malfunction, particularly as the duration of deployments extended beyond 1 month after deployment or the most recent servicing.

longer period of winter and early spring conditions in a salmonid spawning and rearing zone of the watershed. The second deployment was intended to characterize conditions between mid-spring and late summer across a larger range of the watershed. We expected that the warmer season would exhibit lower dissolved oxygen levels and be more likely to limit habitat quality for aquatic life, particularly salmonids and invertebrates. This second round of monitoring was initiated on April 21st, 2016 and consisted of monitoring at three sites: Coon Lower 4, Coon Upper 1 and Coon Upper 3 (also labeled as SONDE-3 in Figure 45). These sensors were serviced on June 21st and then retrieved between September 13th and 15th.

Upper Coon

Dissolved oxygen measurements at Coon Upper 1 fluctuated between 9.5 mg/L and 13.2 mg/L between December 8th and early February (Figure 59). Between early February and early March, the hourly data suggests that the sensor became fouled but was then "cleaned" by a high-flow event that occurred on March 6th. Between March 6th and April 5th, dissolved oxygen values began to decline slightly relative to winter values (likely due to rising water temperatures) and expressed a minimum value near 8.5 mg/L.

During the second deployment period between late April and mid-September, Coon Upper 1 and Coon Upper 3 exhibited fairly similar DO measurements. Daily average DO levels generally declined from roughly 9 mg/L to 7 mg/L between late April and end of June. During this same time range, minimum DO values were as low as 6.3 and 4.7 mg/L at Coon Upper 1 and Coon Upper 3, respectively. Between late June and mid-September, DO levels at Coon Upper 1 and Coon Upper 2 remained fairly low with daily averages generally between 7 and 8 mg/L and daily minimum values dropping as low as 4.7 and 5.3 mg/L, respectively. Overall, it appears that the Upper Coon monitoring sites generally exhibited dissolved oxygen levels that were suitable to salmonids, invertebrates and other aquatic life through late May. Between early June and early September, DO levels were frequently below the Basin Plan criterion of 7 mg/L and likely resulted in minor to significant levels of stress or impairment in any sensitive species present, particularly salmonids.

Lower Coon

The DO measurements at Coon Lower 4 were generally 1 and 2.5 mg/L less than the Coon Upper sites except for occasional peaks and drops (Figure 59). Beginning in late May, it appears the sensor may have become fouled or suffered from another issue that may have influenced portions of the monitoring data. Because it is unclear, though, we have left the data as is in Figure 59 and have provided discussion of that data here. Observed DO values fluctuated significantly through the summer and occasionally dropped as low 0.5 mg/L. While these values are very low (which could be due at least in part to sensor fouling), the conditions at Coon Lower 4 during the irrigation season (particularly later into the summer) can include zero or near-zero flows, fairly stagnant water and only partial riparian shading. Therefore, these observed values may reflect actual conditions.

Between late April and mid-May, Coon Lower 4 generally exhibited DO levels suitable for most aquatic life expected in Coon Creek. However, between late May and early September, DO levels consistently fall below the Basin Plan criterion of 7 mg/L and likely caused habitat conditions ranging from stressful

to lethal for many sensitive aquatic species. These low DO levels (in addition to warm water temperatures) may have also affected successful emigration of juvenile salmonids out of Coon Creek during late spring and early summer.

4.4 ANALYTICAL LABORATORY ANALYSIS

4.4.1 Sampling Methodology

Discrete samples were collected at five locations throughout the watershed (labeled as LAB1-5 in Figure 45) to allow for laboratory analysis of a large range of chemical parameters. These sampling locations included 4 sites on Coon Creek and one site on Doty Ravine. Constituents measured by the laboratory included general chemistry parameters (hardness, total suspended solids (TSS)) nutrients (nitrogen and phosphorus), chlorinated pesticides and PCBs, nitrogen/phosphorus pesticides, metals and metalloids, and microbial pathogen indicators. Grab samples were collected during a range of seasons and flow conditions including (1) late irrigation season conditions in September 2015, (2) minor early winter storm flow conditions in November 2015, and (3) elevated flow conditions following a storm event in March 2016. Table 7 summarizes the parameters measured for the different sampling events.

Table 7. Summary of Discrete Sampling Efforts for Laboratory Analysis

Date	Description	Locations Sampled	Gen. Chem.	Nutrients	Chlorinated Pesticides	N&P Pesticides	Metals	Micro-biological
Sept. 2015	Late irrigation season conditions	LAB-1	●	●	●	●	●	●
		LAB-2	●	●	●	●		●
		LAB-3	●	●			●	●
		LAB-4	●	●	●	●	●	●
		LAB-5	●	●				●
Nov. 2015	Minor early winter storm flow conditions	LAB-1	●	●	●	●	●	●
		LAB-2	●	●	●	●		●
		LAB-3	●	●			●	●
		LAB-4	●	●	●	●	●	●
		LAB-5	●	●				●
March 2016	Elevated flow conditions following a storm event	LAB-1	●	●	●	●	●	●
		LAB-2	●	●	●	●		●
		LAB-3	●	●	●		●	●
		LAB-4	●	●	●	●	●	●
		LAB-5	●	●			●	●

Sampling for general chemical parameters, nutrients, and coliform were performed at all 5 sites in the Coon Creek watershed (indicated by the large magenta circles in Figure 45). Metals were sampled at a subset of 3 of these same 5 locations (LAB-1, LAB-3 and LAB-4) during all three sampling events as well as at LAB-5 in March 2016 (indicated by yellow circles in Figure 45). Chlorinated and organophosphate-

based pesticides were sampled at a different subset of 3 of the 5 sites (LAB-1, LAB-2 and LAB-4) that are focused in the lower portions of the watershed where agricultural land use is concentrated (see small blue circles in Figure 45). Due to the presence of chlorinated pesticides in the November 2015 sampling event, LAB-3 was also sampled in March 2016.

Laboratory analyses were performed by California Laboratory Services (CLS). CLS is a full-service environmental laboratory certified by the Department of Health Services by the Environmental Laboratory Accreditation Program Certificate #1233. Samples were collected using proper field sampling protocols to avoid sample contamination. These protocols include: (1) Ultra-Clean sampling techniques, (2) wearing gloves and frequently changing gloves, (3) not smoking while collecting, handling, or processing samples, and (4) following applicable sample collection, preservation, and storage guidelines. The analytical laboratory conducted analyses on method blanks, matrix spikes and matrix spike duplicates, lab control sample and lab control sample duplicates.

4.4.2 Results and Discussion

Results of laboratory analyses were plotted to identify for spatial and temporal trends within the data. Analytical results were compared to water quality-based assessment thresholds derived using algorithms from the California Water Resources Control Board. Several analytes exceeded the criteria for protection of aquatic life or human health (based on drinking water or fish consumption) during at least one sampling event. These exceedances are summarized in Table 8 and Table 9.

General Chemistry Parameters

The water of Coon Creek and Doty Ravine is soft to moderately hard, and no spatial or temporal trends were evident with respect to hardness. Water hardness is not expected to pose a concern in the watershed. Total suspended solids levels also fall within typical ranges and are not expected to pose a concern. TSS values recorded in March 2016 were up to 4 times higher than those observed in the September and November 2015 sampling events. We presume these increased TSS values were driven by the higher flows accompanying the storm event that immediately preceded the March 2016 sampling.

Microbiological Pathogen Indicators

Results of microbiological testing showed that pathogen indicators including E. coli, fecal coliform, and total coliform bacteria were all present in Coon Creek and Doty Ravine. In most cases, the number of bacteria exceeded the upper limit of the testing method. Numbers of both E. coli and fecal coliform were slightly lower in September than in November and March. Because the results were uniformly high, it is difficult to draw specific conclusions about the origin of microbiological pathogen indicators in the watershed. Possible sources include the SMD-1 wastewater treatment plant (now out of operation), suburban runoff, wildlife, and cattle (particularly in areas where cattle have direct stream access).

Nutrients

Ammonia concentrations measured in this study fall within the range reported by past monitoring efforts in the watershed. Ammonia concentrations were highest in September. No spatial trends were discernible in the ammonia data. A few of the results for ammonia approach the fish toxicity criteria of 490 µg/L, though none exceed it.

Nitrate concentrations measured in this study also fall within the range reported by past monitoring efforts. Nitrate was not detected at any sampling locations in September, but it was detected at multiple locations in November and March, with concentrations increasing in the upstream direction. This spatial trend supports the conclusion that has been made by past monitoring efforts that the SMD-1 wastewater treatment plant was a major source of nitrate to the watershed. Closure of the plant in May 2016 will likely reduce the loading of all forms of nitrogen to the watershed. Other sources of nitrate are likely to include irrigation return water and runoff from both suburban and agricultural lands. There is no water quality assessment criterion available from California for nitrate. However, concentrations of nitrate measured in Coon Creek and Doty Ravine fall well below the guideline of 10 mg/L used by some states.

Similarly, there is no California assessment criterion for phosphorus. A general rule of thumb is that the ratio of nitrate to orthophosphate should be limited to 10 or less to prevent eutrophication (Bailey, 2003). Results from this study show that this ratio did not exceed 10 in any instance, and thus, phosphorus concentrations are likely not a concern in the watershed at this time.

Metals and Metalloids

Results of the analytical testing indicate that metal and metalloid toxicity may be a concern in the watershed. Concentrations of aluminum and arsenic regularly exceeded assessment criteria (Figure 60), while copper, iron, and lead all came within one order of magnitude of criteria levels. Heavy metals such as aluminum and copper are established toxicity concerns for the development of anadramous species in surface waters of the Central Valley (USBR, 2014).

Aluminum concentrations in the watershed (measured as total recoverable aluminum) exceeded the chronic toxicity criteria for protection of aquatic life in more than half of all samples, sometimes by more than an order of magnitude (Figure 60). Aluminum levels increase in the downstream direction, which suggests that the source is background mineralogy as opposed to a point source in the upper reaches of the watershed. Higher concentrations observed during the March sampling event are attributable to aluminum contained in particulate matter suspended by the high flow conditions.

Measured concentrations of copper, iron, and lead all fell within one order of magnitude below the respective chronic toxicity criteria for protection of aquatic life in September and November, and nearly all samples from March exceeded the criteria. However, the criteria for these constituents are written in terms of dissolved metals, while the results of our study were reported as total recoverable metals. Because a significant fraction of total metal is non-dissolved (i.e. particulate), it is likely that concentrations of these metals do not exceed the criteria. The higher concentrations observed during

the March sampling event are attributable to metals contained in particulate matter suspended by the high flow conditions.

Arsenic concentrations in the watershed are two orders of magnitude below the chronic toxicity criteria for protection of aquatic life, but only one order of magnitude below the California primary drinking water maximum contaminant level (MCL) and nearly two orders of magnitude above the human health criteria for fish consumption (Figure 60).

Pesticides

The only pesticide that was detected during this monitoring effort was heptachlor. Heptachlor was measured at three of five sampling locations during the November event at concentrations that exceeded both the chronic toxicity criteria for protection of aquatic life and the California primary drinking water MCL (Figure 60). Heptachlor has been banned for all uses since 1988. It may be entering the creek through contaminated runoff in the upper or middle watershed. This possibility is supported by the fact that heptachlor was not detected in September, when flows in the creek were likely dominated by irrigation water imported from outside of the watershed.

Table 8. Exceedances of Aquatic Toxicity Criteria

Constituent	Criteria for Protection of Aquatic Life (Chronic, 4-day average) µg/L	Date	Sample Location	Result
Aluminum, total	87	9/2/15	1, 3	510, 140
		11/30/15	1	720
		3/7/16	1, 3, 4, 5	2300, 2900, 1600, 1100
Copper, dissolved*	4.1	11/30/15	1	4.9
		3/7/16	1, 3, 4, 5	11, 13, 8.3, 4.5
Heptachlor	0.0038	11/30/15	1, 2, 4	0.015, 0.16, 0.017
Iron, dissolved*	1000	9/2/15	1, 2	1100, 1100
		11/30/15	1	1200
		3/7/16	1, 3, 4, 5	2800, 4000, 2100, 1100
Lead, dissolved*	0.92	3/7/16	1, 3	1.3, 1.6

* Possible exceedance. Assessment criteria is for dissolved metal species, but total recoverable metals were measured.

Table 9. Exceedances of Human Health Criteria

Constituent	Criteria Exceeded	Criteria, ug/L	Date	Sample Location	Result
Arsenic	Fish consumption	0.018	9/2/15	1, 3, 4	1.3, 1.4, 0.74
			11/30/15	1, 3, 4	0.97, 0.66, 0.45
			3/7/16	1, 3, 4, 5	1.9, 2, 0.96, 0.71
Heptachlor	Drinking water	0.00021	11/30/15	1, 2, 4	0.015, 0.16, 0.017

5 RIPARIAN AND AQUATIC HABITAT ASSESSMENT

This section describes riparian and aquatic habitat assessments completed for the Coon Creek Watershed. Both a coarse-scale assessment, using GIS, and a site-specific assessment, using the California Rapid Assessment Method (CRAM), were completed. Each assessment is described separately below.

5.1 COARSE-SCALE ASSESSMENT

H. T. Harvey & Associates completed a coarse-scale riparian habitat quality assessment by mapping habitat quality along Coon Creek downstream of the Dry Creek/Orr Creek confluence and along Doty Ravine downstream of Sailor's Ravine. Habitat assessments were completed in ArcGIS through visual interpretation of high-resolution aerial photographs taken during the peak growing season (Google Earth 2016) and heads-up digitizing of creek reaches that were similar in habitat quality. Data collected at 19 CRAM assessment areas (Section 5.2) were consulted to help determine the quality of riparian habitat along each mapped reach of Coon Creek and Doty Ravine. Line segments of 1,000 feet or greater were delineated along the creek channels, representing high-, medium-, and low-quality habitat. The characteristics that were used to define habitat quality were: percent cover and extent of native woody vegetation, surrounding land use, evidence of natural processes (e.g., gravel bars, cut banks, meanders, and oxbows), signs of disturbance, and the cover of invasive plant species, especially Himalayan blackberry (Rubus armeniacus).

Habitat quality categories were defined as:

- High quality: >66% native woody cover extending 60 feet or more from both sides of the channel; low-intensity surrounding land use; evidence of natural processes (e.g., fluvial production, transport, or deposition; meanders; oxbows), little or no disturbance; and low cover of Himalayan blackberry.
- Medium quality: 34–66% native woody cover extending less than 60 feet from one or both sides of the channel; moderate-intensity surrounding land use; moderate level of disturbance or modification; or moderate to high cover of Himalayan blackberry.
- Low quality: <34% native woody cover extending less than 60 feet from the channel; high-intensity surrounding land use; or highly disturbed, modified, or constrained channel.

Sixty feet was used as a cutoff between high- and medium-quality habitat for the extent of native woody cover because it is considered by the U.S. Environmental Protection Agency to be an acceptable riparian-zone buffer width on either side of a stream, in the context of stream habitat assessments (Barton et al. 1985, Barbour et al. 1999). Low-intensity surrounding land use was considered to be undeveloped and open space and unirrigated pasture. Moderate-intensity land use included scattered homes and structures and irrigated pasture. High-intensity land use included agricultural fields and residential development. Results of the mapping were rounded to the nearest 100 feet.

A total of 256,000 linear feet of riparian habitat was mapped: 79,100 linear feet of high-quality habitat, 133,100 linear feet of medium-quality habitat, and 43,800 linear feet of low-quality habitat (Figure 61). High-quality riparian habitat was mapped along Coon Creek and Doty Ravine in the upper watershed and through three portions of the lower watershed: one stretch north of the intersection of Old Highway 65 and Chamberlain Road, a second stretch northwest of West Wise Road and North Dowd Road, and a third stretch southwest of Nicolaus Avenue. Moderate-quality habitat was identified generally between Garden Bar Road and Highway 70. Low-quality habitat was mapped east and west of Old Highway 65, between Waltz Road and West Wise Road, east and west of Pleasant Grove Road, and west of Pacific Avenue.

5.2 CRAM ASSESSMENT

In conjunction with coarse-scale habitat quality mapping, H. T. Harvey & Associates developed and implemented a site-specific riparian and aquatic habitat assessment for the Coon Creek watershed using CRAM. The purpose of the program was to document ambient and baseline conditions of riparian and aquatic habitats in the Coon Creek watershed and to create a framework for future CRAM programs that may be implemented to assess watershed changes through time. The program was designed specifically to assess the possible ecological lift that could occur throughout the watershed with implementation of the Placer County Conservation Plan.

CRAM evaluates overall ecological condition of aquatic habitats by assessing their buffer and landscape context, hydrology, physical structure, and biological structure (California Wetland Monitoring Workgroup 2013). It also includes an evaluation of stressors that may be negatively affecting aquatic habitat condition. CRAM does not evaluate watershed related stressors at a regional scale (e.g., dams and flow diversions more than 2 kilometers upstream of assessment areas). As a result, CRAM scores related to hydrology might not necessarily reflect the overall hydrologic conditions of the Coon Creek watershed, which has been altered by flow augmentations and diversions. Nonetheless, this CRAM assessment provides a good objective measure of the overall condition of the watershed and provides a basis for comparison of the watershed's condition in the future.

5.2.1 Methods

H. T. Harvey & Associates conducted this study in the Coon Creek watershed in Placer and Sutter Counties, California. Nineteen CRAM assessment areas totaling 27 acres were evaluated (Figure 62). Assessment areas were chosen to represent reaches of Coon Creek and other streams in the Coon Creek watershed that are representative of general watershed conditions; however, because most of the watershed is privately owned, assessment area selection was largely driven by access to public land (i.e., Hidden Falls Regional Park) or provided by property owners. Data from hydrologic and geomorphic assessments conducted by cbec and a review of biological resources data completed by H. T. Harvey & Associates also were used to inform the selection of assessment areas.

Within each parcel where access was granted, the downstream end of each assessment area was randomly selected along the stream channel. The precise location of each assessment area was adjusted in the field to avoid hydrologic or geomorphic breaks in channel form or structure that correspond to signification changes in flow or sediment regimes per CRAM methodologies.

Surveys were conducted June 8–24, 2015 by two or more H. T. Harvey & Associates ecologists, at least one of whom was a CRAM-trained practitioner. The ambient riverine wetland condition of each assessment area was evaluated using the CRAM Riverine Wetlands Field Book and data sheets, Version 6.1 (California Wetland Monitoring Workgroup 2013). The evaluation included assigning CRAM scores to various metrics and identifying stressors in the assessment area and its surrounding environment. All analyses were done using Microsoft Excel 2010. All CRAM scores were uploaded to the eCRAM database. The uploaded CRAM data remain private. Representative photographs of each assessment area are presented in Appendix C. All data sheets and maps can be requested from Placer County.

CRAM scores were analyzed at three spatial scales: assessment area, reach, and watershed. For the reach analysis, the watershed was divided into four reaches: Upper Coon Creek, Lower Coon Creek, Doty Ravine, and East Side Canal. Upper Coon Creek is east of the confluence with Doty Ravine (Figure 62). Lower Coon Creek is west of the confluence with Doty Ravine.

The qualitative conditions of the assessment areas were determined by assigning categories to ranges of scores according to the classification system used by O'Connor et al. (2008) to assess the conditions of CRAM assessment areas in the Morro Bay watershed in San Luis Obispo County, California. The ranges of scores and their conditions are presented in Table 10.

Table 10. Qualitative Conditions of CRAM Score Ranges

Condition	CRAM Score Range
Excellent	82–100
Good	63–81
Fair	44–62
Poor	25–43

The overall CRAM and attribute scores for the Coon Creek watershed were compared to CRAM assessment areas throughout California using data from EcoAtlas (California Wetlands Monitoring Workgroup 2015). All assessment areas used for the comparison are riverine wetlands that were part of ambient studies conducted from 2005 through 2015. In addition to CRAM scores, a number of stressors were identified that are present and likely to negatively affect the condition and function of the assessment areas. Stressors that are present and likely to have a significant negative effect on assessment areas are identified below.

5.2.2 Results

CRAM Scores

Cumulative average overall CRAM scores were calculated to determine whether or not the number of assessment areas that were sampled adequately represents the overall condition of the watershed. A relatively stable estimate of the average overall CRAM score was obtained after eight assessment areas were surveyed (Figure 63). The average overall CRAM score for the Coon Creek Watershed was 73.9 (Table 11). Overall CRAM scores ranged from 53 (SMD-1 Wastewater Treatment Plant) to 89 (Upper Hidden Falls). Average attribute scores were highest for buffer and landscape context (89.3) and lowest for physical structure (61.8).

Table 11. CRAM Attribute and Overall Scores for 19 Assessment Areas in the Coon Creek Watershed

Assessment Area Name	Buffer and Landscape Context	Hydrology	Physical Structure	Biotic Structure	Overall CRAM Score
Doty Ravine Preserve	85	75	50	78	72
East Side Canal 1	83	58	38	39	54
East Side Canal 2	80	67	50	56	63
Flemming	100	75	88	89	88
Hanley Ranch	85	83	88	67	81
John Foggy	80	75	50	78	71
Lower Hidden Falls	93	83	88	78	85
Mehalakis	93	83	75	58	77
Nader Ranch	85	58	63	69	69
Proceed Lincoln Investments	93	50	75	94	78
Scilacci	86	58	50	75	67
Tahti Bates	85	83	88	72	82
Talley	93	83	25	64	66
Taylor Ranch 1	93	83	75	89	85
Taylor Ranch 2	93	58	38	89	70
Upper Hidden Falls	93	75	88	100	89
Warren Property	93	75	38	69	69
SMD-1 Wastewater Treatment Plant	86	67	25	33	53
Weygandt	93	92	88	72	86
Average	**89.3**	**72.8**	**61.8**	**72.1**	**73.9**

Assessment areas scored high for the following metrics: stream corridor continuity, percent of assessment area with buffer, average buffer width, channel stability, and number of plant layers (Figure 64). Metric scores were generally lower for buffer condition, water source, structural patch richness, topographic complexity, number of codominant species, percent invasion, and horizontal interspersion.

Overall CRAM scores were generally higher in the upper watershed (Upper Coon Creek and Doty Ravine) than in the lower watershed (Lower Coon Creek and East Side Canal) (Table 12). Buffer and landscape context attribute scores were lowest on East Side Canal because of narrow average buffer width and poor buffer condition characterized by substantial amounts of nonnative vegetation and a moderate degree of soil disturbance and compaction. Hydrology attribute scores were lowest on Lower Coon Creek and East Side Canal because of indications of substantial artificial hydrology in the immediate drainage basin upstream of the assessment areas (water source) and poor hydrologic connectivity due to entrenchment. Physical structure attribute scores were lowest on Doty Ravine and East Side Canal because of low structural patch richness and a lack of topographic complexity. Biotic structure attributes scores were lowest on East Side Canal because of an abundance of nonnative invasive plants (percent invasion), a low degree of horizontal interspersion, and a low degree of overlap among plant layers (vertical biotic structure).

Table 12. Average Overall CRAM Scores by Reach

Reach	Buffer and Landscape Context	Hydrology	Physical Structure	Biotic Structure	Overall Assessment Area Score
Upper Coon Creek (n=11)	91	77	67	75	77
Doty Ravine (n=3)	91	83	54	71	75
Lower Coon Creek (n=3)	88	56	63	80	71
East Side Canal (n=2)	81	63	44	47	59

On the basis of categories developed by O'Connor et al. (2008), nearly 90% of the assessment areas in the Coon Creek watershed were in "good" or "excellent" condition (Figure 65). Two of the 19 assessment areas (East Side Canal 1 and Wastewater Treatment Plant) were in "fair" or suboptimal condition. None of the assessment areas that were evaluated were in "poor" condition.

The average overall CRAM, hydrology, and physical structure scores for the Coon Creek watershed are similar to scores for riverine wetlands throughout California (Figure 66). Average attribute scores for buffer and landscape context and biotic structure are higher in the Coon Creek watershed than riverine wetlands throughout the state.

Stressors

The five most common stressors that are likely to have significant negative effects on the condition and function of CRAM assessment areas in the Coon Creek watershed are invasive plants, intensive row-crop agriculture, dams, levees, and a lack of vegetation management (e.g., livestock grazing, removal of dense, floating aquatic vegetation) (Figure 67). Invasive plants within 50 meters of the assessment area is a stressor in the biotic structure attribute. Intensive row-crop agriculture and levees within 500 meters of the assessment area are stressors in the buffer and landscape context attribute. Lack of vegetation management within 50 meters of the assessment area is a stressor in the physical structure attribute.

A list of the assessment areas and the five most significant stressors affecting CRAM assessment areas in the Coon Creek watershed is presented in Table 13. These stressors are not having significant effects on Flemming, Nader Ranch, Upper Hidden Falls, or Warren Property.

Table 13. The Five Most Significant Stressors Affecting the Coon Creek Watershed

Assessment Area Name	Invasive Plants	Intensive Row-crop Agriculture	Dams	Dikes/Levees	Lack of Vegetation Management
Doty Ravine Preserve				X	
East Side Canal 1	X	X		X	X
East Side Canal 2		X		X	
Flemming					
Hanley Ranch	X				
John Foggy	X				
Lower Hidden Falls	X				
Mehalakis	X				
Nader Ranch					
Proceed Lincoln Investments		X			X
Scilacci		X			
Tahti Bates	X				

Assessment Area Name	Invasive Plants	Intensive Row-crop Agriculture	Dams	Dikes/Levees	Lack of Vegetation Management
Talley	X		X		
Taylor Ranch 1	X		X		
Taylor Ranch 2			X		
Upper Hidden Falls					
Warren Property					
Wastewater Treatment Plant	X				
Weygandt	X				

5.2.3 Conclusion

Results of this study indicate that the Coon Creek watershed is in good condition. Less than 11% of the CRAM sites that were evaluated were in fair condition. Actions that could result in possible ecological lift with implementation of the Placer County Conservation Plan include those that improve hydrologic connectivity (e.g., especially in Lower Coon Creek), physical structure (e.g., topographic complexity), and biotic structure (e.g., treatment of invasive plants, habitat restoration, and vegetation management) of riverine wetlands in the Coon Creek watershed. Actions that maintain or improve buffer and landscape conditions will help ensure that the overall condition of the Coon Creek watershed is maintained or improved.

6 FISHERIES ASSESSMENT

6.1 INTRODUCTION

Coon Creek and Doty Ravine in western Placer County has been documented to support Chinook salmon and, historically, the California Central Valley (CV) steelhead Distinct Population Segment (DPS) (NOAA 2005, NMFS 2014). The California Department of Fish and Wildlife has suggested that winter-run, spring-run, and fall-run Chinook salmon occur in Auburn Ravine (and by association may occur in Coon Creek) based on size-at-date metrics applied to juveniles captured in a downstream migrant trap (Healey, 2014). Size-at-date metrics have a high rate of error, and recent analyses have concluded that they cannot be used to reliably assign juvenile Chinook salmon to any particular run (Harvey et al. 2014, Merz et al. 2014). In addition, Auburn Ravine is not included as critical habitat for Sacramento River winter-run or CV spring-run Chinook salmon (NMFS 1993, NMFS 2005), indicating that NMFS does not consider these runs to occur in this watershed at any life history stage. Any Chinook salmon occurring in Coon Creek and Doty Ravine, therefore, are most likely CV fall/late fall-run; CV fall/late fall-run Chinook salmon are not state or federally listed.

Steelhead were once widespread and abundant throughout the California Central Valley, but their abundance declined precipitously following the construction of dams in the first half of the 20th century that blocked access to nearly all of their historical spawning grounds (NFMS 2014). In 1998 the California CV steelhead DPS was listed as threatened under the federal Endangered Species Act (NMFS 1998), and critical habitat was designated in 2005, including Coon Creek and Doty Ravine (NMFS 2005). Steelhead occurring in Coon Creek and Doty Ravine are members of the northern Sierra Nevada diversity group (NMFS 2005). Coon Creek is not specifically identified as a watershed supporting a viable population contributing to recovery of this diversity group. However, neighboring Auburn Ravine is designated as a Core 2 population, and Coon Creek is explicitly included in many of the recovery actions for Auburn Ravine (NMFS 2014). Juvenile steelhead cannot be distinguished from resident rainbow trout through visual inspection, thus we refer to all those encountered as *Oncorhynchus mykiss* unless otherwise stated.

Fish and fish habitat surveys were conducted in Coon Creek and Doty Ravine in 2015 and 2016 to document 1) the distribution and quality of adult spawning habitat for anadromous salmonids, 2) the distribution and quality of juvenile rearing habitat, 3) the occurrence and distribution of anadromous salmonids, 4) fish species assemblages, and 5) the timing of juvenile emigration. In winter 2015 fish ecologists from H. T. Harvey & Associates (surveyors) conducted reconnaissance-level surveys in select areas throughout the two watersheds while collecting data on spawning habitat and looking for stream reaches in which to conduct more targeted fish surveys. In spring 2015 surveyors conducted seining and snorkel dive surveys to document the presence and distribution of anadromous salmonids, document fish species assemblages, and collect habitat quality data. Following these surveys, fish ecologists from H. T. Harvey & Associates and ecohydrologists from cbec developed an additional study to document the timing of emigration for juvenile Chinook salmon in relation to the timing of water withdrawals during the irrigation season. In spring 2016 surveyors completed these surveys along with an additional reconnaissance survey upstream of Lower Hidden Falls on Coon Creek. The following sections describe

this work in detail, and recommendations based on these surveys and discussions among project staff are presented in Section 6.5.

6.2 METHODS

6.2.1 Fish Habitat Reconnaissance Assessment–Winter 2015

On 16–19 February, 2015, fish ecologists Neil Kalson and Ken Lindke (surveyors) conducted reconnaissance surveys focusing on habitat assessments in portions of both Coon Creek and Doty Ravine (Figure 68). The habitat assessment reaches were selected based on a review of existing information provided by Placer County and obtained from other sources (Jones & Stokes 2004, 2005; Bailey and Buell 2005; CDFW 2008) and on observations made during geomorphic assessments conducted by cbec as a related component of the Coon Creek Watershed Assessment. All of Coon Creek and portions of Doty Ravine between Gladding Road and old Highway 65 were not surveyed because access was not granted by the landowners.

Surveyors identified areas containing potential spawning habitat (Figure 68) and used their professional judgment to classify sections of each reach based on water depth, flow, and gravel size, relative to the overall quality of spawning habitat conditions in the reach. Spawning habitat was classified as follows, assuming that a patch of spawning gravel must be at least 2.0 by 2.0 meters to support one redd: high-quality habitat contained abundant spawning gravel 2–15 centimeters in diameter and with numerous patches large enough to support multiple redds; marginal-quality habitat could support salmonid spawning but contained less abundant spawning gravel than high-quality habitat and patch sizes often were too small to support more than one redd; and poor-quality habitat had little to no spawning gravel, or gravels were dominated by fine sediments with only marginal spawning substrate in both gravel size and patch size.

The number of suspected redds observed and the number of individual spawning patches containing enough spawning substrate to support at least one redd (pool tailouts larger than approximately 2.0 by 2.0 meters with suitably sized gravel) were recorded in each reach. Habitat assessments also served to identify specific reaches in which focused surveys for juvenile salmonids would be conducted during the following spring.

6.2.2 Fish Distribution and Species Assemblage Surveys–Spring 2015

On 4–8 May 2015, fish ecologists Neil Kalson and Ken Lindke (surveyors) conducted snorkel observations and seining in Coon Creek and Doty Ravine to document the presence and distribution of salmonids, fish species assemblages, and to describe pool habitat quality important for juvenile rearing. Four survey reaches were located in Coon Creek (Reaches 1-4), and two were located in Doty Ravine (Reaches 5 and 6) (Figure 69). Reaches were selected based on information collected during winter habitat assessments and to ensure that survey reaches were distributed throughout the two watersheds; each reach was approximately 1000 meters long.

Beginning at the downstream end of each reach, the surveyors surveyed every even- or odd-numbered pool for a maximum of 4 hours or a minimum of six pools. The first pool to be surveyed in each reach (even or odd) was randomly selected. When water was sufficiently clear or channel characteristics, such as aquatic vegetation, precluded efficient seining, surveyors conducted single-pass snorkel observations. A diver entered the survey pool at the downstream end and progressed upstream in a zig-zag pattern visually surveying all accessible habitat using a submersible flashlight. Divers moved quickly and efficiently to avoid fish from circling upstream and being double counted, and whenever possible used arms and legs to block fish that had already been counted from moving upstream. All fish were counted and identified to species. In pools surveyed by two snorkelers, the pool was divided in half laterally, or based on a definable feature, and surveyors counted fish in the two separate portions to avoid double counting. When snorkel surveys could not be conducted because of poor visibility, small seines (1.5 by 3.0 meters with 6.35-millimeter mesh) were used to capture fish. The first 20 individuals of each species captured by seine in each pool were measured (total length in millimeters), and the remaining individuals were counted. Supplementary spot check snorkel surveys were also conducted in select pools near diversions and presumed natural or constructed barriers to document fish species assemblages and distribution.

During fish surveys, surveyors also documented pool size and habitat complexity in each surveyed pool using the following Level IV habitat type descriptors from the *California Salmonid Stream Habitat Restoration Manual* (Flosi et al. 2010): the pool dimensions (length, width, and maximum depth in meters), and habitat complexity value ranging from 0 (least complex) to 3 (most complex) (Table 14). Water temperature was measured at the beginning and end of each survey reach, and in most surveyed pools. Georeferenced photographs and location coordinates were taken at the downstream end of each surveyed pool and at the start and end points of surveyed portions of each reach.

Table 14. Criteria of Pool Habitat Complexity Values

Habitat Complexity Value	Criteria
0	No shelter
1	One to five boulders Bare undercut bank or bedrock ledge Single piece of large wood (>12"diameter x 6' long) defined as large woody debris (LWD)
2	One or two pieces of LWD associated with any amount of small wood (< 12" diameter) defined as small woody debris (SWD) Six or more boulders per 50 feet Stable undercut bank with root mass, and less than 12" undercut A single root wad lacking complexity Branches in or near the water Limited submersed vegetative fish cover Bubble curtain
3	Combinations of (must have at least two cover types): LWD/boulders/root wads Three or more pieces of LWD combined with SWD Three or more boulders combined with LWD/SWD Bubble curtain combined with LWD or boulders Stable undercut bank with greater than 12" undercut, associated with root mass or LWD Extensive submersed vegetative fish cover

Source: Flosi et al. 2010.

6.2.3 Chinook Salmon Emigration Timing Surveys–Spring 2016

On 4–5 May, 18 May, and 1 June, 2016, fish ecologists Neil Kalson and Ken Lindke (surveyors) conducted snorkel surveys in Coon Creek, and on 4 May in Doty Ravine, to document presence of anadromous salmonids and the approximate timing of juvenile emigration. During 4–5 May, surveys were conducted in Reaches 1, 2, 4, and 5, and spot checks at specific locations in both Doty Ravine and Coon Creek (Figure 70, Table 16). The spot check on Coon Creek was upstream of Lower Hidden Falls, which differed from the spot checks conducted in spring 2015 (Figure 69 and Figure 70). Survey objectives during this visit were to: 1) confirm the presence of juvenile salmonids in downstream reaches of Coon Creek and Doty Ravine (Reaches 1, 2, and 5) for revisit surveys to establish emigration timing, and 2) confirm the presence of salmonids in upstream reaches (Reach 4 and the spot check location in Doty Ravine) before surveying upstream of presumed anadromous barriers. Reach 2 was surveyed on all three visits and provided the basis for inferring emigration timing. The presence of juvenile Chinook during one survey, followed by the absence in the next survey indicated that emigration had occurred during the intervening period. Surveys were scheduled to begin in early May because juvenile Chinook salmon were observed throughout the watershed in early May 2015, and because water temperature data in 2015 indicated that temperatures increase substantially in mid-May, which may cause emigration.

The selection of pool units within each reach and survey protocols for snorkel diving followed the same methods as in spring 2015 (see section 6.2.2). During revisit surveys in Reach 2, the same pools were surveyed each time (i.e., surveyors did not choose a new random staring pool after the first survey).

6.3 RESULTS

6.3.1 Fish Habitat Reconnaissance Assessment–Winter 2015

Reconnaissance surveys were conducted in a total of 12.95 kilometers in Coon Creek and Doty Ravine in February of 2015. More than half of the reaches contained high-quality (36%) or marginal-quality (20%) spawning habitat. Forty-four percent contained poor-quality spawning habitat (Table 15). Seven suspected redds were observed in Coon Creek, and no redds were observed in Doty Ravine. Suspected redds appeared old and degraded, lacking clearly defined features (e.g., pot and tailspill) that are used to identify salmonid redds. Areas used by livestock for watering and fording streams were located in all habitat assessment reaches, and livestock stream fords often occurred in spawning substrate. Considerable stream bank erosion was associated with most livestock stream fords, and surveyors observed cow feces in or near the water at multiple locations.

Table 15. Results of Winter 2015 Fish Habitat Reconnaissance Assessment

Creek	Reach Name[2]	Number of Spawning Patches	Density (patches/ kilometer)	Number of Suspected Redds Observed	Spawning Habitat (meters)[1]				Reach Length (meters)	Reach Coordinates
					High Quality	Marginal Quality	Poor Quality	Percent High Quality		
Coon Creek	Highway 65 to Old Highway 65	12	6	0	0	497	1474	0	1971	Start: 38.932915, -121.368885 End: 38.937498, -121.350448
Coon Creek	Gladding Road to upstream of McCourtney Road	37	11	3	3470	0	0	100	3470	Start: 38.970548, -121.293396 End: 38.987198, -121.266727
Coon Creek	Garden Bar Road	19	7.5	4	621	447	1466	24.5	2534	Start: 38.985437, -121.226512 End: 38.972798, -121.207910
Doty Ravine	Manzanita Road to Gladding Road	14	5	0	0	665	2215	0	2880	Start: 38.938307, -121.316249 End: 38.937624, -121.290172
Doty Ravine	South Canal to Crosby-Herold Road	11	15	0	0	605	129	0	734	Start: 38.937160, -121.253390 End: 38.939634, -121.246669
Doty Ravine	Garden Bar Road to Wise Road	31	23	0	623	324	417	45	1364	Start: 38.933726, -121.228237 End: 38.930514, -121.216570

[1] The proportion of the assessed reach that contained discrete areas of high-, marginal-, or poor-quality spawning habitat.
[2] Survey reaches had not been established before the winter 2015 survey, thus survey locations are provided and not reach numbers.

6.3.2 Fish Distribution and Species Assemblage Surveys–Spring 2015

In spring 2015, sixty pools covering more than 2,150 meters of habitat in Coon Creek and Doty Ravine were surveyed by seine and snorkel observations (Table 16), resulting in a total of eleven fish species observed (Table 17).

Juvenile Chinook salmon were captured or observed in every surveyed area (both survey reaches and spot check locations) except for upstream of the Garden Bar Road culvert (Figure 69, Table 17 and Table 18). Notably, salmon were observed immediately downstream of Garden Bar Road culvert, but not upstream. Salmon were also observed in the Nevada Irrigation District's South Canal (NID) Diversion Canal where nearly all of the stream flow was diverted. The pool downstream of the diversion dam, and in the natural stream bed, was stagnant and did not provide suitable habitat for juvenile salmonids, and no salmonids were observed there (Table 18). Chinook salmon captured by seine ranged from 68-100 millimeters in total length, with an average of 81 mm (Table 18). Most Chinook salmon observed during snorkeling were within the same size range, though one school observed in Reach 4 was noticeably smaller (30-50 mm, Table 18).

Oncorhynchus mykiss were observed in Reach 4, Reach 6 and upstream of Garden Bar Road in Doty Ravine. The *O. mykiss* in Reach 4 and upstream of Garden Bar Road in Doty Ravine were similar in length to the juvenile Chinook salmon observed (30–90 millimeters), but occurred in much lower abundance. The *O. mykiss* observed near Lower Hidden Falls in Coon Creek were between 100 and 150 millimeters total length, and appeared to be resident rainbow trout.

Sacramento sucker was the most abundant species observed overall, followed by Sacramento pikeminnow, Chinook salmon, smallmouth bass, green sunfish, bluegill sunfish, mosquitofish, *O. mykiss*, hardhead, largemouth bass, golden shiner, unidentified cyprinids and unidentified centrarchids. Sacramento sucker, Sacramento pikeminnow, and Chinook salmon comprised approximately 90% of all fish captured or observed (Table 17). The proportion of non-native fish species observed ranged from a low of 0.20 in Reach 4 to a high of 0.57 in Reach 3 (Table 18).

In Coon Creek and Doty Ravine, most pools had a level 1 or level 2 habitat complexity value; however, each reach had at least one pool with a level 3 habitat complexity value, and Reaches 3 and 5 had two pools with a level 3 habitat complexity value. No units in Coon Creek had a level 0 habitat complexity value (no shelter), but one unit in Doty Ravine was level 0 (Table 19). Water temperatures ranged from 16.5 to 24°C in Coon Creek, and from 14.5 to 22°C in Doty Ravine (Table 20).

Surveyors observed invasive bullfrog (*Lithobates catesbeinus)* larvae in Coon Creek and Doty Ravine. In some reaches, particularly Reach 3, they were ubiquitous and in extremely high abundance. Adult bullfrogs have been documented as predators of juvenile salmonids (Garwood et al. 2010). Three red-eared slider turtles (*Trachemys scripta elegans*) were observed in Reach 3, and 2 western pond turtles (*Actinemys marmorata*) were observed in Reach 4. Active beaver (*Castor canadensis*) dams were observed in Reaches 3 and 5.

Table 16. Spring 2015 Fish Survey Reach Descriptions

Creek	Reach and Nearby Landmarks	Length of Surveyed Reach (meters)	Number of Pools Surveyed	Total Length of Habitat Surveyed in Survey Reaches (meters)	Reach Coordinates
Coon Creek	Reach 1; Old Highway 65	800	6	361	Start: 38.936270, -121.361896 End: 38.935103, -121.353923
Coon Creek	Reach 2; Gladding Road	820	8	290	Start: 38.970433, -121.293749 End: 38.971388, -121.286111
Coon Creek	Reach 3; McCourtney Road	1150	6	831	Start: 38.981760, -121.272628 End: 38.989674, -121.265508
Coon Creek	Reach 4; Salmon Bridge	530	7	220	Start: 38.975212, -121.211046 End: 38.973205, -121.207327
Coon Creek	Spot-check location—Lower Hidden Falls	327	6	Not measured	Start: 38.965391, -121.178887 End: 38.967697, -121.178051
Doty Ravine	Reach 5; Gladding Road	550	6	209	Start: 38.938156, -121.296057 End: 38.937645, -121.290203
Doty Ravine	Reach 6; Crosby-Herold Road	750	10	238	Start: 38.938457, -121.251319 End: 38.940038, -121.243936
Doty Ravine	Spot-check location—Garden Bar Road Culvert	370	9	Not measured	Start: 38.934818, -121.230040 End: 38.933449, -121.226662
Doty Ravine	Spot-check location—South Canal Diversion Ditch	20	1	Not measured	Start: 38.936528, -121.253710 End: 38.936832, -121.253500
Doty Ravine	Spot-check location—base of South Canal Diversion Dam	20	1	Not measured	Start: 38.936806, -121.253825 End: 38.937086, -121.253529
Total		**5337**	**60**	**>2149**	

Table 17. Count of Each Species Captured or Observed During Seine or Snorkel Surveys in Coon Creek and Doty Ravine in Spring 2015.

		Coon Creek				Doty Ravine		Spot-check Locations		
		Reach 1	**Reach 2**	**Reach 3**	**Reach 4**	**Reach 5**	**Reach 6**	**Doty Ravine**	**Coon Creek**	**Total**
Length of stream surveyed (meters)		1185	951	2726	723	687	782	NA	NA	7054
Common name (Native or Introduced)	Scientific name									
Chinook salmon (N)	*Oncorhynchus tshawytscha*	2	24	172	288	4	27	35	0	552
Rainbow trout/steelhead (N)	*Oncorhynchus mykiss*	0	0	0	1	0	2	11	3	17
Sacramento sucker (N)	*Catostomus occidentalis*	322	27	517–892	150–200	30	483–583	70–95	10	1609–2159
Hardhead (N)	*Mylopharodon conocephalus*	10	0	0	0	5	0	0	0	15
Sacramento pikeminnow (N)	*Ptychocheilus grandis*	15	12	397–577	67	3	43	35	30-55	602–807
Golden shiner (I)	*Notemigonus crysoleucas*	0	0	0	0	8	0	0	0	8
Unidentified cyprinid (I)	family: *Cyprinidae*	6	0	0	0	0	0	0	0	6
Green sunfish (I)	*lepomis cyanellus*	6	5	64–69	0	12	0	0	6	93–98
Bluegill sunfish (I)	*Lepomis macrochirus*	10	0	16	0	7	9	12	2	56
Unidentified centrarchid (I)	family: *Centrarchidae*	0	0	0	0	0	1	0	0	1
Smallmouth bass (I)	*Micropterus dolomieu*	0	1	35	16	0	0	0	27–52	79–104
Largemouth bass (I)	*Micropterus salmoides*	0	0	0	0	1	4	5	0	10
Mosquitofish (I)	*Gambusia affinis*	12	1	5	0	28	0	0	0	46
Total		**383**	**70**	**1206–1766**	**522–572**	**98**	**569–669**	**168–193**	**78–128**	**3094–3879**

Table 18. Number of Fall-run Chinook Salmon and *O. mykiss*, and Proportion of Native Species by Reach in Coon Creek and Doty Ravine in Spring 2015.

	Coon Creek				Doty Ravine		Spot-check Locations	
	Reach 1	**Reach 2**	**Reach 3**	**Reach 4**	**Reach 5**	**Reach 6**	**Coon Creek**	**Doty Ravine**
Survey method	Seine	Seine	Snorkel	Snorkel	Seine	Snorkel	Snorkel	Snorkel
Number of pools sampled	6	8	6	7	6	10	6	13
Number of Chinook salmon captured or observed	2	24	172	288	4	27	0	35
Mean length of Chinook salmon (millimeters)	84.5	80.7	70–90	30–90[a]	82.5	70–90	70–90	70–90
Number of *O. mykiss* observed	0	0	0	1	0	2	3	11
Number of native species observed	4	3	3	4	4	4	3	4
Number of nonnative species observed	4	3	4	1	5	3	3	2
Total number of species observed	8	6	7	5	9	7	6	6
Proportion of nonnative species	0.50	0.50	0.57	0.20	0.56	0.43	0.50	0.33

[a] Two size classes were observed: 30–50 millimeters and 70–90 millimeters.

Table 19. Number of Times Each Pool Habitat Complexity Value Was Observed in Each Reach

Creek	Habitat Complexity Value			
	0	**1**	**2**	**3**
Coon Creek; Reach 1	0	2	3	1
Coon Creek; Reach 2	0	2	5	1
Coon Creek; Reach 3	0	2	3	2
Coon Creek; Reach 4	0	3	3	1
Total	**0**	**9**	**14**	**5**
Doty Ravine; Reach 5	0	3	1	2
Doty Ravine; Reach 6	1	6	3	1
Total	**1**	**9**	**4**	**3**

Table 20. Mean Water Temperature of Survey Reaches

Creek Name and Reach Number	Number of Temperature Records	Mean Temperature (°C)	Minimum and Maximum Temperatures (°C)	Time Recorded
Coon Creek; Reach 1	5	22.0	19–24	1355–1745; 0850–0940[a]
Coon Creek; Reach 2	6	19.75	18.5–20.5	1100–1420
Coon Creek; Reach 3	3	18.33	17–20	0900–1230
Coon Creek; Reach 4	4	17.0	16.5–17.5	0939–1115
Doty Ravine; Reach 5	3	21.33	21–22	1500–1824
Doty Ravine; Reach 6	5	15.0	14.5–16	0910–1135

[a] Reach 1 was sampled on 2 days.

6.3.3 Chinook Salmon Emigration Timing Surveys–Spring 2016

During the first site visit on 4 and 5 May 2016, snorkel surveys were attempted in Reaches 1, 2, 4, and 5, and spot check locations in Coon Creek and Doty Ravine. Water visibility was marginal in Reach 2 (approximately 2 meters); however, we observed Chinook salmon in the first pool and thus decided to survey the entire reach. Reach 2 was revisited on two subsequent surveys, on 18 May and 1 June, to assess emigration timing. Water visibility was too poor (approximately 1 meter) in Reaches 1 and 5 on the first site visit to conduct reliable snorkel observations. A survey was completed in Reach 5, however, we consider these data to be unreliable indicators of Chinook salmon presence due to poor visibility. Surveyors revisited these reaches on 18 May and 1 June, but water visibility remained too poor to conduct reliable surveys. On 18 May we attempted to survey Reach 1, but water visibility was poor and we abandoned the survey after 4 pools. Juvenile Chinook salmon were observed in Reach 4 downstream of Lower Hidden Falls, providing justification for conducting spot checks in 6 pools upstream of Lower Hidden Falls to see whether anadromous salmonids had spawned upstream of the falls and to document the presence or absence of *O. mykiss*.

Chinook salmon abundance in Reach 2 on 4 May and 18 May were similar, but much lower on 1 June (Figure 70, Table 21). Water visibility became worse with each successive survey, and was less than 2 meters during the 1 June survey. Abundance and distribution of Chinook salmon in Coon Creek and Doty Ravine appeared to be substantially less than in 2015. Counts were lower in all reaches that were revisited in 2016, and no salmon were observed in Doty Ravine (Table 18 and Table 20). Species assemblages were similar to 2015 with the most numerous species being Sacramento sucker, Sacramento pikeminnow, and Chinook salmon (except for one large school of California roach observed upstream of Lower Hidden Falls). Due to poor visibility in most downstream reaches, many fish could not be identified to species (Table 21). Fish were only observed in 2 of 6 pools upstream of Lower Hidden Falls. Notably a school of approximately 200 roach were observed in one pool, a species that had not been observed during any surveys conducted in 2015 or 2016. No suitable spawning habitat for salmonids was observed in the surveyed areas upstream of Lower Hidden Falls.

Table 21. Count of Each Species Observed During Snorkel Surveys in Coon Creek and Doty Ravine in Spring 2016

		Coon Creek			Doty Ravine	
		5/4/2016[a]	5/18/2016	6/1/2016		5/4/2016
Chinook salmon	Reach 1	NA	2	NA	Reach 5	0
	Reach 2	33	29	2	Spot Check	0
	Reach 4	21	NA	NA		
	Spot Check	0	NA	NA		
Sacramento sucker	Reach 1	NA	29	NA	Reach 5	1
	Reach 2	3	1	2	Spot Check	0
	Reach 4	0	NA	NA		
	Spot Check	0	NA	NA		
hardhead	Reach 1	NA	0	NA	Reach 5	2
	Reach 2	0	0	0	Spot Check	0
	Reach 4	0	NA	NA		
	Spot Check	0	NA	NA		
Sacramento pikeminnow	Reach 1	NA	9	NA	Reach 5	14
	Reach 2	16	27	21	Spot Check	0
	Reach 4	0	NA	NA		
	Spot Check	0	NA	NA		
unidentified cyprinid	Reach 1	NA	0	NA	Reach 5	1
	Reach 2	0	0	0	Spot Check	0
	Reach 4	0	NA	NA		
	Spot Check	0	NA	NA		
California roach	Reach 1	NA	0	NA	Reach 5	0
	Reach 2	0	0	0	Spot Check	0
	Reach 4	0	NA	NA		
	Spot Check	200	NA	NA		

		Coon Creek			Doty Ravine	
		5/4/2016[a]	5/18/2016	6/1/2016		5/4/2016
green sunfish	Reach 1	NA	0	NA	Reach 5	16
	Reach 2	0	9	7	Spot Check	1
	Reach 4	0	NA	NA		
	Spot Check	1[b]	NA	NA		
bluegill sunfish	Reach 1	NA	0	NA	Reach 5	27
	Reach 2	0	2	17	Spot Check	38
	Reach 4	0	NA	NA		
	Spot Check	0	NA	NA		
unidentified centrarchid	Reach 1	NA	0	NA	Reach 5	0
	Reach 2	0	0	2	Spot Check	0
	Reach 4	0	NA	NA		
	Spot Check	0	NA	NA		
smallmouth bass	Reach 1	NA	0	NA	Reach 5	0
	Reach 2	6	20	14	Spot Check	0
	Reach 4	0	NA	NA		
	Spot Check	0	NA	NA		
largemouth bass	Reach 1	NA	0	NA	Reach 5	11
	Reach 2	0	0	0	Spot Check	12
	Reach 4	0	NA	NA		
	Spot Check	0	NA	NA		
unknown	Reach 1	NA	0	NA	Reach 5	9
	Reach 2	88	30	52	Spot Check	0
	Reach 4	35	NA	NA		
	Spot Check	1[c]	NA	NA		

[a] Surveys were conducted on 4 May in reaches 2, 5, and the spot check reach in Doty Ravine, and on 5 May in all other reaches.
[b] Found floating and freshly dead in pool after dive pass was completed. There were no visible signs of predation or disease.
[c] Hidden in rock crevice with only caudal fin visible for a few seconds. Was not a salmonid.

6.4 DISCUSSION

Chinook salmon were present in nearly all surveyed reaches during spring 2015, indicating that Chinook salmon spawned successfully in Coon Creek and Doty Ravine in 2014–2015. The presence of two size classes in Reach 4 suggests that at least two different spawning events (i.e., one or more pairs spawning during different times) occurred. It is also possible that incubating eggs and/or growing juveniles experienced different environmental conditions that resulted in different incubation times and growth rates. The smaller size class was not observed elsewhere in the watershed; however, this does not preclude the possibility that multiple spawning events occurred elsewhere in the watershed because we surveyed only a small portion of potential habitat. In early May 2016 abundance and distribution of

juvenile Chinook salmon appeared to be substantially reduced compared to the same time in 2015. An obvious explanation is that fewer adults returned to Coon Creek in the winter of 2015-2016, but it is also possible that most juveniles had emigrated earlier in 2016 (before our surveys).

It seems likely that a large portion of juvenile Chinook salmon emigrated from Coon Creek in late May, 2016, as evidenced by the significantly lower counts in Reach 2 on 1 June as compared to 18 May. Water visibility was less than 2 meters during the 1 June survey, but it was not substantially worse than during the 18 May survey. While the reduced visibility may partially explain the much lower count of Chinook salmon on 1 June, we believe our observations represent a real and substantial reduction in abundance between the two surveys. There were numerous pools that we were able to survey effectively in which Chinook salmon were observed on 18 May, but were apparently absent on 1 June. In addition, a small storm event delivered approximately 0.3 inches of rain to the region on 24 May (CDWR 2013), and daily average water temperature in the survey reach increased from 22.1°C (maximum 24.6°C) on 18 May to 24.2°C (maximum 26.8°C) on 1 June (preliminary data from Coon Upper 1 DO). Increased stream flow (which may or may not have resulted from the 24 May rain event) and/or the increase in temperature to chronically lethal temperatures for Chinook salmon (approximately 25°C, Myrick and Cech 2001) could have stimulated emigration.

Resident and anadromous juvenile *O. mykiss* are indistinguishable before smoltification, and progeny of resident *O. mykiss* can adopt an anadromous life history (Kendall et al. 2015). The presence of juvenile Chinook salmon in all survey reaches in 2015 indicates that anadromous salmonids can, at a minimum, access all areas of Coon Creek downstream of Lower Hidden Falls and all areas of Doty Ravine downstream of the Garden Bar Road culvert. If steelhead successfully spawned in the watershed we would expect to see young-of-the-year and/or age 1+ juveniles in greater abundance and more widely distributed than we observed. Consequently we suspect that the *O. mykiss* observed in 2015 were resident rainbow trout rather than anadromous steelhead.

Habitat conditions did not appear to be a limiting factor in early May 2015. There was abundant cool clear water within the range of temperature tolerances for both Chinook salmon and *O. mykiss*; suitable spawning substrate for Chinook salmon, steelhead, and resident rainbow trout; and abundant, deep pools. In May 2016 habitat conditions were similar except that turbidity was substantially higher. Habitat and water quality conditions in Coon Creek appear to be suitable for supporting Chinook salmon and steelhead spawning in winter and rearing in spring. However, temperatures exceeding the tolerable limits of CV Chinook salmon and steelhead (approximately 25°C, Myrick and Cech 2001) occur regularly throughout the watershed during summer months (Figure 56 and Figure 57), which likely causes high mortality for any juvenile salmonids that are unable to find thermal refugia.

Physical barriers limit juvenile and adult migration in Coon Creek. The Camp Far West Canal Diversion Dam (38.971624, -121.152003) is the constructed limit to adult salmonids as they migrate upstream to spawn in Coon Creek (California Fish Passage Assessment Database [CFPAD] 2015); however, the natural upstream limit is unknown. Prior work has indicated that both Lower and Upper Hidden Falls are barriers to fish passage in Coon Creek under most flow conditions based on professional judgment (Bailey and Buell 2005, CFPAD 2015). In Doty Ravine, the Garden Bar Road culvert may limit upstream adult migration. This culvert is described as a total barrier at all flows except those high enough to force water to back up in the culvert (Bailey and Buell 2005, CFPAD 2015). In 2015, we observed juvenile

Chinook salmon immediately downstream of the culvert but none in the few hundred meters immediately upstream of the culvert suggesting that the culvert was a barrier in that year. We surveyed only 370 meters upstream of the culvert (Table 16), so the failure to detect salmon in this area should not be considered direct evidence that the culvert is a barrier to anadromy. Notably, we observed high quality spawning habitat upstream of the culvert.

Seaward migration of juvenile Chinook salmon and adult and juvenile steelhead may be impeded by the complete diversion of Doty Ravine at the NID Diversion Dam into Doty South Canal. The presence of juvenile Chinook salmon in the Doty South Canal immediately downstream of the dam demonstrates that fish are being entrained in the unscreened canal. Downstream-migrating fish have no alternative other than to enter the canal when the water is not spilling over the flashboards. Juvenile Chinook salmon were observed in Doty Ravine downstream of the South Canal diversion (Reach 5), indicating that spawning may have occurred in Doty Ravine downstream of the diversion, that fish migrated downstream before the dam flashboards were installed, or that the fish entering the diversion canal were able to return to the natural stream channel at a downstream location. Review of aerial imagery suggests that there is no route through this canal system that could provide emigrating fish access to the natural stream channel at a downstream location, which likely results in increased or total mortality. It is important to note, however, that review of aerial imagery is inconclusive and formal surveys should be conducted (see further discussion below).

A basin-level summary of stressors to salmonids by relevant life stage is provided below in Table 22. As discussed in this chapter and others, stressors to salmonids in this watershed are due to a combination of natural conditions and human disturbances. Addressing these stressors will be an important component of rehabilitation efforts focused on improving anadramous salmonid populations.

Table 22. Stressors to Anadromous Fish by Relevant Life Stage

Stressor	Relevant Life Stages				Driven by Natural Conditions, Human Impacts or Both?	Description
	Spawning	Embryo Incubation	Rearing	Out-migration		
Quality and Abundance of Habitat	X	X	X	X	Both	Some spawning habitat upstream of Garden Bar Rd. on Coon Creek is embeded. Available spawning habitat has also been reduced by channel realignment and cattle poaching. Channelization, floodplain grading, hydrograph manipulation, and impacts to riparian vegetation have reduced habitat complexity and availability for juveniles.
Flow Regime	X	X	X	X	Both	Adult migration through much of the watershed is flow-dependent, potentially limiting habitat availability depending on the natural hydrograph. Changes to the natural hydrograph associated with water conveyence may induce juveniles to migrate at unsuitable times.
Temperature	X	X	X	X	Both	Water temperatures in late spring and summer exceed lethal tolerances for juvenile salmonids in many portions of the watershed causing unsuitable conditions for over-summer rearing. Thermal barriers to emigration may exist (e.g., in the Cross Canal).
Water Quality	X	X	X	X	Both	Impacts to water quality include low dissolved oxygen associated with elevated temperatures and primary production; nutrient runoff from agriculture and livestock; livestock feces; increased turbidity due to streambank errosion, especially associated with livestock; and chronic toxicity from pesticides and metals.
Passage Barriers	X		X	X	Human	Partial or complete barriers to upstream migration for adult salmonids (e.g., NID Doty South at Head and the Garden Bar Rd. culvert) restrict access to spawning habitat. Seasonal and permanent barriers to upstream migration for juveniles restrict movment for rearing juveniles.
Lifestock Impacts		X	X		Human	Egg and larval salmonids may be killed by trampling of redds at stream crossings. Stream bank errosion results in increased sediment delivery to the stream and inhibits development of riparian vegetation.
Predation	X		X	X	Both	Adults are vulnerable to poaching by humans. Juveniles are vulnerable to predation by native (e.g., Sacramento pikeminnow and avian predators) and non-native (e.g., bass and American bullfrog) predators.
Entrainment at Unscreened Diversions and Extraction Points			X	X	Human	Unscreened diversions can allow access to dead-end canals preventing successful emigration for juveniles. Unscreened abstraction points can capture and kill rearing and emigrating juveniles.
Lack of Seasonal Floodplain Habitat			X	X	Human	Channelization, incision and berms have disconnected the main stream channel from adjacent floodplains in much of the lower and middle watershed. Floodplains provide high food production, refugia from high velocities during high discharge events and refugia from predators among other services that are particularly valuable to rearing juveniles.
Introgression with Hatchery Fish	X	X	X	X	Human	Introgression between natural and hatchery-derived fall-run Chinook salmon throughout the Central Valley has reduced life history diversity, and thus increased interannual variability in abundance due to increased vulnerability to natural and human-caused stochastic environmental events.

6.5 CONSIDERATIONS REGARDING FUTURE ACTIONS

Perhaps the two most important findings from fish surveys conducted in Coon Creek and Doty Ravine in 2015 and 2016 are that adult salmonids are capable of spawning throughout these watersheds, at least downstream of Lower Hidden Falls and the Garden Bar Road culvert, and that juvenile Chinook salmon emigration may not occur until late May. Emigration appears to occur after the initiation of water diversions used to irrigate local agriculture, which can potentially have significant consequences for juvenile salmonids occurring in the watershed. While we did not observe what we considered to be CV steelhead, if steelhead successfully spawned in the watershed they would be vulnerable to all the same concerns as juvenile Chinook salmon.

Based on our observations, there are several actions that would likely improve conditions for adult salmonids spawning and juveniles rearing in Coon Creek and Doty Ravine. These include, in no particular order, reducing the reliance on surface water diversions (e.g., use more well and groundwater extraction, or intercept and store winter runoff) to maintain flow and reduce the potential for entrainment; screen diversions and points of extraction to minimize entrainment; improve constructed barriers to provide fish passage for both adults and juveniles; maintain downstream migration pathways for juvenile salmonids and adult steelhead; adapt the timing of diversions and extractions to support juvenile salmonid emigration; limit livestock access to the stream to minimize trampling of redds and spawning habitat, reduce impacts associated with livestock including streambank erosion and excessive levels of nutrient input (i.e., livestock feces) and promote riparian vegetation growth; and develop and implement a non-native predator control plan to reduce predation rates on juvenile native species including salmonids from non-native species such as bass and bullfrogs.

We agree with Bailey and Buell's (2005) assessment of the NID Doty South at Head diversion that it is likely passable by adult steelhead and Chinook salmon under most higher flows, assuming the wicket gates are not in place, and that a more formal passage assessment is warranted. Additionally, we recommend a survey of the NID diversion canal system to identify locations presenting a high risk of fish mortality associated with entrainment in diversion or to irrigation canals that do not provide a route for fish to emigrate because there is no connection to a natural stream channel at a downstream location. It is important to understand the implications of diverting nearly 100% of flow in Doty Ravine into this canal system, including the potential negative effects on aquatic habitat in Doty Ravine downstream of the diversion. The abundance of juvenile Chinook salmon well upstream of the NID diversion in 2015 provides strong evidence that anadromous salmonids spawn upstream of this site, and juveniles attempting to emigrate after diversion has begun would likely experience high or complete mortality if they are unable to return to the natural stream channel.

Bailey and Buell (2005) assessed four potential anadromous barriers in upper Coon Creek, and provided a general description of habitat conditions for salmonid spawning and juvenile rearing. They indicate that spawning habitat was good and abundant above Lower Hidden Falls and recommended barrier modifications to allow passage of adult anadromous salmonids. We surveyed approximately 600 meters of habitat upstream of Lower Hidden Falls and observed fish in only two out of 5 pools. Further, we observed no suitable spawning habitat for salmonids, as substrate was either bedrock or cobble too large for spawning. Review of helicopter video footage suggests that the stream channel between Lower

Hidden Falls and the Camp Far West diversion dam is largely comprised of bedrock and contains little suitable spawning habitat. Consequently, providing access to this stream reach may provide little to no benefit for steelhead or Chinook salmon spawning although greater potential may exist for habitat utilization for rearing purposes. Additional assessment of the habitat utilization potential of this portion of the watershed is recommended before any barrier modifications are pursued.

Bailey and Buell (2005) indicated that the seasonal Coppin Dam in the East Side Canal is installed in early April, and claim that this is mostly outside the downstream migration period for smolts. However, we observed juvenile Chinook salmon in Coon Creek as late as June in 2016, and juveniles were widely distributed throughout the watershed in May of 2015. Presumably these fish had yet to emigrate, although it is possible that they attempted to oversummer in Coon Creek. We suspect that at least some juvenile Chinook salmon emigrated from Coon Creek in late May 2015 (see Section 6.3.3). We recommend that the Coppin Dam be considered for barrier modification to allow downstream migration of juvenile salmonids. We visited the Coppin Dam in May 2016, but were unable to determine whether the water intake immediately upstream of the dam was screened. If it is not already, this intake should be screened to reduce the potential for entrainment.

7 WATERSHED DISTURBANCE ASSESSMENT

7.1 REFERENCE STATE CONDITIONS

The reference state of a system generally refers to its pre-disturbance or natural condition. This pre-disturbance state can be compared with present conditions to evaluate human disturbances to the system and the degree to which natural processes have recovered. In most cases, the reference state is no longer a realistic nor desired condition for the system, but can provide useful insights on healthy physical processes and ecological conditions and also inform rehabilitation and management strategies. For the purposes of this assessment, the reference state described here refers to the condition of the environment prior to western exploration and settlement in the 1800s and subsequent development and land use change. The Coon Creek watershed was likely used and altered by native peoples for several millennia prior to these disturbances. However, the scale of these disturbances is not considered to be anywhere near the magnitude of those occurring since the mid 1800s.

It should be noted that the physical processes and biological communities present within the Coon Creek watershed have varied dramatically over geologic time scales due to natural climatic variability. The reference state described in this assessment refers to the conditions of the current warmer, drier interglacial period.

Hydrology

Pre-disturbance hydrologic conditions were characterized by natural land cover and runoff patterns. Prior to the conversion of natural spaces to agricultural and grazing uses and the development of land within the watershed, soils would have more effectively captured rainfall and maintained higher levels of infiltration than occurs today. A smaller fraction of precipitation would have become direct surface runoff, and the surface runoff would concentrate as it followed the natural contours and topography of the landscape. Peak stream flows would likely be somewhat less than they are today, especially along Dry Creek and other headwater tributaries (i.e. Rock Creek) that today drain parts of Auburn. More significantly, much of Coon Creek's stream network would have functioned as intermittent streams. Because of the watershed’s Mediterranean climate and low elevation, flowing water throughout both Doty Ravine and Coon Creek was likely a byproduct of winter and spring storms. Base flows from late spring through early fall (today's irrigation season) would have gradually declined to zero or near-zero flow rates in most years (with the exception of any precipitation events). Except where groundwater discharged through springs and seeps created localized areas of perennial flow, both streams likely functioned as intermittent drainages.

To provide a more quantitative comparison, the Bear River, as measured at a gauging station near Wheatland, drains an approximately 270 square mile basin (roughly 2.7 times larger than Coon Creek). This watershed is located immediately north of the Coon Creek watershed. In addition to having a larger drainage area than Coon Creek, the Bear River's contributing watershed extends much higher into the Sierras and consequently experiences snowpack formation. Despite having larger snowmelt derived

flows in the late spring and early summer, unimpaired[8] flows for the Bear River would have typically declined to less than 3.5 cfs, on average, during August and September. In over 40% of the years between 1921 and 2003, average unimpaired flows for the Bear River would have been zero in the months of August and/or September (CDWR 2007). Given its smaller drainage area and lack of snowpack, Coon Creek would most likely have functioned as an intermittent stream in most if not all years prior to human disturbance.

Physical Processes and Channel Form

At the basin-scale, sediment dynamics of the Coon Creek watershed were driven by natural processes. Upland sediment production would have been supported largely by hillslope erosion of more easily eroded soils. Particularly in areas of steeper slope in the middle and upper watershed, highly erodible soils would have supplied much of the finer-grained materials to the stream network. Events such as fire and hillslope failures may have occasionally delivered significant volumes of sediment to the stream network. Much of this fine-grained material would have been transported to the lower half of the watershed, and likely deposited on the floodplain, or transported out of the basin altogether.

Channel form would have been driven in large part by the interactions of fluvial processes with the surrounding valley structure and underlying geology. The canyon reaches of Coon Creek likely functioned fairly similarly to present day conditions, with a steep channel morphology characterized by high sediment transport capacity, the laterally confined valley bottom and bedrock outcrops. Once Coon Creek exited the canyon (just upstream of present-day McCourtney Road), the stream likely exhibited greater lateral movement and may have utilized multiple channel threads as valley slope declined and the stream deposited coarse and fine sediment. From the end of the canyon and continuing past the confluence with Doty Ravine, the stream likely exhibited fairly dynamic behavior as indicated by the numerous secondary channel alignments still visible in the LiDAR data.

The stream reaches extending from the end of the canyon to the lower end of the watershed would have generally been less incised than they are today and would have likely exhibited greater levels of floodplain connectivity. The floodplains in the lower half of the watershed likely featured significantly greater topographic complexity and would have extended significant distances from the active channel in many areas. When combined with secondary channels, the system would have provided much greater off-channel habitat area, complexity and quality. In the lowest portions of the watershed (likely from the present-day Placer-Sutter County boundary and continuing downstream), floodplain inundation due to overbank flows would likely have persisted significantly longer due to greater floodplain connectivity with the stream channel, the absence of artificial drainage features, and greater floodplain topographic complexity. It is also likely that the flood flows from Coon Creek comingled with flows other watersheds (i.e., Markham Ravine, Auburn Ravine, the Bear and Feather Rivers) and created a larger complex of seasonal wetlands and off-channel habitat areas.

[8] Unimpaired flow refers to the flow that would have occurred prior to human disturbances to a watershed. These values are computed for many major rivers in California using historical flows, snowpack measurements, reservoir inflows and other data.

Water Quality

In the absence of flow management activities, water temperatures were likely less spatially and temporally variable and potentially warmer during the summer months (in some locations). The stream may have supported more and deeper pools and was potentially better shaded by denser riparian forests, which conversely may have supported cooler temperatures in some locations. Pre-disturbance water quality conditions would likely have been characterized by higher dissolved oxygen concentrations (except where flow management today supports cooler water temperatures and greater dissolved oxygen solubility). The levels of toxic constituents likely posed little harm to aquatic life. Metals and metalloids such as aluminum, copper, and arsenic would have been present as a result of naturally-occurring rock weathering processes. While background metals concentrations (especially aluminum) may have been high compared to some present-day toxicity thresholds, native species would probably have been well adapted to these conditions. Concentrations of pathogens such as fecal coliform would have been low, but measurable, due to native wildlife populations. Concentrations of nitrogen and phosphorus would have been below levels likely to cause eutrophication. Periodic events including fires, extreme precipitation events, and salmon runs likely caused fluctuations in all of these parameters.

Aquatic and Riparian Communities

Historically, aquatic and riparian habitats in the Coon Creek watershed most probably consisted of extensive oak, willow, cottonwood, and alder-dominated woodlands and associated wetlands, as described below. Unfortunately, reference state habitat conditions in the historical watershed only can be inferred based on an understanding of current and historical anthropogenic impacts to the watershed, and based on limited knowledge of pre-disturbance riparian conditions along the western Sierra Nevada foothills, almost all of which has been extensively modified by mining, development, channel modifications, flow management, and other disturbances. While it is difficult or impossible to describe historical conditions with certainty, the characteristics of today's higher-functioning reaches are assumed to be representative of historical, reference state conditions.

Native anadromous Chinook salmon and steelhead were likely able to exploit the natural seasonal and inter-annual variability in flows for spawning, at least in some years, and the refugia provided by pools of relatively cooler water may have provided potentially suitable rearing habitat for juvenile steelhead; although this habitat would have most probably been limited throughout the watershed.

Habitat functions historically provided by the watershed likely varied between the upper and lower portions of the watershed. The confined, high-gradient reaches characteristic of the upper watershed east of McCourtney Road probably were lined with white alder (*Alnus rhombifolia*), willows (*Salix* spp.), and Fremont cottonwood (*Populus fremontii*) among barren rock outcrops and cliffs. Much like today, the riparian zone was closely confined to the active stream channel in many locations because the zone of groundwater influence was narrow. The creeks were surrounded by stands of interior live oak (*Quercus wislizeni*) woodland, blue oak (*Quercus douglasii*) woodland, foothill pine (*Pinus sabiniana*), and chaparral communities adapted to shallow, rocky soils. Small alluvial valleys of the upper watershed

supported patches of valley oak (*Quercus lobata*) riparian woodland, freshwater emergent marsh, and seasonal wetland. These high-gradient stream reaches likely provided only migration corridors for anadromous salmonids, and possibly juvenile rearing habitat, because stream power would have prevented the accumulation of spawning gravels. Small alluvial valleys of the upper watershed, and downstream of the Camp Far West Diversion Dam, likely contained more and better-quality spawning gravels, which in turn supported abundant macroinvertebrate communities and salmonid spawning, egg and larval survival, and juvenile rearing.

Conversely, the unconfined, low-gradient reaches of the middle and lower watershed west of McCourtney Road likely had dynamic, structurally diverse, multi-age stands of deciduous riparian woodland communities. Early- and mid-successional species, including mule fat (*Baccharis salicifolia*), willows, white alder, and Fremont cottonwood, colonized gravel bars and floodplains along meandering creeks and streams. Late-successional species, including valley oak and black walnut (*Juglans hindsii*), established in deep silty-clay soils on elevated terraces above and away from active channels. These riparian communities were much wider and more extensive than today. Meandering stream channels produced broad floodplains that were inundated during winter floods and more connected to and influenced by groundwater, both spatially and temporally. Areas of slow-moving and standing water supported freshwater emergent marsh species such as cattails (*Typha* spp.) and bulrush or tule (*Schoenoplectus* spp.). Seasonal wetlands and vernal pool grasslands occurred throughout the surrounding uplands.

Compared to today, historical aquatic habitat in the low-gradient reaches of the middle and lower watershed likely displayed greater complexity and comprised more linear miles, owing to greater channel sinuosity. Reaches in the middle watershed likely contained abundant pools and riffles because lateral scour would have deepened the stream channel at meander bends, with gravels deposited in pool tailouts. Mature riparian forests would have provided large and small woody debris to the stream channel, increasing habitat complexity by providing instream structure and influencing hydrologic processes (e.g., scouring). Spawning gravels likely were less infiltrated with fine sediments than they are today, and thus would have provided better habitat for salmonid eggs and larvae, as well as richer and more abundant macroinvertebrate communities that represent food for juvenile salmonids. Seasonally-available floodplain, particularly in the low-gradient lower watershed within the Natomas basin, would have provided rearing and emigrating juvenile salmonids with abundant feeding opportunities and refugia from storm discharges.

7.2 HYDROLOGIC DISTURBANCES

Distrubances to the hydrology of the Coon Creek watershed can generally be separated into three categories: (1) changes to the peak flow regime resulting from land cover change and hydromodification, (2) channel disconnection due to the East Side Canal construction, and (3) changes resulting from flow conveyance and delivery and irrigation practices.

7.2.1 Land Cover Change and Hydromodification

Alterations to the natural land cover of the Coon Creek watershed have changed its hydrologic regime, particularly with respect to peak flows. Land development has been most concentrated in the upper watershed in the vicinity of Auburn where urban development has increased the impervious cover of the land surface, affected infiltration and altered the flow paths of surface runoff. Other parts of the basin, particularly the lower and middle watersheds, have been affected by the conversion of natural land cover to agricultural and ranching land uses. The presence of canals along many of the middle and upper watershed hillslopes also serves to capture and concentrate surface runoff. Additionally, the construction of roads and highways throughout the watershed alters flows and increases impervious cover.

The effect of these land cover changes on peak flows are presented in the Peak Flow Regime section of Chapter 3. As discussed in that chapter, changes to peak flows (relative to the pre-disturbance land cover) were modeled for existing conditions and future fully-developed conditions. Figure 43 and Figure 44 depict the percentage increase in modeled peak flows along the major stream reaches of the watershed for the 2-year flood event for existing and future fully-developed land cover conditions while Table 1 through Table 3 provide a more comprehensive summary of changes to peak flows. Dry Creek, a tributary to Coon Creek that drains portions of Auburn, demonstrates the greatest percentage increases in stream flows. These increases in peak flows have likely driven changes physical processes and geomorphic form as the stream channels adjust to the increased flow rates. However, compared to more developed and urbanized watersheds in California, the hydrologic model results show relatively minor increases to peak flow magnitudes in the Coon Creek watershed.

7.2.2 Channel Disconnection

The construction of the East Side Canal in the early 1910s resulted in the almost total hydrologic disconnection of Coon Creek from its lower-most reaches (Figure 7). The levees of the East Side Canal intercept the flows of Coon Creek (as well as those of Markham and Auburn Ravines). Today, the only flow from the upper watershed that passes through to this lower reach of Coon Creek is through a pipe controlled by an operable gate. However, it is unclear if this gate and pipe are still in use.

7.2.3 Flow Management Effects

The most significant effects to Coon Creek's hydrology are driven by flow conveyance and delivery and irrigation practices during the irrigation season (generally mid-April to mid-October). As discussed in detail in Chapter 3, the natural stream channels within the Coon Creek watershed are used extensively by NID and SSWD to convey and deliver water, thereby generally increasing stream flows during the irrigation season. These conveyance and diversion activities are summarized in Figure A-1. In addition, irrigation practices rely on both surface and groundwater abstraction and typically increase stream flows in the late summer through discharge of agricultural return water. These flow management practices result in the following hydrologic changes while more extensive discussion is provided in Chapter 3:

Increased Overall Water Volume

The import of water from other river basins into the Coon Creek watershed by water agencies (NID and SSWD) for flow delivery purposes increases the overall volume of water in the watershed relative to pre-disturbance conditions. This water is added to the basin primarily via direct additions to the stream channel through sources including: releases from canals; agricultural return water; and, historically, treated effluent from the SMD-1 wastewater treatment plant in Auburn which discharged to Rock Creek (a tributary of Dry Creek). Water also enters the basin via canals and water distribution infrastructure that do not directly interact with stream channels but may indirectly contribute to stream flows through local increases in groundwater.

Increased Flows During Irrigation Season

Flow management and irrigation practices generally result in increased stream flows during the irrigation season along many reaches of Coon Creek and its tributaries. Prior to disturbance, Coon Creek likely approached near-zero flow rates or would have ceased flowing altogether along much of its length during the late summer. As discussed in the reference state conditions section above, unimpaired flows in the Bear River (the watershed immediately north of Coon Creek with a larger drainage area as well as a snowmelt hydrology) would have averaged less than 3.5 cfs in August and September, and over 40% of the years between 1921 and 2003 would have seen periods of zero flow between July and September (if all human disturbances were undone). Given its smaller drainage area and lack of snowpack formation, Coon Creek would have likely functioned as an even drier system. However, today's conveyance and flow delivery activities maintain Coon Creek and Doty Ravine as perennial streams along almost all of their length through the summer and early fall.

Greater Temporal Variability in Flows

Flow management and irrigation practices also drive greater temporal variability in stream flows than was likely naturally present in the Coon Creek watershed. As described in Chapter 3, there is significant day-to-day variability in stream flows during the summer months due to conveyance and delivery practices, surface water abstraction and agricultural return flows. While historic stream flows would have gradually decreased until ceasing altogether, today's stream flows vary widely during the irrigation season (see Figure 39 for examples).

Increased Spatial Variability of Flows

The spatial variability in stream flows has increased substantially due to flow management and irrigation practices. As depicted visually in Figure A-1 and discussed in Chapter 3, a number of stream reaches are used for conveyance purposes while flow releases from and diversions into canals can create relatively dry conditions upstream and downstream. As Coon Creek and Doty Ravine descend through the watershed towards the outlet at the East Side Canal, they exhibit several cycles of flow augmentation followed by abstractions and/or complete diversions.

7.3 DISTURBANCES TO PHYSICAL PROCESSES AND CONDITIONS

7.3.1 Disturbances to Physical Process Regime

The physical process regime and stream channels of the Coon Creek watershed have been affected both by historical disturbances and ongoing land use changes. The magnitude and impact of disturbances along Coon Creek and Doty Ravine generally increase in the downstream direction. Significant impacts to the watershed likely began in the 1800s and include conversion of natural spaces for agriculture and grazing, channel realignment, canal construction, and mining activities along stream channels and floodplains. The single largest impact to the watershed was the construction of the East Side Canal in the early 1910s. This drainage and flood control channel intercepted Coon Creek, completely disconnecting the downstream-most reach from the rest of the watershed (Figure 7). As described in Chapter 2, the East Side Canal is a constructed channel confined between two levees that has developed limited amounts of sinuosity, morphological complexity and riparian habitat between its levees as it flows from Coon Creek to the Cross Canal.

The lower and middle portions of the watershed experienced significant levels of channel straightening and realignment, with generally increasing intensity as valley slope declines to the west. By the time the first USGS quads were generated for the area (1910), Coon Creek appears to have already been straightened in numerous locations and additional straightening and realignment occurred over the next several decades (Figure 8). In addition, floodplain grading within much of the lower watershed as well as portions of the middle watershed appears to have leveled floodplain areas and eliminated much of their topographic complexity. Low elevation berms are also present along much of Coon Creek below the confluence with Doty Ravine, as well as along portions of Coon Creek and Doty Ravine in the middle watershed. A formal evaluation of the effect of these levees was not conducted, but they appear to reduce floodplain connectivity during smaller flood events.

Inspection of the LiDAR elevation data and limited review of historical documents from the Placer County Archives and Research Center indicate that gold mining was fairly widespread throughout the watershed. As discussed in Chapter 2, the geology of the Doty Ravine watershed was much more likely to support gold-bearing deposits than Coon Creek. Gold-mining era canals are also fairly widespread in the upper and middle watershed. Many of the potential mining sites still visible in today's LiDAR data occur in upland areas and ephemeral drainage features and are fairly small in size. While hydraulic mining was extensive in the neighboring Yuba and American River watersheds, an inspection of the LiDAR data does not provide conclusive evidence of hydraulic mines (at least large ones) within the Coon Creek watershed (Allan James, personal communication). As such, there may have been moderate increases in sediment yields from upland areas and ephemeral drainages associated with small scale mining, but it appears unlikely that Coon Creek and its tributaries experienced the massive levels of sedimentation that occurred in other Sierra foothill drainages like the Yuba River. Several reaches of Doty Ravine also appear to have experienced areas of floodplain mining (likely with dredgers) as mining tailing mounds are still visible in today's LiDAR data (Figure 71). These floodplain mining activities likely resulted in channel realignment and have an ongoing impact on floodplain connectivity with the stream

channel. There are also several instances of grading (both in upland and floodplain areas) that were likely tied to the extraction of other materials (e.g., clays, gravel, etc.).

Channel realignment, floodplain grading and berm construction in the Coon Creek watershed alter physical processes in a number of ways. Channel straightening shortens the length of the stream, locally increasing stream slope and stream power. In turn, this may have contributed to the channel incision observed along many reaches in the lower and middle watershed, which has likely reduced floodplain connectivity. Between Old Hwy 65 and Gladding Road, it appears that the channel was realigned along the far right valley wall prior to 1910, and since then has established an inset floodplain corridor. The construction of berms along many reaches likely further increases the flood flows needed to initiate floodplain inundation and thereby decreases floodplain connectivity. Floodplain grading and field drainage features (i.e. ditches) also reduce duration of floodplain inundation (though rice production may be considered an artificial exception) and the physical complexity of floodplain habitat. On the other hand, floodplain grading for mining activities along Doty Ravine left behind dredger tailing mounds that inhibit floodplain connectivity and lateral channel migration. Channel straightening and decreased sinuosity can also influence channel interaction with the floodplain.

The construction of roads, highways, railroads and canals in the watershed have also affected floodplain connectivity and hydraulics. As an example, the Line 1 Canal presents a north-south oriented berm across the floodplain but passes underneath Coon Creek through a siphon. During larger flood events, downstream flow across the floodplain is likely restricted by this feature and forced back into the main channel. This likely results in local backwater conditions and increased floodplain inundation upstream of the Line 1 Canal and reduced floodplain connectivity and inundation extents immediately downstream. The new Highway 65 embankments may also generate similar effects during large flood events (Thomas Plummer, personal communication). Roads and bridges may also affect in-stream and floodplain hydraulics depending on the degree to which they restrict in-stream flows or influence floodplain flow paths.

Physical processes in the watershed are also influenced by riparian vegetation management and cattle poaching. Much of the lower portions of Coon Creek, particularly the reaches in Sutter County, exhibit heavy degrees of riparian vegetation management and clearing. Some reaches no longer have any established woody vegetation, while others only exhibit woody riparian vegetation between the edge of the wetted base-flow stream channel and the top of the stream bank. The lack of riparian vegetation locally increases the stream channel's susceptibility to bank scour and erosion. Cattle poaching, which is most heavily concentrated in the middle reaches of the watershed, also causes local bank erosion, soil erosion and compaction, and degradation of stream channel morphology. The magnitude of these disturbances in the Coon Creek watershed generally appear to be less than those caused by channel realignment, floodplain grading, and levees and berms but is still significant.

7.3.2 Engineering and Land Use Pressure Index

To better assess the cumulative impact of various channel modifications and engineering measures on healthy physical processes of the Coon Creek stream network, an engineering and land use pressure

index was developed. Engineering features and disturbances both in the stream channel and along the channel margins and nearby floodplains were classified into seven overall categories. These disturbances include both historic activities (e.g., historic channel realignment) and present-day disturbances (levees or berms, hydraulic control structures such as dams and bridges, cattle poaching, bank armoring, etc.). Present-day features of interest were mapped during the fluvial audit and field reconnaissance described in Chapter 2. The pressure index was developed for stream reaches that were surveyed during field work and also approximated for reaches evaluated through desk-based analysis. Weightings were developed based on expert judgment and are indicative of the severity of the impact assigned to each feature as indicated below in Table 23.

Table 23. Summary of engineering and land use pressure feature classes and weightings

Impact Category	Sub-Category	Weighting / Score[1]
Bank Protection	Large Scale	2.0 * length of feature (in feet)
	Small Scale	1.0 * length of feature (in feet)
Hydraulic Control Structures	Weir	Between 20 and 1500 depending on estimated severity of impact
	Dam	Between 250 and 2000 depending on severity of impact
	Open Bridge	Between 20 and 1500 depending on estimated severity of impact
	Culvert	Between 20 and 1500 depending on estimated severity of impact
	Ford	Between 20 and 750 depending on estimated severity of impact
	Bed Armoring	2.0 * length of feature (in feet)
	Relict Structures (e.g., bridge piers)	Between 20 and 750 depending on estimated severity of impact
Floodplain Manipulation (levees/berms, grading, etc.)	High Impact	1.0 * length of impact (in feet)
	Low Impact	0.25 * length of impact (in feet)
Historic Channel Realignment or Straightening	High Impact Realignment	2.0 * length of realigned channel (in feet)
	Low Impact Realignment	0.5 * length of realigned channel (in feet)
Loss of Historic Channel Length	Greater than 50% loss in channel length	0.25 * length of realigned channel (in feet)
Cattle Poaching	Moderate Severity	2.0 * length of feature (in feet)
	Minor Severity	1.0 * length of feature (in feet)
Incision	Moderate Severity	0.5 * length of feature (in feet)
	Minor Severity	0.25 * length of feature (in feet)

[1] Hydraulic control structures and relict structures are assigned scores within the range of values presented in the table by assessing the cumulative disturbances of the feature on physical processes in the channel. Calculations by reach are presented in Appendix D.

Most of the disturbances are scored based on a severity factor multiplied by the feature's physical length. However, the impact scores for hydraulic control structures account for both their local effects (e.g., lateral and vertical restraint of the stream channel and flows, potential for influencing local hydraulics and sediment transport, etc.) as well as their upstream and downstream disturbances due to their influence on longer-scale reach hydraulics and sediment dynamics. The large range in potential values for the hydraulic control structures is due to the significant variability in the impact they can have on a fluvial system. This range in disturbances is due both to the characteristics of the structure (e.g., the height of a weir or dam) and the environmental setting in which the impact is found (e.g., a low gradient, meandering river or a high-energy mountain stream in a steep catchment). As an example, Coppin Dam (a flashboard dam installed during the irrigation season on the East Side Canal) was assigned a higher impact score than the permanent Camp Far West Diversion Dam, largely because of the difference in their geomorphic settings. The presence of the Camp Far West Diversion Dam along a high-gradient reach of Coon Creek with bedrock outcrops likely has a much lesser longitudinal impact on physical processes than Coppin Dam, which drives a backwater effect for over a mile upstream and affects channel form and riparian vegetation establishment, despite its seasonal nature.

A total engineering and land use pressure score was calculated for each geomorphic sub-reach and then divided by the reach length to generate a cumulative impact index for the reach. Each reach's impact index is intended to signify the degree of impairment to physical processes and channel conditions within the reach (Figure 72). It should be noted that the engineering and land use pressure index was calculated for several reaches that were not surveyed during the field-based geomorphic assessment. These include reaches 17, 18, 19 and 28 located along private property where access was not granted, and reaches CU-1 and CU-2 where previous assessments had already been completed (Harris, 2008). Consequently, the index scores for these reaches do not account for disturbances that could not be identified remotely (e.g., bank protection, cattle poaching, certain hydraulic control structures, etc.) and likely underestimate disturbances. This is particularly the case for reaches 17, 18, 19 and 26 which likely have disturbances from cattle and channel engineering measures.

The engineering and land use pressure index varies significantly throughout the watershed, reflecting the wide range in the degree of disturbances to physical processes and channel conditions on a reach-by-reach basis. Cumulative impacts are greatest along the East Side Canal (reaches 1-5) due to high-impact channel realignment into a levee confined system that is also affected by a number of hydraulic control structures. Coon Creek within Sutter County and the western portion of Placer County (reaches 6-16) tend to be highly impacted due to channel realignment, floodplain grading, low elevation berms, and channel incision. These disturbances generally continue but lessen somewhat in intensity and frequency (reaches 17 to 21) along Coon Creek up to McCourtney Road. Land use and engineering pressures are much less significant further upstream (reaches 22 through CU-2) where Coon Creek flows through a high-gradient, laterally-confined and minimally developed corridor. Along Doty Ravine, the intensity and frequency of engineering and land use pressures also generally diminishes further upstream. However, historical floodplain mining impacts along Reach 33 result in a locally high degree of disturbance.

7.4 WATER QUALITY DISTURBANCES

Disturbances to water quality are briefly summarized in the paragraphs below. A more extensive discussion of water quality monitoring and observed disturbances is provided in Chapter 4.

Temperature

Changes to the natural temperature regime of the Coon Creek are likely driven largely by flow management and irrigation practices and the management of riparian vegetation. As discussed in Section 4.2, conveyance of irrigation flows along several reaches of Coon Creek generally results in locally cooler water temperatures. In addition to affecting water temperatures along these select reaches, conveyance practices likely generate greater levels of spatial variability in stream temperatures across the watershed. The increased temporal variability in stream flows during the irrigation season also likely increases the temporal variability of stream temperatures and alters natural temperature patterns. The management and removal of riparian vegetation, particularly riparian canopy, has also likely increased solar exposure of Coon Creek, particularly in Sutter County where agricultural land use often extends to the top of the stream bank. In conclusion, the overall net effect of human disturbances on the Coon Creek temperature regime is difficult to discern, particularly due to the highly complex and variable nature of flow management activities.

Dissolved Oxygen

Development has likely had significant impacts, both positive and negative, on dissolved oxygen concentrations in the Coon Creek Watershed. The two major drivers of this impact are managed flow conditions throughout the watershed and loss of riparian vegetation in the lower reaches of Coon Creek. Irrigation transfers on Coon Creek cause major alterations of the natural flow regime. When transfers result in higher than natural flows, DO levels are likely to be increased compared to background levels. These elevated DO concentrations may provide a potential benefit to aquatic organisms during these periods. Conversely, decreased DO levels caused by lower than natural flows are likely to have adverse impacts on aquatic species. Loss of riparian vegetation in areas of lower Coon Creek caused by cattle grazing has likely increased water temperature and decreased DO concentrations. Finally, while this watershed assessment found that eutrophication is not a major concern in the watershed, it is possible that this process periodically contributes to decreased DO concentrations.

Lab Analytes

Development in the watershed has also increased levels of potentially harmful constituents including nitrate, pesticides, and metals. Before the closure of the SMD-1 WWTP, the plant effluent was a major source of nitrate to the watershed, especially in the relatively undeveloped upper and middle reaches of Coon Creek. The nitrate loading from SMD-1, as well as nitrate-containing runoff and irrigation returns, increased the likelihood of eutrophication events and associated adverse effects in the warmer, lower reaches of the watershed. Agricultural land use in the lower watershed, and potentially suburban land use in the upper watershed, contribute to pesticide loading in the creek. Relatively high concentrations

of some metals are likely a function of the watershed's geology, but may be increased because of past mining activities, inputs from the SMD-1 WWTP or other anthropogenic sources.

7.5 ECOLOGICAL DISTURBANCES

Aquatic and riparian habitats in the Coon Creek Watershed have been affected by a variety of stressors, including: vegetation removal, land alteration, channel realignment and straightening, flow management and water diversion, inappropriate livestock grazing, mining, and the introduction and spread of invasive plants and nonnative fish and other invasive, aquatic species (e.g., bullfrogs, *Lithobates catesbeianus*) (Brussard et al. 2004, Jones & Stokes 2004). These stressors have resulted in impacts to, and loss of, riparian vegetation, soils, water quality, and instream habitat for fish and other native aquatic species.

In many parts of the watershed, riparian vegetation most likely has been removed for cultivation of crops, livestock grazing, residential development, and construction of infrastructure. Vegetation removal reduces riparian canopy cover and stream shading, which causes air and water temperatures to increase; destabilizes streambanks; reduces nutrient inputs from leaves, woody debris, and associated insects (which alters primary and secondary ecosystem productivity); alters groundwater/surface water interactions; and degrades wildlife habitat and water quality (Washington Department of Fish and Wildlife 2009). Vegetation removal also fragments continuous patches of native riparian vegetation, which results in habitat loss, reduced habitat patch size, increased isolation of remnant patches, and increased patch edge that exposes native plants and wildlife to abiotic and biotic factors that may further degrade patch quality (Johnson and Calhoun 1999). Roads are one of the major causes of habitat fragmentation in the Coon Creek Watershed (Jones & Stokes 2004). They result in habitat loss, loss of habitat connectivity, vehicle collisions with wildlife, the introduction and spread of invasive plant propagules by vehicles, increased water runoff, and increased sediment delivery to the stream (Gelbard and Belnap 2003, Watson 2005).

Aside from these direct effects, changes in surrounding land use outside riparian areas can also have indirect effects on aquatic and riparian habitat. For example, even where riparian habitat has not been directly removed, the cultivation of crops in adjacent areas has likely resulted in increased nutrient inputs from fertilizers, increased use of pesticides, and altered hydrology within adjacent riparian areas. In the upper watershed, fire suppression and the shift in dominant land use from livestock grazing to exurban development has likely modified the surrounding landscape from open oak savanna to denser, yet fragmented, oak woodland (Wacker and Kelly 2004).

Channel realignment and straightening diminish dynamic hydrologic and geomorphic processes that sustain aquatic and riparian habitat, such as seasonal floodplain inundation, fine and coarse sediment transport, and the formation of morphological complexity that provides habitat diversity (e.g., gravel bars, cut banks, pools, and riffles) (Charlton 2008). This loss of seasonal floodplain inundation likely has been especially pronounced in the lower reaches of the Coon Creek where, historically, floodwaters from Coon Creek and Doty Ravine probably once contributed to a larger seasonal floodplain in the

Natomas Basin, comprising overbank flows from several drainages (e.g., Auburn Ravine, Dry Creek, the Sacramento River, and the Feather River).

Flow management and irrigation practices have likely resulted in substantial disturbances to aquatic and riparian habitat, along with native species that were adapted to seasonal flow variability and timing. Augmented flows in Coon Creek and Doty Ravine, creating persistent flows in summer and fall, have likely created conditions that support aquatic animals that were unable to persist under more variable and unpredictable natural stream flows, including both native (e.g., resident rainbow trout) and nonnative (e.g., Centrarchids) fishes. Augmentation of the natural hydrograph through water imports and diversions may also affect native, anadromous fishes whose migration timing and patterns are affected by hydrologic or chemical cues (e.g., attracting out-of-basin fish because of chemical cues present in imported water) or allow dispersal of nonnative predators throughout the watershed during summer. Augmented flows also could alter the species composition of riparian vegetation by changing which seeds are dispersed via water and by creating conditions that are favorable to native and nonnative species adapted to summer flows and persistent soil saturation or inundation created through perennial stream flows.

As described earlier, many portions of the watershed have been grazed, and continue to be grazed, by domestic livestock. Inappropriate livestock grazing (e.g., grazing too many animals, grazing for too long, or grazing during periods when livestock are more likely to congregate in riparian zones) not only reduces riparian vegetation cover, but can also alter channel morphology and streamflow patterns, increase soil erosion and compaction, reduce water and wildlife habitat quality, and spread invasive plants (Belsky et al. 1999). These effects can reduce groundwater recharge, lower groundwater tables, narrow riparian zones, reduce the number of channel pools and meanders, increase water temperatures, reduce spawning habitat and habitat for benthic organisms, reduce water depth, increase flooding in surrounding landscapes, speed the loss of fertile topsoil, and disrupt plant community succession and regeneration (Belsky et al. 1999). Livestock stream crossings increase bank erosion, increase fine sediment delivery to the stream, inhibit riparian vegetation development, and negatively affect water quality. Also, trampling can result in mortality of salmonid eggs and larvae where crossings are located in spawning habitat.

Finally, invasive plant species, often aided by many of the stressors described above, occur throughout the Coon Creek Watershed (Jones & Stokes 2004). Many of these species further degrade aquatic and riparian habitats by altering ecosystem processes, displacing native plants, and diminishing wildlife habitat (DiTomaso and Healy 2003). In particular, Himalayan blackberry (*Rubus armeniacus*) is common along the creek banks and floodplains in the Coon Creek Watershed. This species is a strong competitor that rapidly displaces native plants by forming dense, impenetrable thickets that limit the growth of understory plants (Bossard et al. 2000). Other invasive plant species of concern in the watershed include tree of heaven (*Ailanthus altissima*), bigleaf periwinkle (*Vinca major*), yellow star thistle (*Centaurea solstitialis*), giant reed (*Arundo donax*), and water primrose (*Ludwigia* spp.).

7.6 FUTURE DRIVERS OF CHANGE

A number of different factors are likely to drive future changes and disturbances to the Coon Creek watershed. A brief overview of several of these drivers is provided below.

Climate Change

Climate change projections for the Sierra Nevada foothills and Central Valley of California vary widely on the basis of future emissions scenarios and other factors, but generally consistent among projections is an increase in temperatures and decrease in precipitation. In turn, these factors will drive decreases in stream flows and increases in stream temperatures. The region will also be at greater risk for wildfires (PRBO Conservation Science, 2011). All of these factors are likely to drive changes to both the physical conditions and the ecological communities of the Coon Creek watershed.

Changes in Land Use

Ongoing development in the vicinity of Auburn as well as low-density residential development in other areas of the watershed will drive changes in land cover. Additionally, future changes in agricultural practices, particularly in crop selection and acreage under cultivation, may result from changes in crop prices, water availability and costs, climate conditions and other factors. Due to the large degree of agricultural and grazing land use in the watershed, changes in these land use practices can have significant effects on the Coon Creek watershed.

Changes in Flow Management Practices

Future changes in flow management practices within the Coon Creek watershed may occur for a number of reasons. These include but are not limited due changes in water supply levels (particularly out-of-basin reservoirs and stream flows as well as groundwater resources), changes in water demand, changes in water regulations, and changes in conveyance and delivery practices. Because the stream network is so heavily influenced by flow management practices, any of the above changes can drive significant changes to in-stream flows, particularly during the irrigation season.

Mining

A large-scale sand, gravel and granite mining operation is proposed by Teichert, Inc. for properties adjacent to Coon Creek between Old Highway 65 and Gladding Road. Mining and processing activities would occur on approximately 1,000 acres. The Environmental Impact Report (EIR) calls for the removal of 37 million tons of sand and gravel and 120 million tons of granite resources over an 85 year period. While the mining would not directly disturb Coon Creek, and provides for restoration of riparian habitat and cattle exclusion, the reclamation plan would result in the generation of over 500 acres of lake habitat within the mined area (Placer County Planning Department, 1999). These activities have the potential to both directly and indirectly effect the Coon Creek watershed including stream conditions, groundwater resources and upland habitat conditions.

8 OPPORTUNITIES AND CONSTRAINTS ANALYSIS

This chapter presents an opportunities and constraints analysis of the Coon Creek watershed that draws on the preceding analyses. A combination of basin-scale strategies and specific projects are identified to rehabilitate physical processes, hydrology, aquatic and riparian habitat, and anadromous fisheries. High priority initiatives are presented in the opportunities and constraints matrix below which is followed by additional discussion of various considerations for anadromous fisheries enhancement and potential modifications to flow management. Additional studies are presented in the final section of this chapter that could build off the knowledge gained during this assessment to further inform future management actions and rehabilitation projects.

8.1 IDENTIFIED STRATEGIES AND OPPORTUNITIES

Given the Coon Creek's disturbance history and current land uses, returning the watershed to its pre-disturbance condition is considered infeasible. As such, the projects and actions identified in this report seek to mitigate hydrologic disturbances, rehabilitate physical processes, improve water quality and enhance habitat such that the basin can provide greater ecological function within current land use constraints. Rehabilitation and management strategies were developed at both the basin scale and the scale of individual project sites. Field studies, desk-based analysis and conversations with landowners and stakeholders led to the identification of a large number of potential projects. Rather than list all potential project concepts, we present key basin-scale strategies and individual projects that we consider are most meaningful for the rehabilitation of the watershed in Table 24 while additional projects of lesser priority are listed in Appendix E. It should also be noted that all efforts will require further engagement and coordination with landowners, agencies and other stakeholders to evaluate project feasibility and refine concepts before formal design and implementation can occur.

Table 24. Coon Creek Opportunities and Constraints Matrix

ID	Scale [1]	Project Name	Location	Existing Conditions	Project Description and Benefits	Constraints and Potential Negative Impacts	Benefits [2]					Constraints				Cost [3]	Timeline (yrs)	Priority
							Physical Processes	Hydrology	Water Quality	Salmonid Habitat	Riparian Habitat	Land Use / Infrastructure	Stakeholder Complexity	Access	Permitting			
Channel and Floodplain Rehabilitation																		
1	BW	Channel and Floodplain Rehabilitation	Middle and Lower Watershed	Channel realignment, floodplain grading, berms and levees, mining practices, channel incision, cattle grazing, and management of riparian vegetation have impaired physical processes and degraded channel conditions in many parts of the middle and lower watershed. Floodplain connectivity has declined in a number of areas along with the duration of floodplain inundation. The complexity and quality of floodplain and off-channel habitat features has lessened. In-channel morphological complexity has been simplified along more heavily impacted reaches and sediment loading from human-induced bank erosion has increased.	A broad range of strategies can be implemented to improve physical processes and the rehabilitate the watershed's stream channels and floodplains. Specific strategies include expanding the natural floodplain corridor through easements and the intentional breaching or removal of berms. Floodplain topographic complexity can be enhanced through grading practices to create more natural stream corridors. Biotechnical bank stabilization can be used along cattle-impacted reaches to reduce excessive fine sediment loading. The placement of large wood or beaver dam analogs can also encourage bed aggradation along incised reaches and improve morphological and habitat complexity.	Most channel and floodplain rehabilitation efforts involving the floodplain and/or berms will require land owner permission and may compete with existing land uses.	H	M	M	H	H	M	M	M	M	$$ to $$$$$	2 to 6	H
2	BW	Channel Form Rehabilitation	Middle and Lower Watershed	Along some reaches, particularly where the stream channel was realigned, the geometry of the channel has been heavily degraded resulting in a loss of morphological complexity and habitat quality.	The stream channel's cross section, slope and pattern can be rehabilitated through direct intervention with grading and/or realignment to accelerate the stream's recovery.	Channel form rehabilitation often requires a high degree of intervention within existing stream channels and can impact existing (albeit often low-quality) habitat.	H	L-M	L-M	M-H	M-H	M	M	M-H	M-H	$$ to $$$$$	2 to 5	M-H
3	BW	Channel Meander Reconnection	Lower Watershed	Much of lower Coon Creek was realigned and straightened, resulting in the disconnection or historic channel meander bends. Many of these meanders were also partially or completely filled.	Historic meanders that were can be reconnected as overflow or primary channel alignments. This strategy restores sinuosity to the stream and can provide more natural reach-scale hydraulics, and also improve in-stream and riparian habitat conditions.	Reconnecting historic meanders may compete with existing land use, particularly agriculture.	H	L	N	L	M-H	M-H	M	M	M-H	$$ to $$$$	2 to 5	M-H
4	BW	Channel Reprofiling	Middle and Lower Watershed	Many reaches of Coon Creek, particularly in the middle and lower watershed, suffer from fairly significant channel incision (i.e. a deepening of the channel and increase in the slope of the stream banks, often to fairly vertical orientation). In addition to resulting in degraded in-stream habitat conditions, incision also reduces floodplain connectivity.	Where channel incision or a head cut has resulted in channel deepening and decreased floodplain connectivity, measures such as installing engineered log jams, beaver dam analogs or grade control structures (e.g., Newbury weirs or rock ramps) can be pursued to promote bed aggradation.	These measures can reduce channel capacity and increase floodplain connectivity which may be in conflict with existing stream-side land use.	H	L	L	M	M-H	M-H	M	M-H	M-H	$$ to $$$$	2 to 5	H

[1] BW = Basin Wide; IP = Individual Project [2] H = High; M = Moderate; L = Low; N = None [3] $ < $10K; $$ = $10K to $100K; $$$ = $100K to $500K; $$$$ = $500K to $1M; $$$$$ > $1M

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							Physical Processes	Hydrology	Water Quality	Salmonid Habitat	Riparian Habitat	Land Use / Infrastructure	Stakeholder Complexity	Access	Permitting			
5	BW	Reintroduce Large Wood Along Stream Wood-Limited Reaches	Middle and Lower Watershed	The density of large wood features varies dramatically along Coon Creek and Doty Ravine. Along some reaches, it appears that varying combinations of channel and riparian vegetation management practices, channel characteristics and local hydraulics have resulted in little to no large wood occurrence. This may limit in-channel habitat complexity and cover for aquatic species.	Along reaches where large wood is actively removed from the channel or otherwise low in density, engineered large wood features or jams can be installed in the channel to enhance physical processes, increase morphological complexity, improve habitat diversity and provide cover/refugia for aquatic species.	Depending on the design and placement, engineering large wood features can enhance dynamic channel behavior (e.g., lateral migration, bank erosion) which may be in conflict with land use objectives or management styles.	M-H	L	N	M	M	M	L	L	L-M	$$ to $$$$	1 to 4	M-H
6	BW	Biotechnical Bank Stabilization to Reduce Fine Sediment Loading	Middle and Lower Watershed	Along many reaches Coon Creek and Doty Ravine, moderate to severe bank erosion occurrences exacerbate fine sediment loading to the channel, degrade channel conditions and drive change in channel alignment and form. Bank erosion is driven by unrestricted cattle access, channel realignment, incision, natural processes and other factors.	Where bank erosion has been driven by direct anthropogenic influences (e.g., cattle grazing pressures) biotechnical bank stabilization methods (combined with cattle exclusion measures) can be used to restabilize stream banks. Example methods live staking, brushlayering, installing coir netting, longitudinal stone toe protection, live siltation, and installing large wood features.	Project success can require ongoing monitoring and, occasionally, repair work or adjustments. Some methods also have a finite life.	M	N	H	M-H	M-H	M-H	L	L	M	$ to $$$$	1 to 4	M-H
7	BW	Berm Removal	Middle and Lower Watershed	Low height non(Federal)-project levees and berms alongside Coon Creek and Doty Ravine currently reduce floodplain connectivity in many locations and may promote incision	Low elevation levees and berms can be intentionally breached or removed.	Some levees may be in place for agricultural purposes, specifically the retention of water on rice fields. Berm removal may increase frequency of nuissance flooding for some landowners.	H	M	M-H	M	H	M	L	L	M	$$ to $$$$	2 to 5	H
8	BW	Floodplain Re-Contouring / Lowering	Middle and Lower Watershed	Floodplain topographic complexity has been dramatically reduced by grading practices (mostly for agriculture), resulting in reduced habitat heterogeneity and capacity for floodwater retention. Additionally, channel incision and modification along some reaches has reduced floodplain connectivity.	Grading can be performed to increase topographic complexity of the floodplain and generate and/or rehabilitate floodplain, off-channel or secondary channel habitat. Floodplains can also be lowered to increase floodplain connectivity. Increased flooplain area can increase stream capacity and in turn reduce flooding in adjacent lands.	Floodplain lowering or recontouring may compete with agricultural land use (depending on location).	H	H	M-H	M-H	H	M-H	L	L	M-H	$$ to $$$$$	2 to 6	H

[1] BW = Basin Wide; IP = Individual Project [2] H = High; M = Moderate; L = Low; N = None [3] $ < $10K; $$ = $10K to $100K; $$$ = $100K to $500K; $$$$ = $500K to $1M; $$$$$ > $1M

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							Physical Processes	Hydrology	Water Quality	Salmonid Habitat	Riparian Habitat	Land Use / Infrastructure	Stakeholder Complexity	Access	Permitting			
9	BW	Multi-Purpose Floodplain Use for Agriculture and Juvenile Salmonid Rearing	Lower Watershed	Prior to human disturbances, the lower watershed likely featured large expanses of floodplain and seasonal wetland habitat (including areas west or downstream of the East Side Canal) that would have been highly productive habitat areas for rearing juvenile salmon as well as many other species. Today, due to channel realignment, floodplain grading and land use, the quantity, quality and duration of availability of that floodplain habitat is dramatically less.	Agricultural fields adjacent to lower Coon Creek can be managed as floodplain rearing habitat for juvenile salmonids during the winter and early spring months, while still used for rice production from mid-spring through early fall. These practices have generated exceptional growth rates in juvenile salmon in the nearby Yolo Bypass (Katz et al. 2013).	These efforts require farmers and landowners who are willing to implement multi-objective use of their fields as well as install the necessary infrastructure for salmon to successfully rear on and exit farm fields.	L	L	L	H	N	M	M	L	M	$$ to $$$$	2 to 6	H
10	IP	Lower Coon Creek Floodplain Rehabilitation - Placer County	Coon Creek between Brewer Road and Pleasant Grove Road	Coon Creek's floodplain has been extensively graded and leveled for agricultural purposes, particularly rice production, resulting in minimal topographic complexity and natural habitat space. Berms also border much of the stream channel's banks which influence floodplain connectivity. While significant channel realignment occurred in the lower watershed, this reach still features a fairly sinuous channel that may have escaped 19th century realignment efforts. Additionally, the riparian corridor is very narrow, and typical extends only a few feet from the top of the stream bank.	Rehabilitation of the stream channel and floodplain could include partial or complete removal of berms to enhance floodplain interaction with the stream channel. Floodplain topographic complexity can be enhanced through grading practices to improve off-channel habitat quality and diversity. Multi-purpose use of floodplain areas can also be pursued whereby fields are managed as floodplain rearing habitat for juvenile salmonids during the winter and early spring months, while still used for rice production from late spring through early fall.	Channel and floodplain rehabilitation will require land owner agreements and may compete with existing land uses.	H	H	H	H	H	H	M	L-M	M	$$ to $$$$$	3 to 8	H

[1] BW = Basin Wide; IP = Individual Project [2] H = High; M = Moderate; L = Low; N = None [3] $ < $10K; $$ = $10K to $100K; $$$ = $100K to $500K; $$$$ = $500K to $1M; $$$$$ > $1M

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							Physical Processes	Hydrology	Water Quality	Salmonid Habitat	Riparian Habitat	Land Use / Infrastructure	Stakeholder Complexity	Access	Permitting			
11	IP	Lower Coon Creek Channel and Floodplain Rehabilitation - Sutter County	Coon Creek between the Placer-Sutter County Boundary (Line 1 Canal crossing) and Brewer Road	Historic channel realignment practices straightened Coon Creek and disconnected at least one longer meander bend in the project area. The combination of historic channel realignment, intensive riparian vegetation management and a seasonal flashboard dam have resulted in a heavily degraded stream channel and poor-quality habitat. The floodplain has been graded and leveled for agricultural purposes, resulting in minimal topographic complexity and natural habitat space. Berms also border portions of the stream channel's banks which influence floodplain connectivity.	The historic meander bend could be reconnected to serve as the primary channel while the straightened (constructed) channel with poor habitat quality could be filled in or converted to an overflow channel. Upstream, rehabilitation measures could be pursued to re-grade, stabilize and revegetate the stream banks and thereby improve channel conditions and habitat quality. The floodplain could be regraded and revegetated to enhance topographic complexity and provide greater habitat diversity including off-channel seasonal wetland areas. Multi-purpose use of floodplain areas can also be pursued whereby fields are managed as floodplain rearing habitat for juvenile salmonids during the winter and early spring months, while still used for rice production from late spring through early fall.	Channel and floodplain rehabilitation will require land owner agreements and may compete with existing land uses. The project will also need to consider water diversion and pumping needs.	H	H	H	H	H	H	M	L	M	$$$ to $$$$$	3 to 8	H
12	IP	Lower Coon Creek Channel and Floodplain Rehabilitation - Placer County	Coon Creek between Placer-Sutter County Boundary (Line 1 Canal crossing) and Dowd Road	Historic channel realignment practices straightened Coon Creek and disconnected meander bends in the project area. Portions of the floodplain have been graded and leveled for agricultural purposes, resulting in reduced topographic complexity and limited natural habitat space. The riparian corridor along the southern bank is generally narrow to minimal in width while a broader, fairly mature riparian vegetation corridor is present along the northern side of the channel. Berms are also present along the floodplain which influence floodplain connectivity.	The historic meander bend(s) could be reconnected to serve as the primary channel. The floodplain could be regraded and revegetated to enhance topographic complexity and provide greater habitat diversity including off-channel seasonal wetland areas. Multi-purpose use of floodplain areas could also be pursued whereby fields are managed as floodplain rearing habitat for juvenile salmonids and/or floodwater retention areas during the winter and early spring months, while still used for rice production from late spring through early fall.	Channel and floodplain rehabilitation will require land owner agreements and may compete with existing land uses.	H	H	H	H	H	H	M	L	M	$$$ to $$$$$	3 to 8	H

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							Physical Processes	Hydrology	Water Quality	Salmonid Habitat	Riparian Habitat	Land Use / Infrastructure	Stakeholder Complexity	Access	Permitting			
13	IP	Sundance-Lakeview Farms Rehabilitation Site Enhancement	Coon Creek immediately downstream of Dowd Road	Downstream of Dowd Road, Coon Creek flows through a 440-acre property that is protected by an NRCS conservation easement and managed as a recreational hunting preserve. The area is also the site of a 2008 riparian, wetland and floodplain enhancement project that included riparian corridor widening, berm setback, and seasonal and perennial wetland construction. While there is a relatively healthy riparian corridor today and frequent floodplain connectivity today, the stream channel is fairly incised in some locations and many of the constructed wetland areas were intended to be actively managed and do not function as designed The groundwater pump used to provide water to the wetlands is no longer functional and soils in the site may not support the intended wetland design.	Rehabilitation measures can be implemented to further enhance the project site as well as convert areas intended for active management to a passively managed system. A combination of additional berm removal/setbacks, floodplain (re)grading, and overflow channel creation / enhancement can be pursued to improve the riparian and wetland functions of the site. The establishment of additional inset floodplain terraces to the north or south of the channel could also be explored. This project would require a more detailed feasibility study and two-dimensional hydrodynamic modeling to identify maximally effective rehabilitation enhancement measures.	The project will require land owner agreements and would need to be compatible with the hunting preserve land use. The project would also need to be compatible with existing conservation easements and any post-project requirements from past efforts driven by mitigation funds.	H	H	M	M	H	M	M	L	L-M	$$$ to $$$$$	3 to 6	H
14	IP	Channel and Floodplain Rehabilitation Along Middle Coon Creek	Coon Creek between Old Hwy 65 and Gladding Road	While ground-based surveys were not conducted along this section of Coon Creek, aerial imagery, LiDAR and discussions with County staff indicate that the stream is fairly incised, lacks riparian vegetation in numerous places and has suffered from heavy cattle use. It also appears that the stream was historically realigned along the far right valley wall prior to 1910 USGS quadrangle maps and has since developed some degree of geomorphic complexity, though generally remains disconnected from the larger valley bottom.	A broad range of strategies can be implemented along this reach to improve physical processes and enhance channel and floodplain health. Specific examples include channel realignment, channel re-profiling with large wood placement and beaver dam analogs, floodplain grading, secondary channel enhancement / creation, and riparian vegetation enhancement. Depending on the long-term land use and gravel mining practices along this reach, some of these design concepts could be integrated into the post-mining reclamation plans.	Channel and floodplain rehabilitation will require land owner agreements and may compete with existing and future land uses. A feasibility study for the project will need to evaluate any impacts to existing habitat.	H	M-H	M	M-H	H	M	M	L	M-H	$$$ to $$$$$	3 to 10+	M-H

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15	IP	Channel and Floodplain Rehabilitation Project and Middle Coon Creek	Coon Creek between Gladding Road and McCourtney Road	Immediately downstream of McCourtney Road, Coon Creek splits and follows two channel alignments that border the left and right valley walls. Channel incision generally ranges from moderate to severe. It is unclear if the channels were historically realigned along the valley walls for cattle grazing or agriculture. Low-height berms also border some sections of Coon Creek, likely contributing to reduced floodplain connectivity. Inspection of LiDAR data shows multiple historic channel alignments (likely secondary or high flow channels) along the floodplain.	Rehabilitation of the stream channels and floodplain can address channel incision, increase floodplain connectivity and enhance floodplain and off-channel habitat quality. The installation of engineered large wood jams and/or bed level controls (e.g., Newbury Rock Riffles) can be used to aggrade the stream bed and encourage more frequent floodplain connectivity. Removal of berms will further enhance floodplain connectivity. Historic floodplain channel alignments can also be enhanced with grading to increase inundation frequency and habitat quality. The existing riparian corridor can also be widened.	Channel and floodplain rehabilitation will require land owner agreements and may compete with existing land uses. A feasibility study for the project will need to evaluate any impacts to existing habitat.	H	M-H	M	M	H	H	M	L	M	$$$ to $$$$$	3 to 6	H
Riparian Vegetation / Buffer Enhancement																		
16	BW	Riparian Vegetation / Buffer Enhancement	Middle and Lower Watershed	Riparian habitat quality is of moderate to poor quality along much of the middle and lower watershed due to channel realignment, limited native woody riparian vegeatation, inadequate buffer width and agricultural encroachment, invasive plant species and other factors.	Both the physical extent and quality of the riparian corridor can be increased through enhancement of physical habitat conditions (e.g., floodplain grading, increasing channel complexity), planting of native ripairan trees and shrubs and management of invasive plants. Riparian buffer improvements will also reduce impacts to physical and biological processes by enhancing filtration of nutrients, pesticides and herbicides from agricultural runoff and by increasing the width of the riparian zone to provide potentially suitable habitat for a wider variety of riparian-dependent wildlife.	Riparian forest expansion may compete with current land use practices such as livestock grazing or agriculture.	M-H	L	M	M	H	H	M	L	L	$$ to $$$$	1 to 10	H

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Fish Passage Barrier and Unscreened Diversion Improvements																		
17	IP	Coppin Dam and Auburn Extension Canal Retrofit or Operation Changes	East Side Canal immediately downstream of Auburn Ravine confluence	Coppin Dam is a seasonal flashboard dam on the East Side Canal that is operated by the South Sutter Water District (SSWD) to enable gravity-driven flow diversion into the Auburn Extension Canal during the irrigation season. The unscreened diversion, which captures the majority of East Side Canal and Auburn Ravine flows, likely entrains at least a portion of emigrating juveniles after installation (which varies year-to-year but can be as early as April 5th). Attraction flows over the dam (typically less than 1.3 cfs) may also be too small to cue emigrating juveniles. In addition, the lengthy impounded reach of the East Side Canal likely disorients emigrating juveniles and increases mortality due to predatory fish.	A fish screen could be installed on the Auburn Extension Canal diversion to eliminate the risk of lethal entrainment of juvnile salmonids emigrating from Coon Creek, Markham Ravine and Auburn Ravine. A self-cleaning screen could have minimal effect on SSWD operations and would require limited maintenance. Concentrating flow over Coppin Dam across a lesser width may also improve downstream cueing and passage of juvenile salmonids. Other options include management changes (e.g., postponing the installation of the dam until emigration of juvenile salmonids ceases) or more involved structural changes (e.g., complete replacement of Coppin Dam and the diversion with a more updated and fish-friendly structure and/or a pump for diverting flows into the Auburn Extension Canal).	Any physical or operational changes to the dam and diversion would need to be compatible with SSWD operations. A fish screen would need to be self cleaning to avoid clogging with aquatic vegetation. Ongoing maintenance costs would need to considered.	L	L	N	H	L	H	M	L	M	$$$$ to $$$$$	3 to 7	M-H
18	IP	Doty South at Head Diversion Dam Retrofit	Doty Ravine	NID operates a wicket-gate dam and diversion on Doty Ravine to divert flows into the Doty South Canal. The dam and downstream rock ramp serve as a partial barrier to both adult and juvenile salmonids during low flow conditions. Once the wicket gates are raised for the irrigation season (April 15th to Oct 15th), downstream fish passage for juveniles is limited to flow events that overtop the gates. The unscreened diversion likely entrains both rearing and emigrating juveniles in the Doty South Canal.	A fish screen could be installed at or immediately upstream of the diversion inlet to eliminate entrainment and mortaility risks of the diversion. In conjunction, a small and low-cost fish passage ladder such as an Alaska Steeppass ladder could be installed along the side of the channel to provide both upstream and downstream passage for adults and juveniles. Alternatively, the dam's downstream rock ramp could be retrofitted or redesigned altogether to improve passage and/or the wicket-gate dam could be replaced with an adjustable weir or dam to provide occasional downstream passage of juveniles after the irrigation season commences.	Any changes to the dam and diversion would need to be compatible with NID operations. A fish passage ladder would require that continuous flows be passed downstream to enable passage while the diversion is operating during the irrigation season.	L	L	N	H	L	H	M	L	M	$$$ to $$$$$	3 to 7	H

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19	IP	Garden Bar Road Culvert Replacement	Doty Ravine at Garden Bar Road Bridge over Doty Ravine	The creek crossing consists of a perched culvert that is likely impassable for anadromous fish during most, if not all, flow conditions. Fish passage is likely inhibited by the height of the culvert outlet above the downstream pool water surface and velocities in the culvert during higher flows. The bridge is aging and the combination of its narrow width and a sharp curve in the road leading to the southern approach make it somewhat hazardous for vehicular traffic. The culvert is also likely undersized for large flood flows, acts as a hydraulic constriction point, and causes a large scour pool downstream of the bridge.	The existing bridge can be replaced with an open-span bridge or bottomless culvert that allows for a more natural stream bed and provides unimpeded fish passage. Fish friendly grade control structures and channel reprofiling measures would need to be implemented to prevent upward migration of a head cut. The project would enhance longitudinal connectivity of physical processes, alleviate an artificial hydraulic constriction, improve downstream aquatic habitat and provide access to several miles of potential spawning and rearing habitat for anadromous salmonids.	The project will require significant modifications to or complete replacement of the existing bridge.	M	L	N	H	L	L	M	L	M	$$$ to $$$$$	2 to 5	H
20	BW	Diversion Screening	Anadromous Reaches of the Coon Creek and Doty Ravine	Numerous surface water diversions occur throughout the watershed, including for domestic, agricultural/livestock, and rate payer (e.g., NID) uses. Unscreened diversions have the potential to kill juvenile salmonids (and other small fish) when they stray into dead-end canals and cannot return to the natural stream channel.	An inventory of diversions and extractions should be developed throughout the watershed. Funding and screening of diversions can then be addressed on a case-by-case basis.	Development of an inventory and implemntation of a screening program may be limited by landowner participation.	N	L	N	H	N	H	H	H	H	$$$ to $$$$$	5 to 10 +	M
21	BW	Pump Screening	Anadromous Reaches of the Coon Creek and Doty Ravine	Numerous extractions of surface water occur throughout the watershed, primarily for domestic and agricultural/livestock uses. Unscreened inlets to pumps allow juvenile salmonids (and other small fish) to be sucked into pumps and killed.	An inventory of diversions and extractions should be developed throughout the watershed. Funding and screening of diversions can then be addressed on a case-by-case basis.	Development of an inventory and implemntation of a screening program may be limited by landowner participation.	N	L	N	H	N	H	H	M	H	$$ to $$$$	5 to 10 +	M

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							Physical Processes	Hydrology	Water Quality	Salmonid Habitat	Riparian Habitat	Land Use / Infrastructure	Stakeholder Complexity	Access	Permitting			
22	BW	Modify Seasonal Diversion Operation Schedule to Enhance Juvenile Salmonid Emigration	Anadromous Reaches of Coon Creek and Doty Ravine	Juvenile Chinook salmon occur in Coon Creek and Doty Ravine at least until early June, well after the onset of the diversion and extraction season. Diversions and extractions pose many challenges to emigrating salmonids, including mortality, delaying migration, and in some cases preventing migration	The feasibility of delaying the onset of diversion and extractions (including installation of seasonal diversion structures) until after most juvenile salmonids have emigrated should be explored with both the major water suppliers in the watershed and private landowners operating seasonal diversions. A feasibility study will require developing a better understanding of the timing of peak emigration for juvenile salmonids.	The willingness of water suppliers and landowners to participate in such a project is unknown. Additional studies are needed to inform feasibility, specifically determining the timing of peak emigration for juvenile salmonids.	L	M	L	H	L	H	H	M	L	$$ to $$$$$	5 to 10 +	H
23	BW	Provide Improved Passage Around Seasonal Diversions for Emigrating Juvenile Salmonids with Physical Interventions or Increased Flows	Anadromous Reaches of Coon Creek and Doty Ravine	Some privately operated seasonal dams for surface water diversions may limit or inhibit downstream fish passage, particularly emigrating juvenile salmonids.	Where delaying the onset of surface water diversions on private property is infeasible, other measures could be explored for improving the success of juvenile salmonid emigration. These include physical modifications or passageways as well provision of flows to be passed downstream.	The willingness of water suppliers and landowners to participate in such a project is unknown.	N	L	N	H	N	M-H	M-H	M	M-H	$$ to $$$$	5 to 10 +	M-H
Voluntary Land Management Programs																		
24	BW	Implement Voluntary Cattle Exclusion Program to Protect Active Channel Corridor	Middle and Lower Watershed	Unrestricted livestock access to the stream channel degrades habitat quality for fish and wildlife and exacerbates bank erosion along a number of reaches of Coon Creek and Doty Ravine. The presence of livestock in riparian zones likely increases fine sediment, nutrient, and bacteria inputs to the stream and adversely affects anadromous salmonid spawning and rearing habitat.	A local, voluntary conservation program could be implemented, in conjunction with similar state and federal government programs, such as the NRCS's EQIP program, to provide financial and technical support for landowners willing to implement fish-friendly agricultural practices (e.g., cattle exclusion fencing, off-stream water sources, cattle crossings). These practices would reduce cattle impacts on the riparian zone, improve fish habitat, and improve water quality.	The ability for Placer County to fund such a program through PCCP impact fees would need to be determined. There would be administrative burdens with such a program; although administraitve duties could potentially be assigned to a cooperating party, such as a local resource conservation district.	M	L	H	H	M-H	H	L	M	L	$$ to $$$$$	1 to 10+	M-H

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25	BW	Implement a Voluntary Riparian Corridor Conservation Easement Program	Middle and Lower Watershed	Ongoing management and land use practices result in limited riparian buffer width and longitudinal continuity along the stream corridor. This contributes to overall poor riparian habitat quality along much of the middle and lower portions of Coon Creek.	A voluntary conservation easement program could be implemented to collaborate with landowners and limit the use of lands in order to protect, enhance, and restore riparian habitat values, such as corridor width and continuity and ecosystem functions.	Measures may compete with existing land use objectives. The program would also need to overcome landowner reluctance or hesitation to participate due to perceptions around cost, complexity, undesireable impacts, working with government agencies and other concerns.	M	L	M	M	H	M-H	M-H	M	L	$ to $$$	5 to 20+	M
26	BW	Implement Soil Conservation Best Management Practices to Reduce Soil Loss from Floodplain Agricultural Land	Middle and Lower Watershed	Soil loss from agricultural land driven by surface runoff and floodplain inundation can increase sediment loading to the stream, altering sediment dynamics and degrading aquatic habitat.	A voluntary, incentivized program (or existing programs) can be used to encourage a large range of soil conservation practices including but not limited to conservation tillage, cover crops, conservation crop rotation, and conservation drainage. These efforts would reduce fine sediment loading and thereby the loading of other sediment-bound pollutants.	Measures would need to be compatible agricultural objectives. The program would also need to overcome landowner reluctance or hesitation to participate due to perceptions around cost, complexity, undesireable impacts, working with government agencies and other concerns.	M	L	M-H	M	L-M	M-H	M-H	M	N	$$ to $$$$$	1 to 10 +	M
27	BW	Agricultural Runoff Capture and Treatment	Middle and Lower Watershed	Surface runoff from farm land during precipitation events and discharge of agricultural return water likely increases the loading of various pollutants to Coon Creek including pesticides, nutrients and fine sediment. These pollutants degrade water quality and habitat conditions.	The installation of agricultural best management practices (BMPs) can be incentivized on private land through a voluntary landowner program. BMPs can include filter strips, riparian buffer enhancement, sediment basins, treatment wetlands, and other features that can detain or filter agricultural runoff before it discharges into a stream.	Measures would need to be compatible agricultural objectives. The program would also need to overcome landowner reluctance or hesitation to participate due to perceptions around cost, complexity, undesireable impacts, working with government agencies and other concerns.	L	L	H	M	M	M-H	M-H	M	N	$$ to $$$$$	1 to 10 +	M

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28	BW	Urban Stormwater Management	Upper Watershed, particularly in and around Auburn	Urban development increases impervious cover and typically drives greater delivery of surface runoff to streams during precipitation events. While Placer County has recently developed a Low Impact Development (LID) manual that will require on-site stormwater capture for new development, existing development has increased peak flows in Coon Creek, particularly its headwaters around Auburn (i.e. Dry Creek).	In addition to requiring stormwater management practices for new development, a voluntary, incentivized program can be implemented to encourage stormwater management retrofits to locally detain and treat stormwater and thereby reduce the effects of hydromodifcation in the upper watershed. This will reduce development's effects on hydrology and physical processes and reduce pollutant loading to Coon Creek.	Retrofitting existing stormwater infrastruture and installing stormwater best management practices after land has already been developed can be costly and constrained by limited availability of physical space. A program would also need to overcome landowner reluctance or hesistation to participate due to a number of potential concerns.	M-H	H	H	L-M	L	H	M-H	L	L	$$ to $$$$$	1 to 10 +	L-M
Control / Removal of Invasive Species																		
29	BW	Invasive Plants	Watershed-Wide	Non-native, invasive plants such as Himalayan blackberry and water primrose, occur throughout the watershed. Where these species occur, they degrade riparian and aquatic habitat quality for native plants, fish, and wildlife.	Areas with dense infestations of invasive plants could be treated to reduce, or eliminate, these species, and native species could be planted to deter re-colonization of treatment locations by invasive plants. Efforts to manage invasive plants on private lands could be funded through local, voluntary programs or through cooperating parties, such as the Nevada-Placer Weed Management Area.	Wide-scale control of invasive plants is likely only possible through coordinated action throughout the watershed (e.g., to control source populations in the upper watershed). Continued monitoring and management is often required to ensure that invasvie species do not re-colonize treated areas. Some invasive species provide habitat benefits to native fish and wildlife; treatment of these species could result in short-term declines in habitat quality.	M	M	L-M	L-M	M-H	L	H	L	M		5-20	M

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30	BW	Non-Native Predatory Species	Watershed-Wide	Non-native predators, such as warm-water game fish (e.g., smallmouth bass), bull frogs, and red-eared sliders occur throughout Doty Ravine and Coon Creek. Where these species occur, they compete with native aquatic species (e.g., western pond turtles) for resources, and, more pervasively, they prey on native, aquatic species such as juvenile salmonids.	Voluntary control efforts could be implemented to capture and remove these species, where feasible. Additionally, education programs could be developed to inform watershed residents about the threats these species pose to native fish and wildlife and to educate them on responsible care of species such as red-eared sliders, which are often released into creeks and ponds as unwanted pets.	Wide-scale control of these species would only occur through coordinated efforts throughout the watershed. Continued monitoring and management would be required to ensure that species do not re-colonize the watershed. In practice, eliminating many of these species would be difficult or impossible, although localized control may be feasible in some instances.	N	N	N	H	N	N	H	L	L		5-20	L

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8.1.1 Considerations for Anadromous Fisheries Enhancement

Rehabilitation of anadromous fisheries within disturbed watersheds is often a complex, challenging and, at times, elusive process. It is critical that rehabilitation efforts fully consider stressors and limiting factors to salmonids by species and life stage in order to achieve success. While many unknowns still remain regarding anadromous fish populations and life history strategies within the Coon Creek watershed, this study has significantly informed an understanding of anadromous fisheries and several basin-scale strategies and specific project recommendations are provided to enhance anadromous fish populations in Table 24 as well as some general discussion of rehabilitation approaches. Anadromous fisheries rehabilitation efforts in the Coon Creek watershed should target Central Valley fall/late fall-run Chinook salmon and Central Valley steelhead. We suspect that land use and flow management practices have most significantly affected juvenile salmonid rearing and emigration in the Coon Creek watershed. Access to and quality of salmonid spawning habitat may also be a limiting factor for salmonid populations in the watershed, but likely to a lesser extent relative to a lack of juvenile rearing habitat and barriers to successful juvenile emigration.

Some of the highest-priority projects to address these challenges include retrofitting or eliminating fish passage barriers and unscreened diversions. Examples of these include, modifying the perched culvert at Garden Bar Road (Project 19 in Table 24) which presents an excellent opportunity to restore access for anadromous fish to additional spawning habitat that occurs upstream of the culvert. Due to flow conveyance practices by NID, this reach of Doty Ravine generally exhibits cooler water temperatures and therefore potentially represents a reach of Doty Ravine with higher quality salmonid habitat during the spring and summer (i.e., for juvenile steelhead, if they were to occur in Doty Ravine). The Doty South at Head Diversion Dam and Coppin Dam (Projects 18 and 17) are also high priority locations for projects to remove passage barriers and reduce entrainment risk for rearing and emigrating juveniles, though they would need to be compatible with water agency operations. Addressing other smaller-scale unscreened diversions and pumps throughout the anadromous reaches of the watershed would likely benefit rearing and emigrating juveniles though their current effect is unknown.

Past studies of Coon Creek (e.g., Bailey and Buell, 2005) have proposed extending anadromous access upstream of natural passage barriers within Hidden Falls Regional Park as well as the Camp Far West Diversion Dam located further upstream. However, we believe these projects should not be considered or be given a low priority compared with other efforts within the watershed. Our limited surveys upstream of Lower Hidden Falls revealed no suitable spawning habitat, and our stream power analysis suggests that the entire reach between Lower Hidden Falls and the Camp Far West Diversion Dam is unlikely to provide suitable spawning habitat. However, one potential benefit of extending access upstream of Camp Far West Diversion Dam is to provide anadromous fish access to habitat in one of the coldest reaches in the watershed during the late spring and summer juvenile rearing period. NID utilizes Orr Creek and Coon Creek to convey flows, and during WY 2016, this reach maintained cooler temperatures than neighboring reaches. However, before considering such a project two additional studies would be required: 1) a formal assessment of Lower Hidden Falls for passage by anadromous

salmonids, and 2) comprehensive surveys to determine whether suitable spawning and rearing habitat occurs upstream of Camp far West Diversion Dam (other than the known suitable temperatures).

Other efforts that could be pursued to improve habitat quality for salmonids include restoring physical processes, riparian vegetation and habitat diversity. In particular, efforts in the lower watershed to enhance floodplain connectivity, topographic complexity, and the duration of floodplain inundation would benefit juvenile rearing and emigration opportunities through increased food supplies, providing refugia from high velocities during storm events, refugia from predators, and other ecological functions. Enhancing the riparian corridor and canopy, particularly in the lower and middle watershed, can improve aquatic habitat and water quality conditions. In addition, exclusion of livestock can reduce direct mortality of eggs and larvae from trampling of redds, protect and encourage regeneration of riparian habitat, and improve water quality. Due in part to the diversity of salmonid life histories and their interaction with many components of watershed health, almost all projects identified as part of this assessment have the potential to benefit salmonids either directly or indirectly.

8.1.2 Considerations for Flow Management

As described in the preceding chapters, flow management practices have fundamentally altered the hydrology and habitat conditions of the Coon Creek watershed. The benefits and negative effects resulting from flow management practices vary spatially and temporally, by physical and ecological function, and by species. The factors affecting hydrology and habitat conditions as a result of flow management are extremely complex and consequently, it is difficult to state whether the net effect of changing these practices would be positive or negative as the underlying complexity of benefits and detriments is beyond the scope of this assessment. While we provide several recommendations regarding flow management infrastructure improvements for aquatic species in the preceding opportunities matrix, we do not make specific recommendations here regarding changes to flow management practices. Instead, we present a discussion of potential concepts requiring further exploration as well as some of the human and environmental factors that must be considered in determining the feasibility and likely effects of any proposed modifications.

Water Demand, Conveyance and Delivery Considerations

The water management agencies operating in the Coon Creek watershed utilize a complex network of reservoirs, canals, stream channels and diversions to supply water to their customers on a consistent and timely basis. The following are a description of some of the most pertinent considerations and constraints for delivery of water to customers in the Coon Creek watershed.

<u>Timing and Variability of Water Demand</u>

Depending on customer use of water, demand for water can be highly variable on both daily and seasonal time scales. In particular, demand for irrigation water is driven by the objectives of farmers and ranchers in the watershed which vary by crop, weather, timing of planting, harvest timing, and

numerous other factors. For instance, rice growers often require significant volumes of water over short periods of time during initial field wet-up (Brad Arnold, personal communication).

Conveyance and Delivery Along Stream Channels

As described in the hydrology chapter, water agencies deliver flows via a complex network of reservoirs, canals, natural channels, dams, and diversions. A substantial length of Coon Creek and its tributaries currently serves as a component of NID and SSWD's conveyance and delivery pathways which results in both greater spatial and temporal variability of in-stream flows, particularly during the irrigation season, compared to pre-disturbance conditions. In many cases flow paths that utilize natural stream channels are the only existing pathways to deliver water to many customers.

Meeting Water Demand

In order for water agencies to reliably meet customer demand, they must err on the side of over-providing water to ensure that no customer is left without water. Water loss along canals varies daily and seasonally based on groundwater interactions, evapotranspiration rates, riparian water user demands, unauthorized pumping, and other factors. Instantaneous water demand can be variable due to inconsistent diversion or pumping of water by customers and riparian water right holders.

Alternative Water Sources

In addition to utilizing surface water, many farmers in the watershed rely on groundwater pumping to meet at least a portion of their water demand. However, groundwater pumping is generally more expensive (due to the energy required to pump the water) and can typically only be drawn at a lesser flow rate than surface water can be diverted from a stream. Additionally, some water users have constructed ponds to store water, enabling them to pump large volumes of water from Coon Creek and its tributaries over certain, and often shorter, durations and then use that water as needed over a longer period.

Return Water

Many farmers, particularly rice growers, discharge water when draining their fields thereby increasing stream flow at certain times of the year. Return flows can also reach the creek via subsurface pathways. The volume of return flows from rice fields is especially pronounced during the late irrigation season (August and September). Unlike flows added by water management agencies, the volumes of return flows are difficult to predict or quantify.

Inter-Annual Variability in Water Supplies

California's climate is characterized by a high degree of inter-annual variability in precipitation amounts and water supply. During periods of drought, water supplies are limited and it is not uncommon for at least some water demand to go unfulfilled. As a result, less flow is often conveyed along Coon Creek during periods of extended drought conditions (e.g., 2015 irrigation season) while more flow is conveyed along Coon Creek when water supplies are more abundant.

Environmental Considerations

Prior to human intervention, much of Coon Creek and its tributaries likely functioned as intermittent streams (described in more detail in Chapter 7). However, many of the aquatic and riparian species currently inhabiting these streams have become adapted to the perennial flow conditions that are now present, or perennial flow conditions have allowed certain species to colonize the watershed and persist when they would have been unable to do so under unaltered intermittent flow conditions. Additionally, flow conveyance along certain reaches results in localized areas of colder water that may have both unintended benefits (e.g., extending thermal suitability for juvenile salmonid rearing later into the spring and summer) and disturbances (e.g., delayed migration of emigrating juvenile salmonids and exposure to stressful or lethal thermal barriers downstream). Any changes to flow management practices intended to improve habitat conditions must consider the dependence of species on present-day practices as well as unintended benefits and disturbances.

Potential Flow Management Modification Concepts Requiring Further Exploration

Modifying the reliance on natural stream channels to convey irrigation water and flow deliveries could be pursued for a number of different benefits. An overall decrease or increase in reliance on conveyance along stream reaches across the watershed could be explored. These changes could also be explored with respect to seasons or specific salmonid life stages. The feasibility of reducing spatial or temporal variability of flows should also be explored. Some of these concepts and specific examples are discussed in greater detail below. Any conveyance modifications could require permits or other authorizations from State and Federal agencies along with the cooperation of water districts and water consumers relying on conveyances within the watershed. They may also require modifications to diversion and canal infrastructure and additional flow gauging infrastructure.

<u>1. Reduce Reliance on Surface Water Conveyance During Salmonid Emigration Period</u>

A feasibility analysis could be conducted to evaluate reducing reliance on surface water for irrigation purposes during some or all of the emigration period for juvenile fall-run Chinook salmon that currently coincides with the irrigation season (likely early/mid-April through mid-June). Alternative water sources might include groundwater and surface water stored in off-channel impoundments. These off-channel storage features could be fed by rainwater, concentration of water along natural drainages (e.g., a pond located along an existing drainage pathway), and/or pumping earlier in the season. This reduced reliance on stream diversions before June (or delaying diversion as long as feasible) could reduce the likelihood of entrainment of juvenile salmonids in diversions or extractions. However, if reduced or delayed diversions and extractions also resulted in reduced stream flow (i.e., water delivery is not adjusted accordingly), there could be unintended negative effects such as increased stream temperatures, reduced physical habitat area and formation of flow-dependent downstream migration barriers.

2. Increase Conveyance Along Stream Reaches

Conversely, opportunities could be explored to increase conveyance along stream reaches to provide greater continuity in flow rates between Coon Creek's headwaters and its outlet. A feasibility study could be conducted to determine if flows could be released in the upper watershed (perhaps by NID or PG&E) and conveyed to customers near the outlet of the system (likely those within SSWD's purview or just upstream of the Placer-Sutter County boundary). This greater continuity in flow would likely provide cooler temperatures throughout the anadromous reaches of the watershed, enhance passage of emigrating juveniles and increase physical habitat area. However, it would also likely require inter-agency coordination and flow delivery, which has become less common in the watershed in recent years (Brad Arnold, personal communication), and possibly the relocation downstream of major diversions and extractions.

3. Reduce Spatial Variability of Flows

Flow management practices currently drive significant changes in flow rates longitudinally along stream channels. An example of a rapid change in flow rates along Coon Creek occurs at the Camp Far West Diversion. During the summer, flows above the diversion may be in the 20-30 cfs range (consisting largely of conveyance flows), while flows downstream of the diversion may be less than 1 or 2 cfs. An effort could be pursued to specifically convey the same flows past the dam (along Coon Creek rather than the Camp Far West Canal) that are ultimately spilled from the canal back into Coon Creek via NID's #10 spill several miles downstream. Conveying these flows along Coon Creek instead of the Camp Far West Canal would increase in-stream flows during the irrigation season, which could potentially provide cooler stream temperatures and greater physical habitat area along this reach Figure 73. This could benefit juvenile salmonids by extending the thermally-suitable rearing window along this reach. However, as mentioned in the environmental considerations section above, it could also delay juvenile emigration such that juveniles leave later in the season when downstream water temperatures are actually more likely to be lethal. This change would also subject these conveyed flows to greater levels of groundwater interaction than occurs along the Camp Far West Canal.

4. Reduce Temporal Variability of Flows

Actions could also be pursued to reduce the temporal variability of stream flows along Coon Creek and its tributaries. As described in the disturbance chapter and observed in Figure 39, there is a significant and unnatural degree of day-to-day variability in flow rates during the irrigation season. A feasibility analysis could investigate opportunities to create a more natural spring and summer hydrograph by coordinating water deliveries, abstractions and return flow timing in a manner that reduces day-to-day variability of flows. Additionally, this analysis could evaluate potential for providing more gradual transitions in flow rates such that flows are ramped up or down over longer periods of time.

5. Preferentially Convey Colder Flows Along Stream Reaches

Temperature monitoring of canal water could be conducted to identify relative temperature differences among canals used to deliver flows to Coon Creek and its tributaries. If significant variability in temperatures exist, further feasibility analysis could be performed to evaluate whether colder canal water could be preferentially conveyed along the stream network while warmer canal flows are kept out

of natural stream channels. As discussed above, these cooler temperatures could provide both benefits and unintended negative effects to juvenile salmonids.

6. Adjust Flow Management to Reduce Non-Native Predatory Fish Populations

Native fish species are generally better adapted to the natural hydrology of California's streams than many non-native predatory fish species. A feasibility analysis could evaluate the potential for coordinating flow management activities to provide periods of little to no flow during the late summer (as would likely have naturally occurred in the watershed) to help reduce the abundance of non-native aquatic predators. This may also support native riparian vegetation by impacting non-native plant species that have benefited from unnatural augmented summer flows.

8.2 PRIORITIZED STRATEGIES AND PROJECTS

Following the opportunity identification and prioritization process, a subset of the highest-priority basin-scale strategies and individual projects were selected for further development in project sheets. The project sheets provide more detailed information on existing conditions, strategy or project descriptions, anticipated benefits and potential constraints. They also include photos, maps and concept sketches to further communicate the strategy or project components. The project sheets were developed for the following fourteen opportunities (not listed in any order of priority; corresponding individual project opportunity numbers from Table 24 and Figure 74 are provided in parentheses after project name):

Basin-Scale Strategies

- Channel and Floodplain Rehabilitation Strategies
- Riparian Corridor Enhancement
- Strategies for Improving Juvenile Salmonid Rearing Success
- Strategies for Improving Juvenile Salmonid Emigration Success
- Biotechnical Bank Stabilization
- Voluntary Land Management Programs

Individual Projects

- Coppin Dam and Auburn Extension Diversion Retrofit (17)
- Lower Coon Creek Floodplain Rehabilitation - Placer County (10)
- Lower Coon Creek Channel and Floodplain Rehabilitation - Sutter County (11)
- Lower Coon Creek Channel and Floodplain Rehabilitation - Placer County (12)
- Sundance-Lakeview Farms Rehabilitation Site Enhancement (13)
- Channel and Floodplain Rehabilitation Project - Middle Coon Creek (15)
- Doty Ravine South at Head Diversion Dam Retrofit (18)
- Garden Bar Road Culvert Replacement (19)

It should also be noted that the project sheets are not intended to be an exhaustive list of the high-priority projects within the Coon Creek watershed. There are many other opportunities that would significantly benefit the watershed. Additionally, it is important to note that the projects presented in the following sheets are intended to be concept-level only and have not been reviewed with relevant land owners or managers. Further assessment will be required to evaluate constraints, project feasibility, design details, permitting and project scope. Cost estimates provided in the sheets indicate order of magnitude cost only. A range of costs is provided when there exists a significant range in project size, construction and land acquisition costs, and scale of implementation.

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Channel and Floodplain Rehabilitation Strategies

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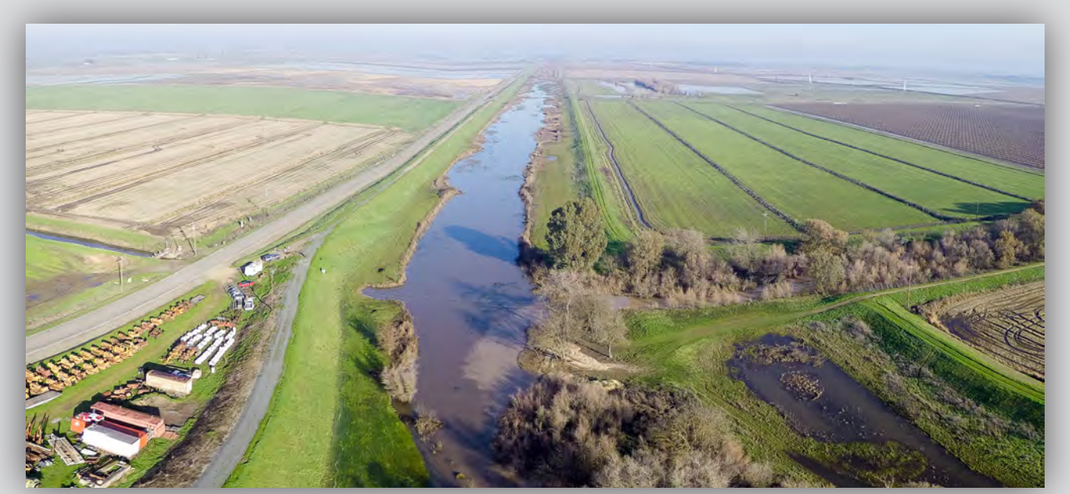

Aerial view of East Side Canal, looking north. Photo by Scott Walls, cbec.

COON CREEK WATERSHED

OVERVIEW OF CHANNEL AND FLOODPLAIN DISTURBANCES

- **Channel Straightening and Realignment:** In the middle and lower portions of the Coon Creek watershed, the natural stream channel has been straightened and realigned along a significant portion of its length for agriculture, drainage, cattle grazing and mining. This has resulted in sub-optimal channel conditions, altered channel geometry, and impaired physical processes. It has also affected reach-scale hydraulics by considerably shortening stream length along some reaches. The most substantial impact is the interception of lower Coon Creek by the East Side Canal.
- **Levee and Berm Construction:** Low-height berms alongside Coon Creek and Doty Ravine as well as larger levees along the East Side Canal currently reduce floodplain connectivity in many locations and may promote incision.
- **Floodplain Grading:** Floodplain topographic complexity has been dramatically reduced by grading practices (mostly for agriculture), which has impaired physical processes, reduced habitat complexity and quality, and lessened floodwater retention in areas.
- **Channel Incision:** Channel incision has reduced floodplain connectivity and in-channel habitat quality along a number of stream reaches in the middle and lower watershed.
- **Excessive Bank Erosion:** Exacerbated levels of bank erosion and fine sediment loading exist along some reaches due to historical channel realignment, cattle poaching and intensive riparian vegetation management.

Eroding bank along Coon Creek. Photo by Jai Singh, cbec.

Channel conditions in the East Side Canal. Photo by Jai Singh, cbec.

SUMMARY OF STRATEGIES

The following strategies can be used to rehabilitate the stream channels, floodplains and physical process regime of the lower and middle Coon Creek watershed. At nearly all identified sites, a combination of multiple strategies are advisable to achieve maximum uplift of the stream system.

Channel Rehabilitation Measures

- Channel Form Rehabilitation
- Channel Meander Reconnection
- Channel Reprofiling
- Large Wood Reintroduction
- Biotechnical Bank Stabilization
- Riparian Vegetation Enhancement

Floodplain Rehabilitation Measures

- Secondary Channel Enhancement / Creation
- Berm Removal, Notching and Setbacks
- Floodplain Re-contouring
- Floodplain Lowering

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Channel and Floodplain Rehabilitation Strategies

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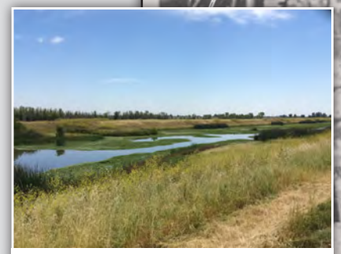
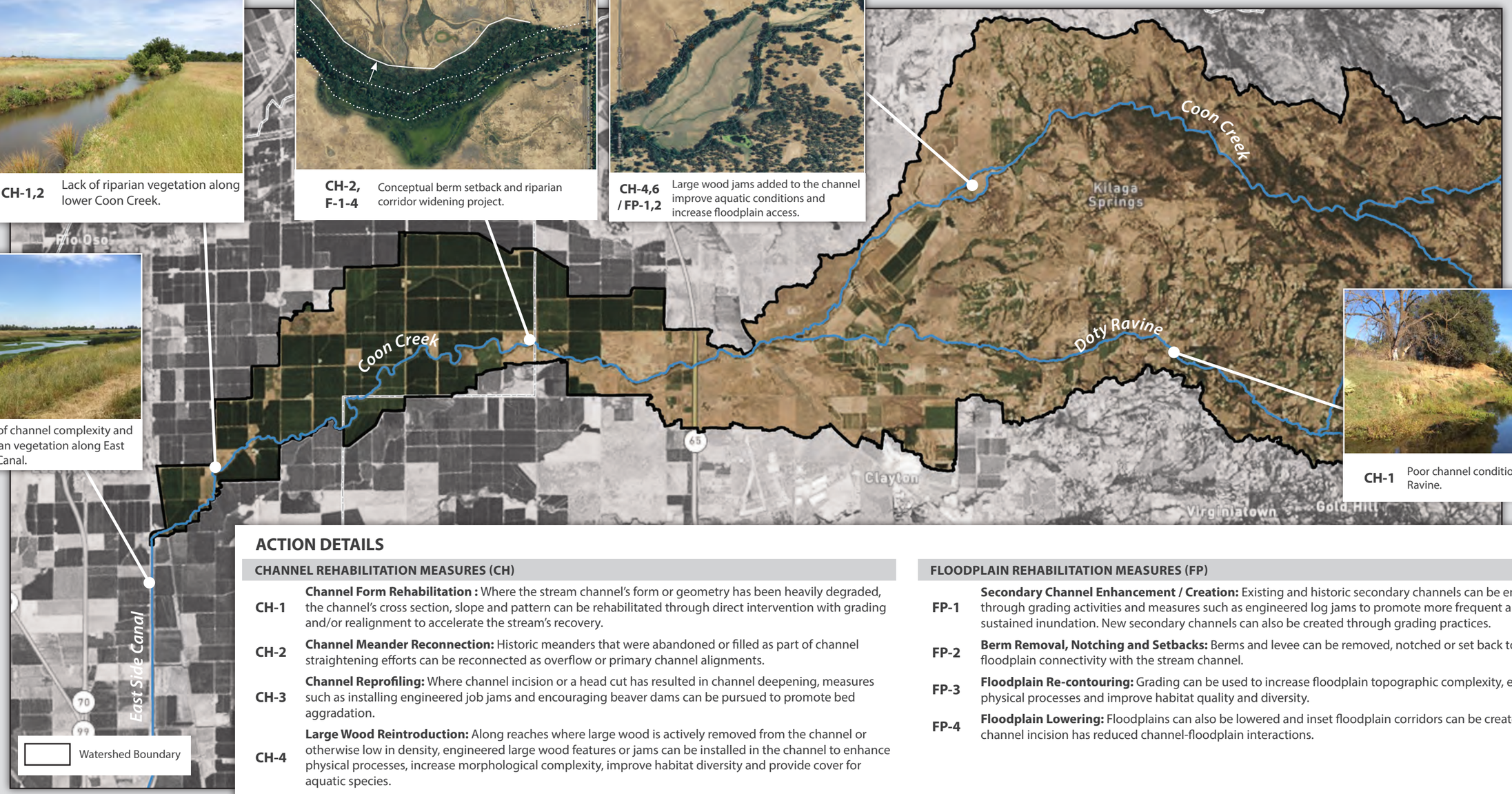
CH-1,2 Lack of riparian vegetation along lower Coon Creek.

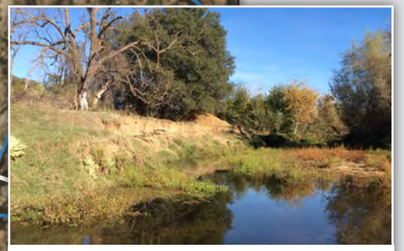
CH-2, F-1-4 Conceptual berm setback and riparian corridor widening project.

CH-4,6 / FP-1,2 Large wood jams added to the channel improve aquatic conditions and increase floodplain access.



CH-1 Lack of channel complexity and riparian vegetation along East Side Canal.





CH-1 Poor channel conditions along Doty Ravine.

ACTION DETAILS

CHANNEL REHABILITATION MEASURES (CH)

CH-1 **Channel Form Rehabilitation :** Where the stream channel's form or geometry has been heavily degraded, the channel's cross section, slope and pattern can be rehabilitated through direct intervention with grading and/or realignment to accelerate the stream's recovery.

CH-2 **Channel Meander Reconnection:** Historic meanders that were abandoned or filled as part of channel straightening efforts can be reconnected as overflow or primary channel alignments.

CH-3 **Channel Reprofiling:** Where channel incision or a head cut has resulted in channel deepening, measures such as installing engineered job jams and encouraging beaver dams can be pursued to promote bed aggradation.

CH-4 **Large Wood Reintroduction:** Along reaches where large wood is actively removed from the channel or otherwise low in density, engineered large wood features or jams can be installed in the channel to enhance physical processes, increase morphological complexity, improve habitat diversity and provide cover for aquatic species.

CH-5 **Biotechnical Bank Stabilization:** Where bank erosion has been driven by direct anthropogenic influences (e.g., cattle poaching), biotechnical bank stabilization methods can be used to restabilize stream banks.

CH-6 **Riparian Vegetation Enhancement:** Re-vegetating the stream banks and riparian corridor can help stabilize and rehabilitate some portions of lower Coon Creek and the East Side Canal.

FLOODPLAIN REHABILITATION MEASURES (FP)

FP-1 **Secondary Channel Enhancement / Creation:** Existing and historic secondary channels can be enhanced through grading activities and measures such as engineered log jams to promote more frequent and sustained inundation. New secondary channels can also be created through grading practices.

FP-2 **Berm Removal, Notching and Setbacks:** Berms and levee can be removed, notched or set back to increase floodplain connectivity with the stream channel.

FP-3 **Floodplain Re-contouring:** Grading can be used to increase floodplain topographic complexity, enhance physical processes and improve habitat quality and diversity.

FP-4 **Floodplain Lowering:** Floodplains can also be lowered and inset floodplain corridors can be created where channel incision has reduced channel-floodplain interactions.

Coon Creek Watershed Assessment

Riparian Corridor Enhancement

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Aerial view of lower Coon Creek with a discontinuous riparian corridor. Photo by Scott Walls, cbec.

COON CREEK WATERSHED

Summary of Challenges: Riparian habitat is of moderate to poor quality along much of the middle and lower portions of the Coon Creek watershed due to both historical and present-day disturbances.

- **Channel and Floodplain Impacts:** Channel realignment, floodplain grading, berms and levees, channel incision and management of riparian habitat have both directly degraded riparian habitat conditions and impaired physical processes that sustain healthy riparian habitat areas.
- **Inadequate Riparian Buffer Width and Continuity:** The width and continuity of the riparian corridor have been reduced by agricultural encroachment, vegetation management, roads, canals, and levees. The riparian corridor is fragmented and lacks connectivity, which is important to wildlife.
- **Maturity / Quality of Riparian Corridor:** Non-native vegetation, soil disturbance, and soil compaction have reduced the quality of the riparian corridor by creating conditions that do not favor the natural regeneration of native plant communities and the development of structurally complex and unevenly-aged stands of riparian forest.
- **Lack of Native Woody Riparian Vegetation:** Residential development, construction of infrastructure, cultivation of crops, and livestock grazing have resulted in the removal of native woody riparian vegetation in many parts of the watershed. Vegetation removal reduces riparian canopy cover, stream shading, ecosystem productivity, groundwater/surface water interactions, wildlife habitat quality, and water quality.
- **Invasive Species:** Invasive plant species occur throughout the watershed. Many of these species degrade aquatic and riparian habitats by altering ecosystem processes, displacing native plants, and diminishing wildlife habitat.
- **Livestock Impacts:** Unrestricted livestock access to the riparian corridor degrades riparian vegetation and exacerbates bank erosion along a number of reaches of Coon Creek and Doty Ravine.

Narrow discontinuous riparian corridor along lower Coon Creek. Photo by Jai Singh, cbec.

Lack of riparian corridor along lower Coon Creek. Photo by Jai Singh, cbec.

SUMMARY OF ACTIONS

Improving Channel and Floodplain Processes

- Channel Form Rehabilitation
- Channel Meander Reconnection
- Channel Reprofiling
- Biotechnical Bank Stabilization
- Floodplain Re-Contouring / Lowering
- Berm Removal, Notching and Setbacks

Improving Riparian Habitat Quality

- Riparian Vegetation and Buffer Enhancement
- Invasive Plant Species Control and Removal

Developing Voluntary Land Management Programs

- Voluntary Cattle Exclusion to Protect Active Channel Corridor
- Voluntary Conservation Easement Program

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Riparian Corridor Enhancement

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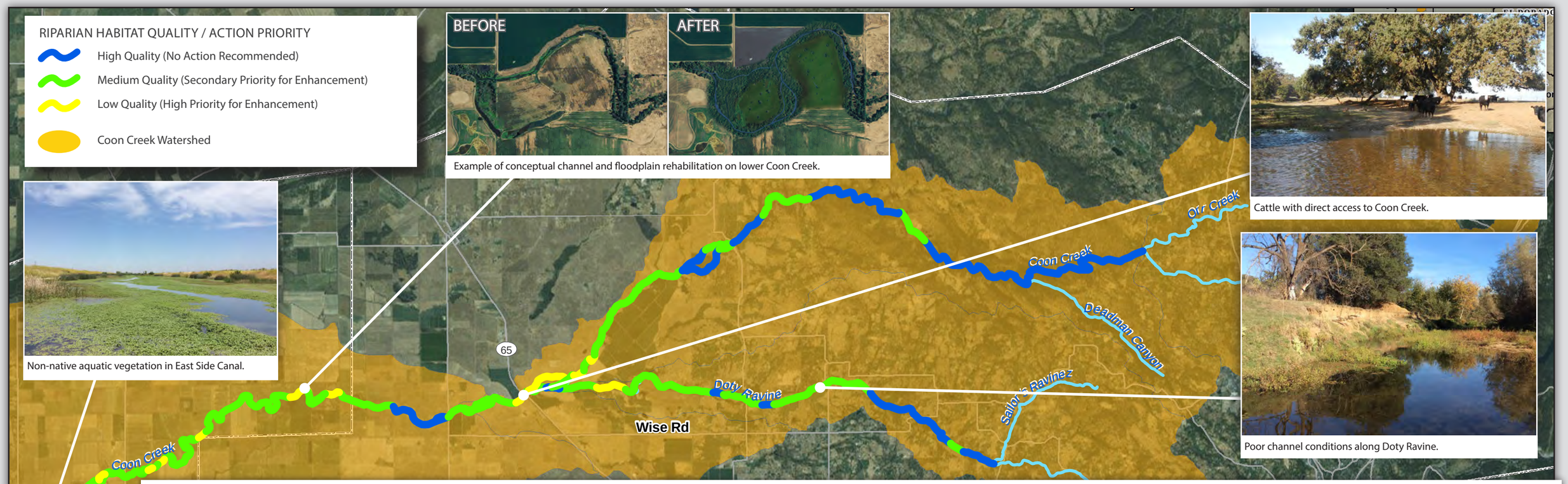

Example of conceptual channel and floodplain rehabilitation on lower Coon Creek.

Non-native aquatic vegetation in East Side Canal.

Cattle with direct access to Coon Creek.

Poor channel conditions along Doty Ravine.

ACTION DETAILS

IMPROVING RIPARIAN HABITAT QUALITY

Riparian Corridor Buffer Enhancement: Both the physical extent and quality of the riparian corridor can be increased through enhancement of physical habitat conditions (e.g., floodplain grading, increasing channel complexity), planting of native riparian trees and shrubs and management of invasive plants. Riparian buffer improvements will also reduce impacts on physical and biological processes by enhancing filtration of nutrients, pesticides and herbicides from agricultural runoff. Increasing the width and continuity of the riparian zone can also improve habitat suitability for a wider variety of riparian-dependent wildlife.

Native Riparian Trees and Shrubs: Habitat restoration throughout the riparian corridor would provide excellent opportunities to establish high-quality riparian forest, riparian woodland, and oak savanna. A variety of locally-native riparian trees and shrubs could be planted to maximize habitat values and the structural diversity of each restoration site. The plants used would come from propagules (seeds, acorns, cuttings) that originate from the watershed in the vicinity of each site to ensure that the plants are adapted to local conditions and to protect the genetic integrity of these species' local populations.

Invasive Plant Species Control and Removal: Areas with dense infestations of invasive plants could be treated to reduce, or eliminate, these species, and native species could be planted to deter re-colonization of treatment locations by invasive plants. Efforts to manage invasive plants on private lands could be funded through local, voluntary programs or through cooperating parties, such as the Nevada-Placer Weed Management Area.

IMPROVING CHANNEL AND FLOODPLAIN PROCESSES

Channel and Floodplain Habitat Rehabilitation: A wide range of strategies can be implemented that can either directly or indirectly improve riparian habitat conditions by enhancing physical processes and the condition of the stream corridor. Specific examples include channel form rehabilitation, channel meander reconnection, channel reprofiling, biotechnical bank stabilization, floodplain re-contouring / lowering and berm removal, notching and setbacks. More details and examples are provided on the accompanying "Channel and Floodplain Rehabilitation Strategies" project sheet.

DEVELOPING VOLUNTARY LAND MANAGEMENT PROGRAMS

Voluntary Cattle Exclusion to Protect Active Channel Corridor: A local, voluntary conservation program could be implemented, in conjunction with similar state and federal government programs, such as the NRCS's EQIP program, to provide financial and technical support for landowners willing to implement fish-friendly cattle ranching practices (e.g., cattle exclusion fencing, off-stream water sources, cattle crossings). These practices would reduce cattle impacts on the riparian zone, improve fish habitat, and improve water quality.

Voluntary Conservation Easement Program for Riparian Corridor: A voluntary conservation easement program could be implemented to collaborate with landowners and limit the use of lands in order to protect, enhance, and restore riparian habitat values, such as corridor width and continuity and ecosystem functions.

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Strategies for Improving Juvenile Salmonid Rearing Success

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Aerial view of inundated rice fields adjacent to Coon Creek. Photo by Scott Walls, cbec.

COON CREEK WATERSHED

Summary of Challenges: The successful rearing of juvenile salmonids in the Coon Creek watershed has been affected by both historical and present-day disturbances:

- **Floodplain Impacts:** Prior to human disturbance, the lower portions of the Coon Creek watershed likely provided significant floodplain rearing opportunities to juvenile salmonids, including areas downstream (west) of the East Side Canal. Today's floodplain grading, drainage infrastructure and levees, however, severely limit the quality, quantity and duration of availability of off-channel floodplain habitat for juvenile salmonids, which in turn limits food availability and growth potential.
- **Channel Impacts:** In-channel habitat conditions have been degraded due to channel straightening, intensive riparian vegetation management and agriculture, decline in natural large wood loading, and excessive bank erosion and fine sediment production due to human disturbances.
- **Mortality Due to Unscreened Diversions and Pumps:** While mortality of juvenile salmon due to entrainment at unscreened diversions and pumps has not been quantified, field observations suggest that some portion of the juvenile salmonid population succumbs to unscreened diversions and pumps.
- **Anthropogenic Migratory Barriers:** Juvenile Chinook salmon and steelhead often migrate considerably throughout a stream network during their rearing life phase to exploit various habitat conditions (e.g., food sources, temperature/thermal refugia, etc.). However, several anthropogenic barriers currently limit this natural movement in the Coon Creek watershed.
- **Water Quality and Quantity Impairment:** Today, salmonids may be affected by occasional presence of pesticides, high levels of fecal coliform, excess nitrate and warm stream temperatures. In some locations, rapid changes in flows, both temporally and spatially, due to flow management practices may affect rearing juveniles.
- **Mortality Due to Predation:** Mortality of juveniles due to predation has likely increased significantly due to introduction of non-native predatory fish and loss of cover resulting from degradation of aquatic habitat and management of riparian vegetation.

Cattle with direct access to Coon Creek. Photo by Jai Singh, cbec.

Incised channel with lack of riparian forest in lower Coon Creek. Photo by Jai Singh.

SUMMARY OF ACTIONS:

Improving Availability and Quality of Floodplain Rearing Habitat
- Floodplain Habitat Rehabilitation
- Multi-Objective Floodplain Use

Improving In-Channel Habitat Quality and Cover
- Reestablishing Riparian Vegetation and Canopy
- Large Wood Reintroduction
- Excluding Cattle From Stream Channel
- Reducing Excessive Fine Sediment Loading

Addressing Unscreened Diversions and Pumps
- Doty South Diversion Dam Fish Screen
- Install Screens on Unscreened Irrigation Pumps

Addressing Anthropogenic Migratory Barriers
- Doty South Diversion Dam Passage Improvements
- Garden Bar Road Culvert Replacement
- Private Seasonal Dams

Improving Water Quality and Quantity
- Reducing Contamination and Stream Temperatures
- Flow Management Enhancement

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Coon Creek Watershed Assessment

Strategies for Improving Juvenile Salmonid Rearing Success

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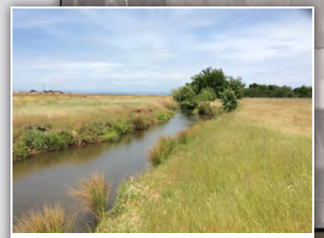
FP-2 Juvenile salmonids before (left) and after (right) winter rearing in rice fields.

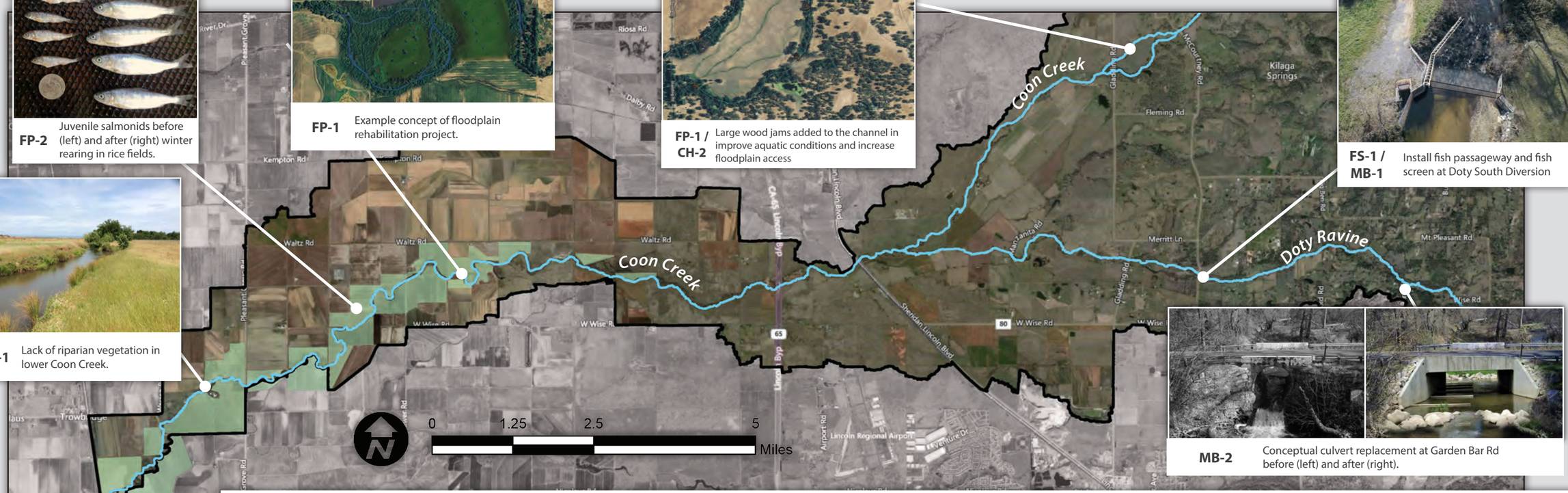
FP-1 Example concept of floodplain rehabilitation project.

FP-1 / CH-2 Large wood jams added to the channel in improve aquatic conditions and increase floodplain access

FS-1 / MB-1 Install fish passageway and fish screen at Doty South Diversion



CH-1 Lack of riparian vegetation in lower Coon Creek.



MB-2 Conceptual culvert replacement at Garden Bar Rd before (left) and after (right).

ACTION DETAILS

IMPROVING AVAILABILITY AND QUALITY OF FLOODPLAIN REARING HABITAT (FP)

FP-1 **Floodplain Habitat Rehabilitation:** Recommended rehabilitation options for improving floodplain habitat quality, access and duration of inundation include berm removal/notching, floodplain grading, and overflow channel creation / enhancement.

FP-2 **Multi-Objective Floodplain Use:** Fields can be managed as floodplain rearing habitat for juvenile salmonids during the winter and early spring months, while still used for rice production from mid-spring through early fall. These practices have generated exceptional growth rates in juvenile salmon in the Yolo Bypass (Katz et al. 2013).

IMPROVING IN-CHANNEL HABITAT QUALITY AND COVER (CH)

CH-1 **Reestablishing Riparian Vegetation and Canopy:** The riparian corridor along stream reaches featuring little to no riparian vegetation or canopy can be enhanced to increase width and improve habitat quality

CH-2 **Large Wood Reintroduction:** Engineered large wood jams can be installed along stream reaches currently lacking large wood to promote healthy physical processes and improve aquatic habitat conditions.

CH-3 **Excluding Cattle From Stream Channel:** Livestock can be excluded from the stream channel with exclusion fencing, off-channel water sources and crossings

CH-4 **Reducing Excessive Fine Sediment Loading:** Unnaturally high levels of bank erosion attributable to human disturbances (e.g., historic mining, channelization, cattle poaching) can be addressed with biotechnical bank stabilization methods, channel rehabilitation efforts and changes in land management practices.

ADDRESSING UNSCREENED DIVERSIONS AND PUMPS (FS)

FS-1 **Doty South Diversion Dam Fish Screen:** Screening this diversion will eliminate the risk of mortality associated with entraining juvenile salmon in the Doty South Canal system.

FS-2 **Install Screens on Unscreened Irrigation Pumps:** Fish screens can be installed on unscreened irrigation pumps to prevent mortality of rearing juveniles

ADDRESSING ANTHROPOGENIC MIGRATORY BARRIERS (MB)

MB-1 **Doty South Diversion Dam Passage Improvements:** An engineered fish passageway and associated flows can provide both upstream and downstream across a broader range of flow conditions.

MB-2 **Garden Bar Road Culvert Replacement:** Replacing the culvert will enable upstream passage of rearing juveniles at what is otherwise likely a complete upstream migration barrier for juvenile salmonids.

MB-3 **Private Seasonal Dams:** Several seasonal dams along agricultural and ranching portions of the stream could be physically modified or managed differently (e.g., installed later in irrigation season) to reduce impacts on rearing juveniles

IMPROVING WATER QUALITY AND QUANTITY (WQ)

WQ-1 **Reducing Contamination and Stream Temperatures:** Actions such as riparian buffer enhancement can improve canopy cover and shading (thereby reducing stream temperatures) and also decrease pollutant loading from stormwater run-off.

WQ-2 **Flow Management Enhancement:** Flow management practices can be implemented to provide greater temporal and spatial continuity of flows along natural stream channels.

Coon Creek Watershed Assessment

Strategies for Improving Juvenile Salmonid Emigration Success

cbec eco engineering with H.T. HARVEY & ASSOCIATES Ecological Consultants FOR COUNTY OF Placer

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Coppin flashboard dam on East Side Canal. Photo by Jai Singh, cbec.

COON CREEK WATERSHED

Summary of Challenges: The successful emigration of juvenile salmonids in the Coon Creek watershed has been affected by both historical and present-day disturbances:

- **Floodplain Impacts:** Floodplain grading, levees and drainage infrastructure severely limit the quality and duration of availability of off-channel floodplain habitat for juvenile salmonids, which in turn reduce the number of emigration pathways available to juvenile salmon and likely increases mortality rates from predation.
- **Channel Impacts:** In-channel habitat conditions have been degraded due to channel straightening, intensive riparian vegetation management and agriculture, and decline in natural large wood loading, which may affect emigrating juveniles because of worsened water quality and lack of cover from predators.
- **Mortality Due to Unscreened Diversions and Pumps:** While mortality of juvenile salmon due to entrainment at unscreened diversions and pumps has not been quantified, field observations suggest that some portion of the juvenile salmonid population are entrained by unscreened diversions and pumps.
- **Anthropogenic Migratory Barriers:** Several anthropogenic barriers may inhibit successful juvenile emigration from the Coon Creek watershed, particularly once the irrigation season has commenced.
- **Water Quality and Quantity Impairment:** Warm stream temperatures, which have been exacerbated along some reaches by human disturbances and flow management, likely inhibit successful emigration during the late spring and summer. In some locations, lack of flow or rapid changes in flows (both temporally and spatially) due to flow management practices may affect emigrating juveniles.
- **Mortality Due to Predation:** Mortality of emigrating juveniles due to predation has likely increased significantly due to introduction of non-native predatory fish and loss of cover resulting from degradation of aquatic habitat and management of riparian vegetation.

Wicket-gate dam on Doty Ravine at Doty South Diversion. Photo by Jai Singh, cbec.

Fish screen on instream diversion pipe. Photo by Washington Dept. of Fish and Wildlife.

SUMMARY OF ACTIONS:

Improving Availability and Quality of Floodplain Habitat
- Floodplain Habitat Rehabilitation

Improving In-Channel Habitat Quality and Cover
- Reestablishing Riparian Vegetation and Canopy
- Large Wood Reintroduction

Addressing Unscreened Diversions and Pumps
- Doty South Diversion Dam Fish Screen
- Fish Screen on Auburn Extension Canal Diversion at Coppin Dam
- Install Screens on Unscreened Irrigation Pumps

Addressing Anthropogenic Migratory Barriers
- Doty South Diversion Dam Passage Improvements
- Private Seasonal Dams

Improving Water Quality and Quantity
- Reducing Contamination and Stream Temperatures
- Flow Management Enhancement

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Coon Creek Watershed Assessment

Strategies for Improving Juvenile Salmonid Emigration Success

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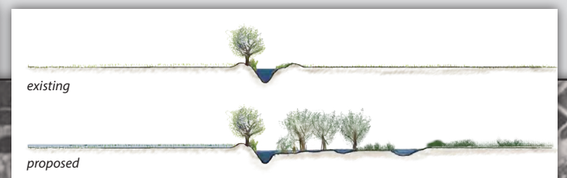
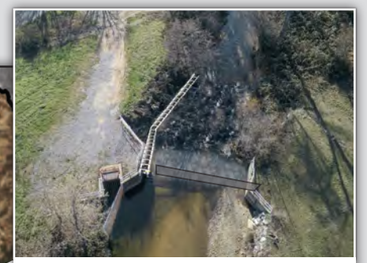
CH-1 Lack of riparian vegetation in lower Coon Creek.



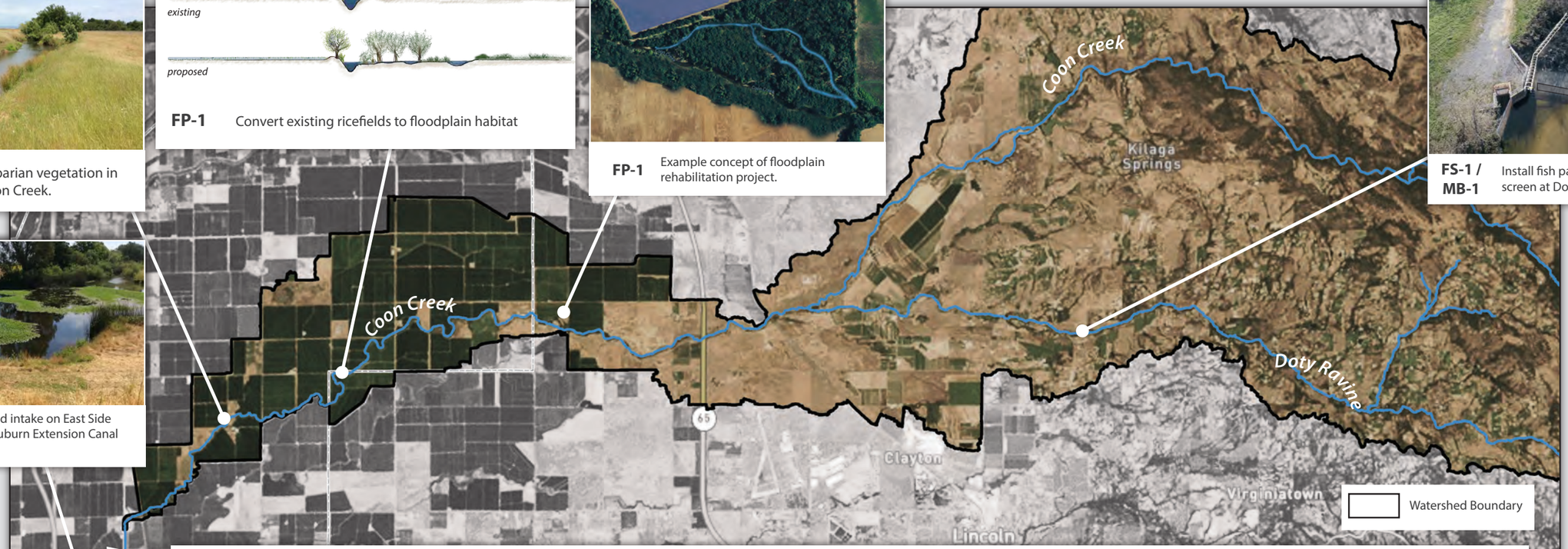
FP-1 Convert existing ricefields to floodplain habitat

FP-1 Example concept of floodplain rehabilitation project.



FS-1 / MB-1 Install fish passageway and fish screen at Doty South Diversion

FS-2 Unscreened intake on East Side Canal at Auburn Extension Canal intake.



ACTION DETAILS

IMPROVING AVAILABILITY AND QUALITY OF FLOODPLAIN REARING HABITAT (FP)

FP-1 **Floodplain Habitat Rehabilitation:** Recommended rehabilitation options for improving floodplain habitat quality, access and duration of inundation include berm removal/notching, floodplain grading, and overflow channel creation / enhancement.

IMPROVING IN-CHANNEL HABITAT QUALITY AND COVER (CH)

CH-1 **Reestablishing Riparian Vegetation and Canopy:** The riparian corridor along stream reaches featuring little to no riparian vegetation or canopy can be enhanced to increase width and improve habitat quality.

CH-2 **Large Wood Reintroduction:** Engineered large wood jams can be installed along stream reaches currently lacking large wood to promote healthy physical processes and improve aquatic habitat conditions.

ADDRESSING UNSCREENED DIVERSIONS AND PUMPS (FS)

FS-1 **Doty South Diversion Dam Fish Screen:** Screening this diversion will eliminate the risk of mortality associated with entraining juvenile salmon in the Doty South Canal system.

FS-2 **Fish Screen on Auburn Extension Canal Diversion at Coppin Dam:** Installing a fish screen on Auburn Extension Canal Diversion will eliminate a significant entrainment threat to emigrating juveniles from Coon Creek, Markham Ravine and Auburn Ravine.

FS-3 **Install Screens on Unscreened Irrigation Pumps:** Fish screens can be installed on unscreened irrigation pumps to prevent mortality of emigrating juveniles.

ADDRESSING ANTHROPOGENIC MIGRATORY BARRIERS (MB)

MB-1 **Doty South Diversion Dam Passage Improvements:** An engineered fish passageway and associated flows can provide both upstream and downstream across a broader range of flow conditions.

MB-2 **Private Seasonal Dams:** Several seasonal dams along agricultural and ranching portions of the stream could be physically modified or managed differently (e.g., installed later in irrigation season) to reduce impacts on emigrating juveniles.

IMPROVING WATER QUALITY AND QUANTITY (WQ)

WQ-1 **Stream Temperature Improvement:** Actions such as riparian buffer enhancement can improve canopy cover and shading, thereby reducing stream temperatures.

WQ-2 **Flow Management Enhancement:** Flow management practices can be implemented to provide greater temporal and spatial continuity of flows along natural stream channels to support successful emigration.

Coon Creek Watershed Assessment

Biotechnical Bank Stabilization

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Severely eroding stream bank along Coon Creek . Photo by Jai Singh, cbec.

COON CREEK WATERSHED

Overview of Challenges: A combination of historic and ongoing disturbances drive excessive levels of bank erosion along many reaches of Coon Creek and Doty Ravine, particularly in the middle and lower watershed. This increased occurrence and severity of bank erosion exacerbates fine sediment loading to the channel, degrades channel conditions and drives change in channel alignment and form. Excessive bank erosion in the Coon Creek watershed is driven by unrestricted livestock access to the stream channel, intensive riparian vegetation management, historic channel realignment and channel incision.

Eroding bank along Coon Creek. Photo by Jai Singh, cbec.

Biotechnical Bank Stabilization: Where bank erosion has been driven by direct anthropogenic influences (e.g., unrestricted livestock access to the channel), biotechnical bank stabilization methods can be used to re-stabilize stream banks. Biotechnical bank stabilization refers to using environmentally sensitive techniques to address bank erosion while also improving stream habitat complexity and diversity, providing cover and shade, increasing substrate complexity and enhancing riparian habitat and functions. Example methods include live staking, brushlayering, installing coir netting, longitudinal stone toe protection, live siltation, and installing large wood features.

Eroding bank along Coon Creek. Photo by Jai Singh, cbec.

Potential Biotechnical Bank Stabilization Techniques:

Several of these techniques are often combined at a single site to achieve the desired bank stabilization outcome. These techniques are often preceded by or combined with grading activities to lessen the slope of on eroding stream bank. Where unrestricted livestock access to a stream has resulted in bank erosion, bank stabilization techniques should be complemented with cattle exclusion measures.

- Live Staking
- Live Brush Layering
- Live Fascine
- Coir Netting
- Longitudinal Stone Toe Protection
- Live Siltation
- Large Wood Structures / Root Wads
- Log Crib Walls
- Coconut Fiber Rolls
- Vegetated Mechanically Stabilized Earth

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Biotechnical Bank Stabilization

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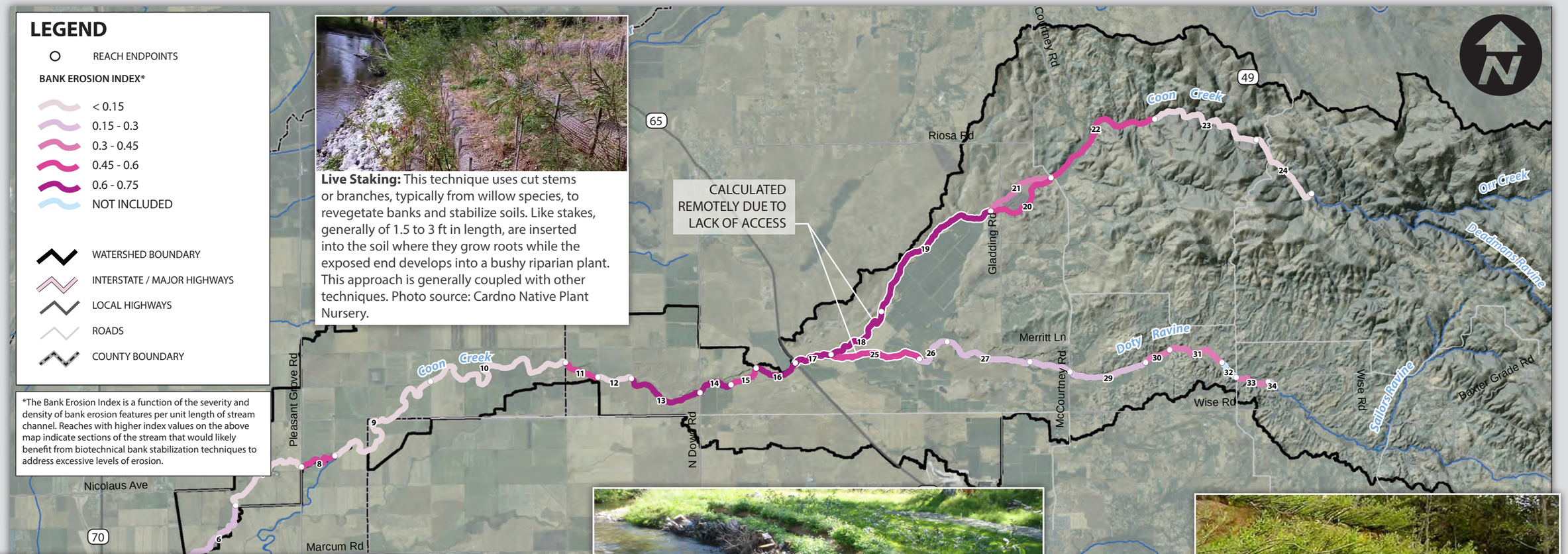
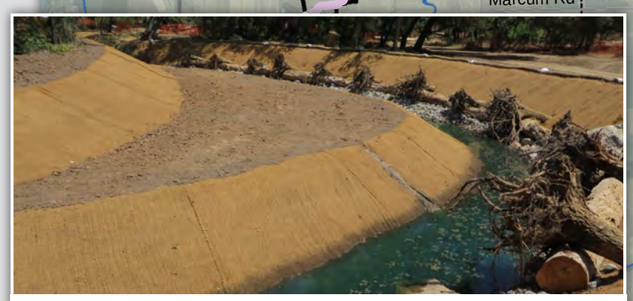
BANK EROSION INDEX MAP AND EXAMPLE BIOTECHNICAL BANK STABILIZATION TECHNIQUE DETAILS



Live Staking: This technique uses cut stems or branches, typically from willow species, to revegetate banks and stabilize soils. Like stakes, generally of 1.5 to 3 ft in length, are inserted into the soil where they grow roots while the exposed end develops into a bushy riparian plant. This approach is generally coupled with other techniques. Photo source: Cardno Native Plant Nursery.



Erosion Control Fabric: Various biodegradable fabrics can be placed on freshly graded stream banks to protect them from scour and erosion while vegetation matures and stabilizes the stream bank. Example fabrics include coir and jute netting.

Large Wood Structures / Root Wads: The trunks and root wads of large-diameter trees can be used to stabilize stream banks, reduce scour and enhance deposition at the toe of the stream bank. In particular, root wads can be placed at the toe of stream bank, such that a tree trunk has been inserted into the bank, supported by a footer log, with the root wad facing the channel, protecting the stream bank and providing aquatic habitat benefits. Photo source: Alaska Sustainable Salmon Fund.

Live Brush Layering: Live brush layering consists of placing alternating layers of live woody cuttings (usually willow, alder or cottonwood) and soil along a reconstructed stream bank. The soil layers can be wrapped in a biodegradable erosion control fabric to enhance the strength of the design (also known as vegetated mechanically stabilized earth).

Coon Creek Watershed Assessment

Voluntary Land Management Programs

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Aerial view of inundated rice fields adjacent to Coon Creek. Photo by Scott Walls, cbec.

COON CREEK WATERSHED

Summary of Challenges: Ongoing land management practices in many locations of the watershed contribute to the degradation of channel conditions and riparian habitat.

- **Unrestricted Livestock Access:** Unrestricted livestock access to the stream channel degrades habitat quality for fish and wildlife and exacerbates bank erosion along a number of reaches of Coon Creek and Doty Ravine. The presence of cattle in the riparian zone likely increases fine sediment, nutrient, and bacteria inputs to the stream and adversely affects anadromous salmonid spawning and rearing habitat.
- **Limited Riparian Buffer Width and Continuity:** Ongoing management and land use practices result in limited riparian buffer width and longitudinal continuity along the stream corridor. This contributes to overall poor riparian habitat quality along much of the middle and lower portions of Coon Creek.
- **Soil Loss from Agricultural Land:** Soil loss from agricultural land driven by surface runoff and floodplain dation is likely increasing sediment loading to the stream, altering sediment dynamics and degrading aquatic habitat.
- **Pollutant Loading from Agricultural Land:** Surface runoff from farm land during precipitation events and discharge of agricultural return water likely increases the loading of various pollutants to Coon Creek including pesticides, nutrients and fine sediment. These pollutants degrade water quality and habitat conditions.
- **Urban Stormwater Discharge:** Urban development increases impervious cover and typically drives greater delivery of surface runoff to streams during precipitation events. While Placer County has recently developed a Low Impact Development (LID) manual that will require on-site stormwater capture for new development, existing development has increased peak flows in Coon Creek, particularly its headwaters around Auburn (i.e. Dry Creek).

Cattle with direct access to Coon Creek. Photo by Jai Singh, cbec.

Cattle path to creek. Photo by Jai Singh.

SUMMARY OF POTENTIAL VOLUNTARY PROGRAMS:

- Cattle Exclusion Program
- Riparian Corridor Conservation Easement Program
- Soil Conservation Best Management Practice Implementation
- Agricultural Runoff Capture and Treatment
- Urban Stormwater Management

Urban stormwater runoff over impervious surfaces.
Source: American Rivers.

Example of agricultural runoff from rainfall.
Source: USDA.

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Coon Creek Watershed Assessment

Voluntary Land Management Programs

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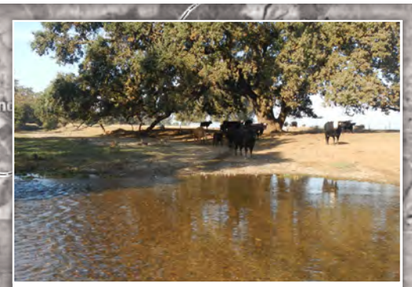
ACTION DETAILS

Agricultural Runoff Capture and Treatment: The installation of agricultural best management practices (BMPs) can be incentivized on private land through a voluntary landowner program. BMPs can include filter strips, riparian buffer enhancement, sediment basins, treatment wetlands, and other features that can detain or filter agricultural runoff before it discharges into a stream.

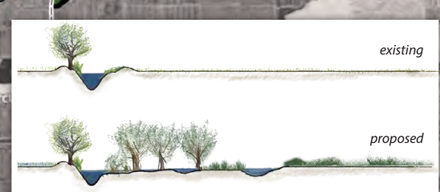
Agricultural BMPs. Source: USDA.



Example of unrestricted livestock access to Coon Creek. Photo by Jai Singh, cbec.

Example of cattle exclusion fencing. Source: luckiamutelwc.org

Cattle Exclusion Program: A local, voluntary conservation program could be implemented, in conjunction with similar state and federal government programs, such as the NRCS's EQIP program, to provide financial and technical support for landowners willing to implement fish-friendly agricultural practices (e.g., cattle exclusion fencing, off-stream water sources, cattle crossings). These practices would reduce cattle impacts on the riparian zone, improve fish habitat, and improve water quality.



Conceptual riparian corridor and floodplain enhancement.

Cover crops and tillage soil conservation techniques. Source: UCANR

Parking lot with LID vegetated swale. Source: West Placer LID Manual

Riparian Corridor Conservation Easement Program: A voluntary conservation easement program could be implemented to collaborate with landowners and limit the use of lands in order to protect, enhance, and restore riparian habitat values, such as corridor width and continuity and ecosystem functions.

Soil Conservation Best Management Practice Implementation: A voluntary, incentivized program (or existing programs) can be used to encourage a large range of soil conservation practices including but not limited to conservation tillage, cover crops, conservation crop rotation, and conservation drainage. These efforts would reduce fine sediment loading and thereby the loading of other sediment-bound pollutants.

Urban Stormwater Management: In addition to requiring stormwater management practices for new development, a voluntary, incentivized program can be implemented to encourage stormwater management retrofits to locally detain and treat stormwater and thereby reduce the effects of hydromodifcation in the upper watershed. This will reduce development's effects on hydrology and physical processes and reduce pollutant loading to Coon Creek.

0 1.25 2.5 5 Miles

Coon Creek Watershed Assessment

Coppin Dam and Auburn Extension Diversion Retrofit

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Aerial view of East Side Canal, looking north, at the confluence with Auburn Ravine and Auburn Extension Canal. Photo by Scott Walls.

Location: Coppin Dam and Auburn Extension Canal Retrofit or Operation Changes

Existing Conditions

Coppin Dam is a seasonal flashboard dam on the East Side Canal that is operated by the South Sutter Water District (SSWD) to enable gravity-driven flow diversion into the Auburn Extension Canal during the irrigation season. The unscreened diversion, which captures the majority of East Side Canal and Auburn Ravine flows, likely entrains at least a portion of emigrating juveniles after installation (which varies year-to-year but can be as early as April 5th). Attraction flows over the dam (typically less than 1.3 cfs) may also be too small to cue emigrating juveniles. In addition, the lengthy impounded reach of the East Side Canal likely disorients emigrating juveniles and increases mortality due to nonnative predatory fish.

Project Description and Benefits

A fish screen could be installed on the Auburn Extension Canal diversion to eliminate the risk of lethal entrainment of juvenile salmonids emigrating from Coon Creek, Markham Ravine and Auburn Ravine. A self-cleaning screen could have minimal effect on SSWD operations and would require limited maintenance. Concentrating flow over Coppin Dam across a lesser width may also improve downstream cueing and passage of juvenile salmonids and possible reductions in aquatic weeds due to increase flow velocities. Other options include management changes (e.g., postponing the installation of the dam until emigration of juvenile salmonids ceases) or more involved structural changes (e.g., complete replacement of Coppin Dam and the diversion with a more updated and fish-friendly structure and/or a pump for diverting flows into the Auburn Extension Canal).

Potential Constraints

Any physical or operational changes to the dam and diversion would need to be compatible with SSWD operations. A fish screen would need to be self cleaning to avoid clogging with aquatic vegetation. Ongoing maintenance costs would need to considered.

Estimated Project Cost Range

$500,000 to >$1,000,000

Timeline

3 to 8 years

Priority

High

Project is conceptual only and assumes the support of all land owners, land managers and stakeholders.

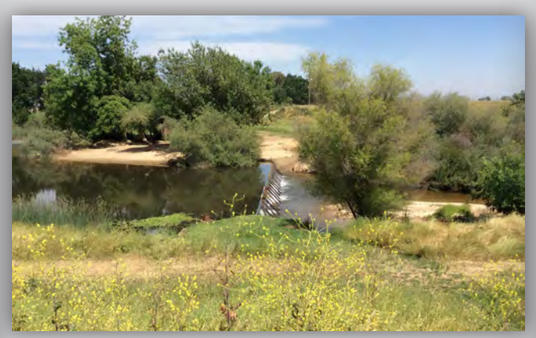

Photo by Jai Singh, cbec. May 2015.

Photo by Jai Singh, cbec. June 2016.

Project Benefits		
Benefit	**Comments**	**Value**
Geomorphic / Physical Processes / Hydrology	Installation of the fish screen would likely have minimal effect on physical processes and hydrology. However, retrofitting, replacement or removal of Coppin Dam could have a more significant impact on physical processes and hydrology along the East Side Canal.	Low
Salmonid Habitat	The fish screen would greatly reduce or eliminate the unintended entrainment of emigrating juvenile salmonids from the Coon Creek, Markham Ravine and Auburn Ravine watersheds into the Auburn Extension Canal after Coppin Dam Retrofitting, replacing or removing Coppin Dam could also improve emigration success by reducing the length of (or eliminating) the backwater reach and the likely higher levels of predation of juveniles by resident fish.	High
Riparian Habitat	Installation of the fish screen would have minor impact on adjacent riparian habitat. However, retrofitting, replacement or removal of Coppin Dam could increase flow velocity through the reach reducing the presence of aquatic weeds such as water primrose.	Low

Project Considerations

A feasibility study should be conducted to evaluate the installation of a fish screen or other measures to modify Coppin Dam. This study should also assess whether the 1.3 cfs attraction flow over, through and under Coppin Dam is adequate for cueing emigrating juveniles, or if additional flows are needed. If a fish screen is installed, monitoring would be required to ensure fish are successfully emigrating and to identify any adjustments to further improve passage. The study should also evaluate the diversion flows required for the fish screen to function correctly as well as the appropriate dimensions for the screen.

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Coon Creek Watershed Assessment

Coppin Dam and Auburn Extension Diversion Retrofit

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FISH SCREEN FOR AUBURN EXTENSION CANAL INTAKE

Aerial views looking north at Auburn Ravine / East Side Canal confluence, with rendering of proposed fish screen at Auburn Extension Canal intake. Photo by Scott Walls, cbec.

FLASHBOARD DAM MODIFICATION

proposed

Existing summer flashboard dam on East Side Canal downstream of Auburn Ravine (above). Photo by Jai Singh, cbec. May, 2015 Rendering of proposed notched flashboard dam concentrating flow for enhanced fish passage (below).

Coon Creek Watershed Assessment

Lower Coon Creek Channel and Floodplain Rehabilitation - Placer County

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Aerial photo of the project area, looking west. Photo by Scott Walls, cbec.

COON CREEK WATERSHED

Location

Coon Creek between Brewer Road and Pleasant Grove Road

Existing Conditions

Coon Creek's floodplain has been extensively graded and leveled for agricultural purposes, particularly rice production, resulting in minimal topographic complexity and natural habitat space. Berms also border much of the stream channel's banks which influence floodplain connectivity. While significant channel realignment occurred in the lower watershed, this reach still features a fairly sinuous channel that may have escaped 19th century realignment efforts. Additionally, the riparian corridor is very narrow, and typically extends only a few feet from the top of the stream bank.

Project Description and Benefits

Rehabilitation of the stream channel and floodplain could include partial or complete removal of berms to enhance floodplain interaction with the stream channel. Floodplain topographic complexity can be enhanced through grading practices to improve off-channel habitat quality and diversity. Multi-purpose use of floodplain areas can also be pursued whereby fields are managed as floodplain rearing habitat for juvenile salmonids during the winter and early spring months, while still used for rice production from mid-spring through early fall.

Potential Constraints

Channel and floodplain rehabilitation will require land owner agreements and may compete with existing land uses.

Estimated Project Cost Range

$100,000 to >$1,000,000

Timeline

3 to 8 years

Priority

High

Project is conceptual only and assumes the support of all land owners, land managers and stakeholders.

Aerial photo of the project site. Photo by Scott Walls, cbec.

Existing channel conditions with little riparian buffer. Photo by Jai Singh, cbec.

PROJECT BENEFITS

Benefit	Comments	Value
Geomorphic / Physical Processes	Partial or complete removal of the berms along the channel will enhance geomorphic processes and floodplain connectivity. Furthermore, the enhanced topographic complexity of the floodplain and re-establishment of a larger riparian vegetation corridor will enhance physical processes (e.g., floodplain sediment storage) and the stream's ability to sustain and create off-channel habitat complexity.	High
Hydrology	Depending on project design, the enhanced topographic complexity of the floodplain may increase retention of floodwaters and groundwater recharge.	High
Water Quality	The rehabilitated floodplain, widened riparian corridor and enhanced floodplain connectivity may increase the capture of fine sediment and contaminants.	High
Salmonid Habitat	Management of floodplain agricultural land as juvenile salmonid rearing habitat during the winter and early spring months could provide significant benefits to anadromous salmonid populations. Complete rehabilitation of the floodplain could also greatly enhance off-channel juvenile salmonid rearing habitat quality and extent of duration.	High
Riparian Habitat	Removal of berms, increasing topographic complexity and increasing interaction between Coon Creek and its seasonal floodplains would facilitate expansion of the riparian corridor and increase the overall diversity of riparian habitats, both in terms of species composition and habitat structure, thereby increasing the suitability of these habitats for a greater diversity of native wildlife.	Low

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Coon Creek Watershed Assessment

Lower Coon Creek Channel and Floodplain Rehabilitation - Placer County

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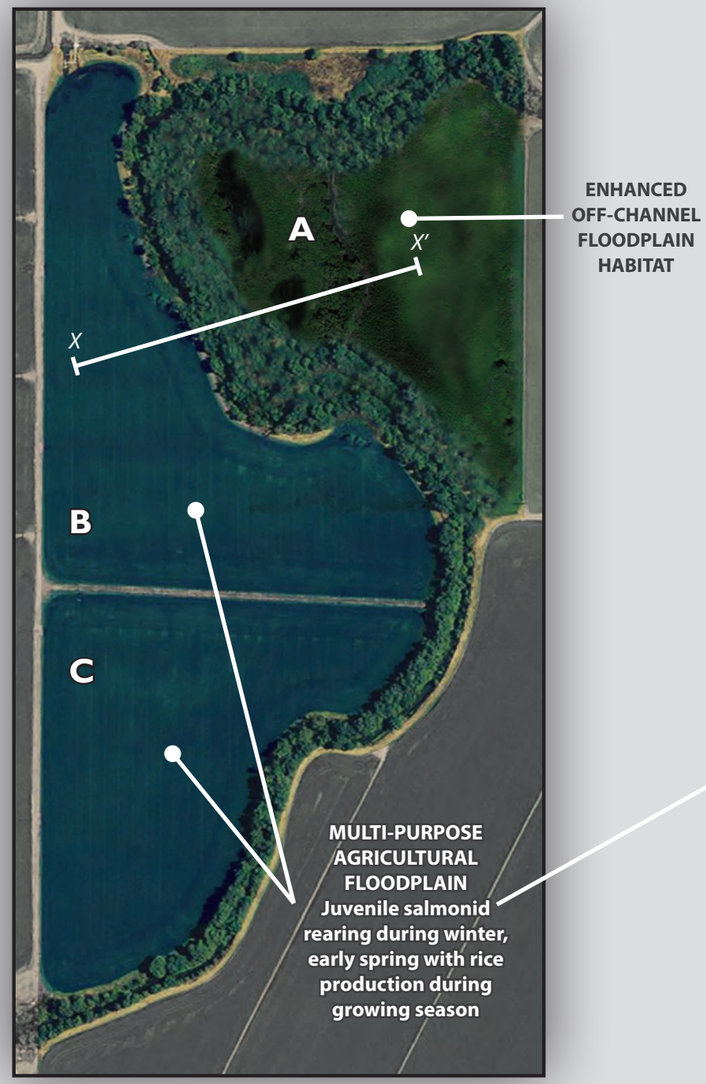
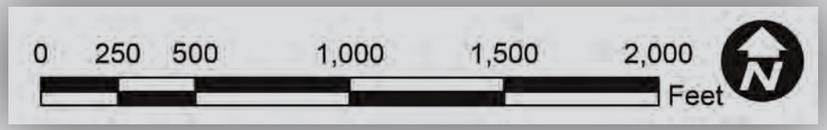
EXISTING CONDITIONS

Satellite image of existing conditions.

PROPOSED CONDITIONS

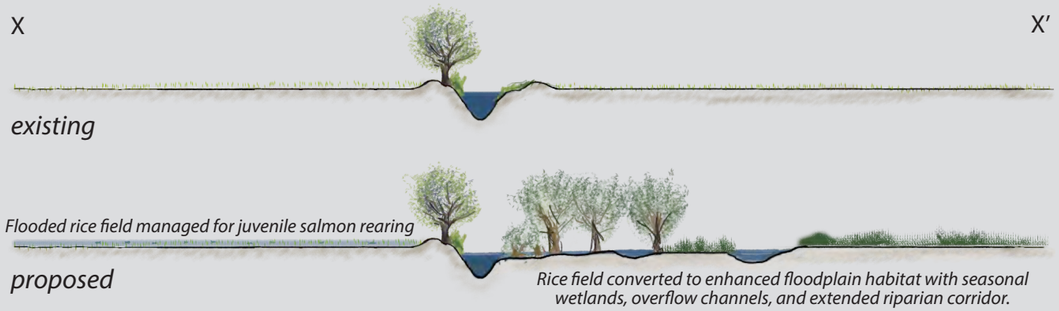


Rendering of proposed conditions.



Aerial view of project parcels A, B, and C, looking west . Photo by Scott Walls, cbec.

Juvenile salmon before (left) and after (right) rearing for 40 days in a rice field in the Yolo Bypass (Katz et al, 2013).



Cross section X-X' with existing and proposed conditions.

Coon Creek Watershed Assessment

Lower Coon Creek Channel and Floodplain Rehabilitation - Sutter County

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Aerial view of the project area, looking northeast. Photo by Scott Walls, cbec. December 2016.

COON CREEK WATERSHED

Location

Coon Creek between the Placer-Sutter County Boundary (Line 1 Canal crossing) and Brewer Road

Existing Conditions

Historic channel realignment practices straightened Coon Creek and disconnected at least one longer meander bend in the project area. The combination of historic channel realignment, intensive riparian vegetation management and a seasonal flashboard dam have resulted in a heavily degraded stream channel and poor-quality habitat. The floodplain has been graded and leveled for agricultural purposes, resulting in minimal topographic complexity and natural habitat space. Berms also border portions of the stream channel's banks which influence floodplain connectivity.

Project Description and Benefits

The historic meander bend could be reconnected to serve as the primary channel while the straightened (constructed) channel with poor habitat quality could be filled in or converted to an overflow channel. Upstream, rehabilitation measures could be pursued to re-grade, stabilize and revegetate the stream banks and thereby improve channel conditions and habitat quality. The floodplain could be regraded and revegetated to enhance topographic complexity and provide greater habitat diversity including off-channel seasonal wetland areas. Multi-purpose use of floodplain areas can also be pursued whereby fields are managed as floodplain rearing habitat for juvenile salmonids during the winter and early spring months, while still used for rice production from mid-spring through early fall.

Potential Constraints

Channel and floodplain rehabilitation will require land owner agreements and may compete with existing land uses. The project will also need to consider water diversion and pumping needs.

Estimated Project Cost Range

$100,000 to >$1,000,000

Timeline

3 to 8 years

Priority

High

Project is conceptual only and assumes the support of all land owners, land managers and stakeholders.

Earthen dam on Coon Creek in project area. Photo by Jai Singh, cbec.

Typical conditions along Coon Creek in the project area. Photo by Jai Singh, cbec.

PROJECT BENEFITS

Benefit	Comments	Value
Geomorphic / Physical Processes	The reconnection of the historic meander bend will restore sinuosity to the stream channel and enhance geomorphic processes. Channel rehabilitation and bank stabilization (and revegetation) measures along the highly degraded channel reach will reduce artificially high levels of bank erosion. The enhanced topographic complexity of the floodplain and re-establishment of a larger riparian corridor will also enhance physical processes and the stream's ability to sustain and create off-channel habitat complexity.	High
Hydrology	Depending on project design, the enhanced topographic complexity of the floodplain may increase retention of floodwaters and groundwater recharge.	High
Water Quality	The rehabilitated floodplain, widened riparian corridor and enhanced floodplain connectivity may increase the capture of fine sediment and contaminants.	High
Salmonid Habitat	Channel rehabilitation and revegetation measures will improve aquatic habitat and reduce late spring and summer temperatures (and thereby reduce passage barriers). Management of floodplain agricultural land as juvenile salmonid rearing habitat during the winter and early spring months could provide significant benefits to anadromous salmonid populations. Juvenile salmonids that reared on flooded rice fields in the nearby Yolo Bypass demonstrated the fastest growth rates ever recorded in California's freshwater environments (Katz et al. 2013). Complete rehabilitation of the floodplain could also greatly enhance off-channel juvenile salmonid rearing habitat quality and extent of duration.	High
Riparian Habitat	Removal of berms, increasing topographic complexity and increasing interaction between Coon Creek and its seasonal floodplains would facilitate expansion of the riparian corridor and increase the overall diversity of riparian habitats, both in terms of species composition and habitat structure, thereby increasing the suitability of these habitats for a greater diversity of native wildlife. Expanding riparian habitat in this reach would also create a continuous corridor of habitat along the stream, portions of which currently lack riparian vegetation altogether. This continuous corridor of riparian habitat would improve wildlife movement between the valley floor and foothill regions of the watershed.	High

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Coon Creek Watershed Assessment

Lower Coon Creek Channel and Floodplain Rehabilitation - Sutter County

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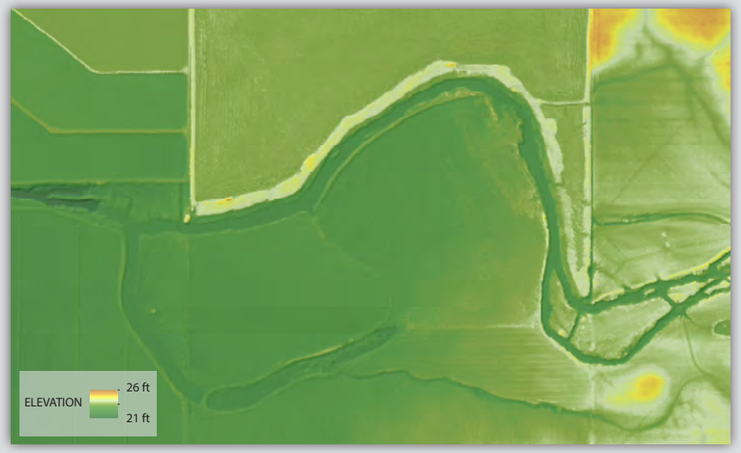
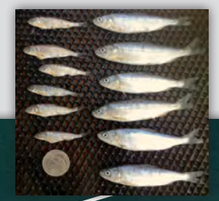
EXISTING CONDITIONS

Satellite imagery of the existing project area.

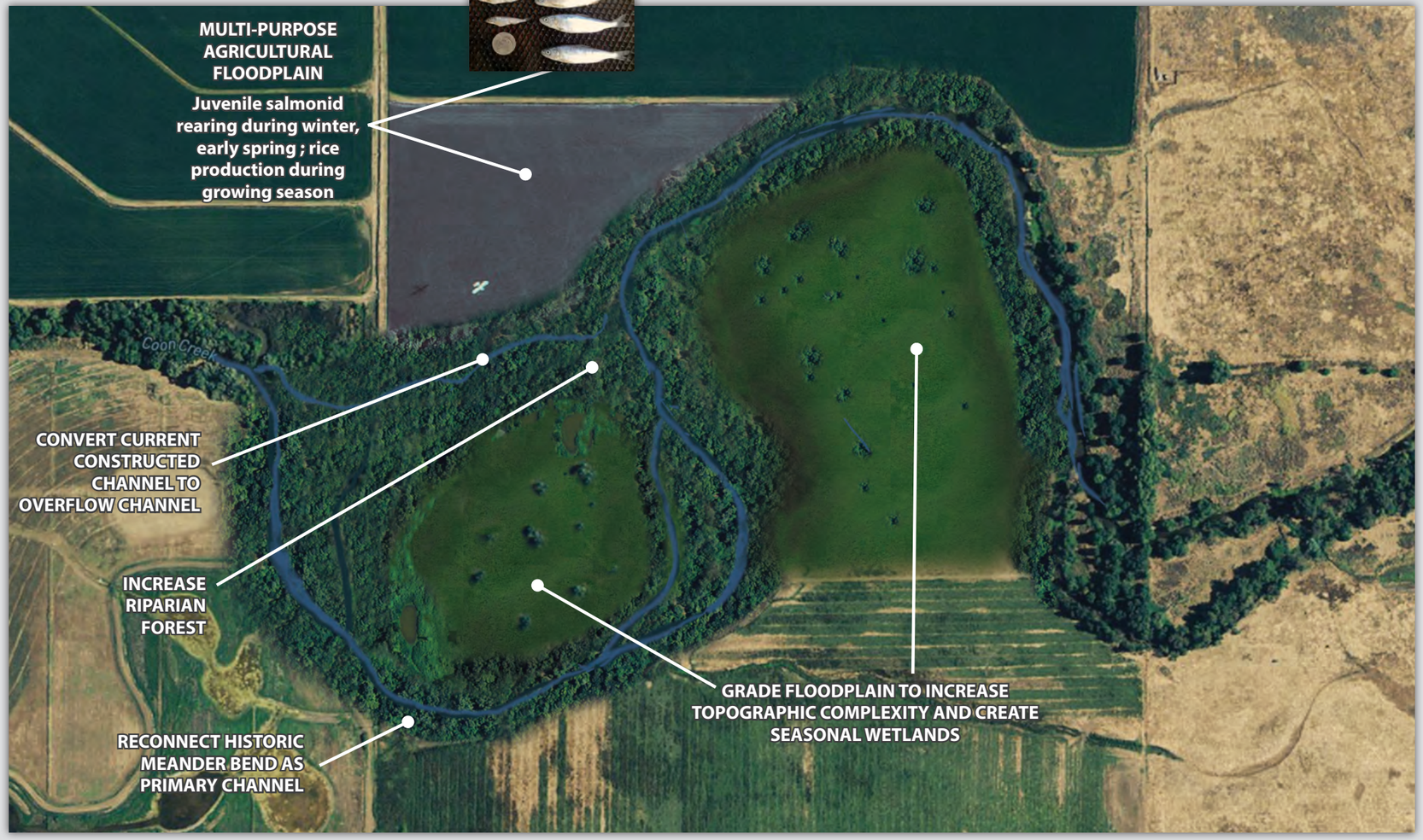


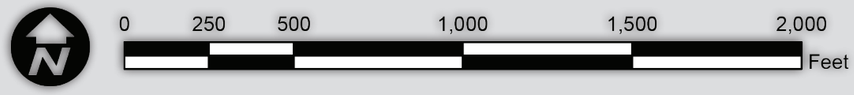
Existing topography in the project area, derived from LiDAR.



Juvenile salmon before (left) and after (right) rearing for 40 days in a rice field in the Yolo bypass (Katz et al, 2013).

PROPOSED CONDITIONS





Coon Creek Watershed Assessment

Lower Coon Creek Channel and Floodplain Rehabilitation - Placer County

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Aerial view of the project area, looking northwest. Photo by Scott Walls, cbec.

Location

Coon Creek between Placer-Sutter County Boundary (Line 1 Canal crossing) and Dowd Road

Existing Conditions

Historic channel realignment practices straightened Coon Creek and disconnected meander bends in the project area. Portions of the floodplain have been graded and leveled for agricultural purposes, resulting in reduced topographic complexity and limited natural habitat space. The riparian corridor along the southern bank is generally narrow to minimal in width while a broader, fairly mature riparian vegetation corridor is present along the northern side of the channel. Berms are also present along the floodplain which influence floodplain connectivity.

Project Description and Benefits

The historic meander bend(s) could be reconnected to serve as the primary channel. The floodplain could be regraded and revegetated to enhance topographic complexity and provide greater habitat diversity including off-channel seasonal wetland areas. Multi-purpose use of floodplain areas could also be pursued whereby fields are managed as floodplain rearing habitat for juvenile salmonids and/or floodwater retention areas during the winter and early spring months, while still used for rice production from mid-spring through early fall.

Potential Constraints

Channel and floodplain rehabilitation will require land owner agreements and may compete with existing land uses.

Estimated Project Cost Range

$100,000 to >$1,000,000

Timeline

3 to 8 years

Priority

High

Project is conceptual only and assumes the support of all land owners, land managers and stakeholders.

Concrete weir in Coon Creek in the project area. Photo by Jai Singh, cbec.

Channel conditions along Coon Creek in the project area. Photo by Jai Singh, cbec.

PROJECT BENEFITS

Benefit	Comments	Value
Geomorphic / Physical Processes	The reconnection of the historic meander bend will restore sinuosity to the stream channel and enhance geomorphic processes. If floodplain rehabilitation efforts are pursued, enhanced topographic complexity of the floodplain and re-establishment of a larger riparian corridor will also enhance physical processes and the stream's ability to sustain and create off-channel habitat complexity.	High
Hydrology	Depending on project design, moderate to significant retention of floodwaters can be achieved on the floodplain which will also enhance groundwater recharge.	High
Water Quality	The rehabilitated floodplain, widened riparian corridor, enhanced floodplain connectivity, and extended duration and increased volume of floodwater retention may increase the capture of fine sediment and contaminants.	High
Salmonid Habitat	Management of floodplain agricultural land as juvenile salmonid rearing habitat during the winter and early spring months could provide significant benefits to anadromous salmonid populations. Juvenile salmonids that reared on flooded rice fields in the nearby Yolo Bypass floodway demonstrated the fastest growth rates ever recorded in California's freshwater environments (Katz et al. 2013). Complete rehabilitation of the floodplain could also greatly enhance off-channel juvenile salmonid rearing habitat quality and extent of duration.	High
Riparian Habitat	Removal of berms, increasing topographic complexity and increasing interaction between Coon Creek and its seasonal floodplains would facilitate expansion of the riparian corridor and increase the overall diversity of riparian habitats, both in terms of species composition and habitat structure, thereby increasing the suitability of these habitats for a greater diversity of native wildlife. Expanding riparian habitat in this reach would also create a continuous corridor of habitat along the stream, portions of which currently lack riparian vegetation altogether. This continuous corridor of riparian habitat would improve wildlife movement between the valley floor and foothill regions of the watershed.	High

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Coon Creek Watershed Assessment

Lower Coon Creek Channel and Floodplain Rehabilitation - Placer County

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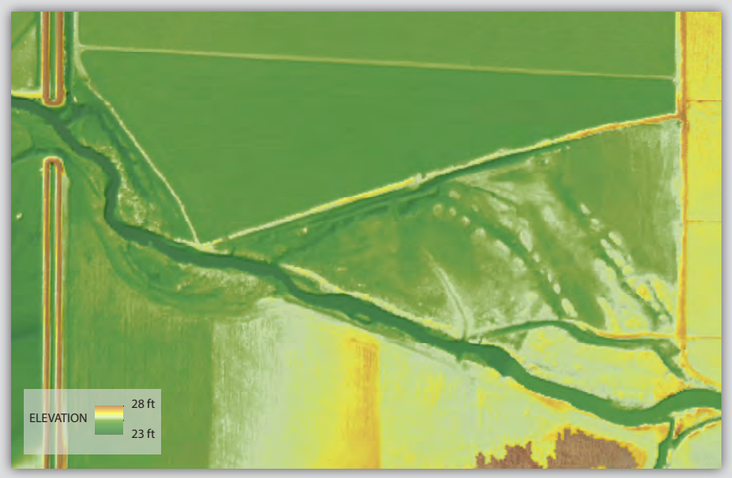
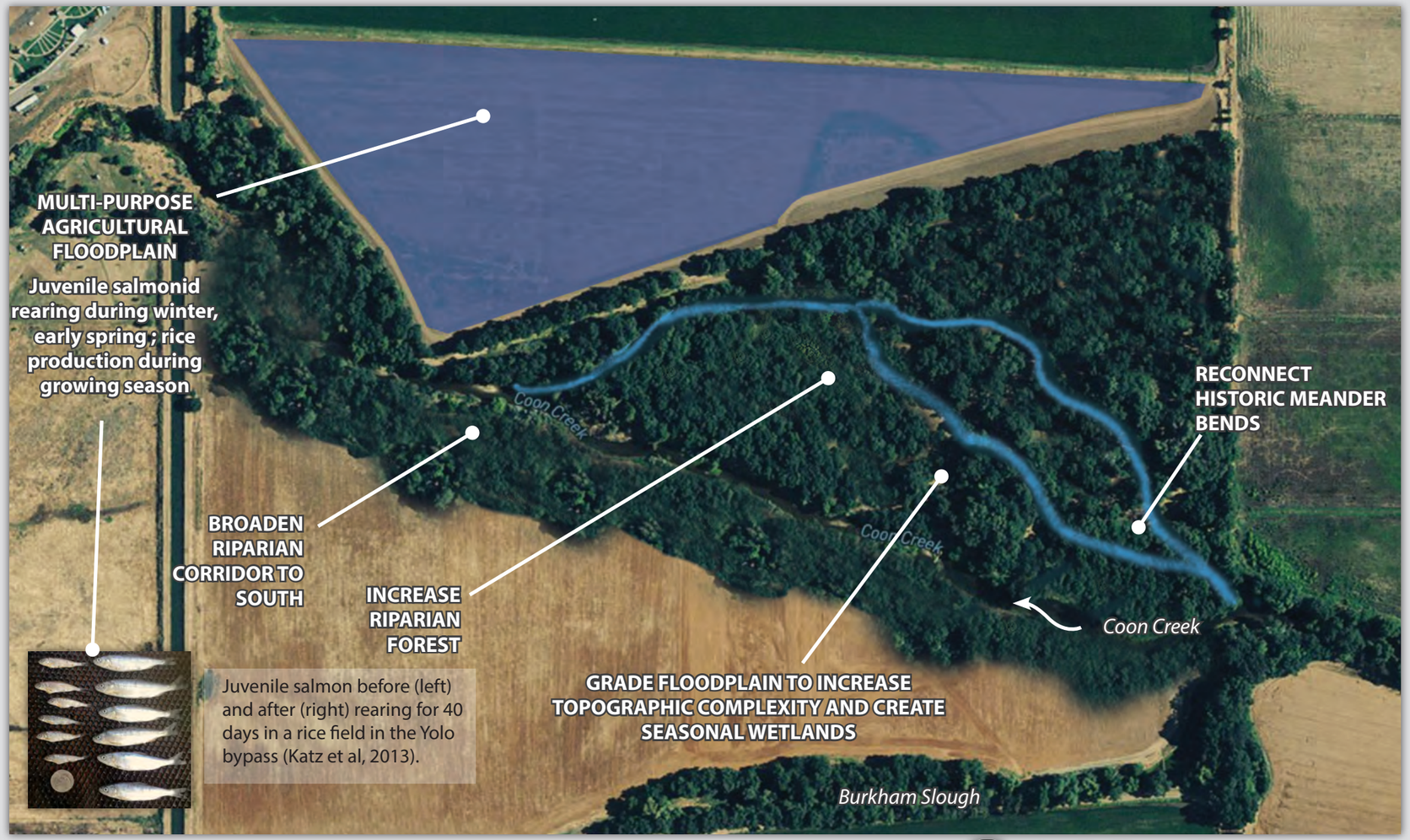
EXISTING CONDITIONS

Satellite imagery of the existing project area.



Existing topography in the project area.

PROPOSED CONDITIONS



Juvenile salmon before (left) and after (right) rearing for 40 days in a rice field in the Yolo bypass (Katz et al, 2013).

Coon Creek Watershed Assessment

Sundance-Lakeview Farms Rehabilitation Site Enhancement

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Aerial view of the project area, looking northwest. Photo by Scott Walls, cbec. December 2016.

COON CREEK WATERSHED

Location

Coon Creek immediately downstream of Dowd Road

Existing Conditions

Downstream of Dowd Road, Coon Creek flows through a 440-acre property that is protected by an NRCS conservation easement and managed as a recreational hunting preserve. The area is also the site of a 2008 riparian, wetland and floodplain enhancement project that included riparian corridor widening, berm setback, and seasonal and perennial wetland construction. While there is a relatively healthy riparian corridor today and frequent floodplain connectivity today, the stream channel is fairly incised in some locations and many of the constructed wetland areas were intended to be actively managed and do not function as designed The groundwater pump used to provide water to the wetlands is no longer functional and soils in the site may not support the intended wetland design.

Project Description and Benefits

Rehabilitation measures can be implemented to further enhance the project site as well as convert areas intended for active management to a passively managed system. A combination of additional berm removal/ setbacks, floodplain (re)grading, and overflow channel creation / enhancement can be pursued to improve the riparian and wetland functions of the site. The establishment of additional inset floodplain terraces to the north or south of the channel could also be explored. This project would require a more detailed feasibility study and two-dimensional hydrodynamic modeling to identify maximally effective rehabilitation enhancement measures.

Potential Constraints

The project will require land owner agreements and would need to be compatible with the hunting preserve land use. The project would also need to be compatible with existing conservation easements and any post-project requirements from past efforts driven by mitigation funds.

Estimated Project Cost Range

$100,000 to >$1,000,000

Timeline

3 to 6 years

Priority

High

Project is conceptual only and assumes the support of all land owners, land managers and stakeholders.

Typical channel conditions along Coon Creek in the project area. Photo by Jai Singh, cbec.

Upland habitat with potential for riparian forest enhancements. Photo by Jai Singh, cbec.

PROJECT BENEFITS

Benefit	Comments	Value
Geomorphic / Physical Processes	Rehabilitation measures will further improve the physical process regime by increasing floodplain connectivity and enhancing the stream's ability to sustain and create off-channel habitat quality and complexity.	High
Hydrology	Depending on project design, the enhanced floodplain connectivity and conversion of the site to a passively managed system may increase retention of floodwaters, eliminate groundwater pumping needs, and increase groundwater recharge.	High
Water Quality	The further rehabilitated floodplain and riparian corridor and enhanced floodplain connectivity may increase the capture of fine sediment and contaminants.	Moderate
Salmonid Habitat	The additional high flow channel and floodplain rehabilitation measures will enhance aquatic and wetland habitat conditions, providing improved habitat complexity, diversity and duration of seasonal availability for salmon.	Moderate
Riparian Habitat	The additional high flow channel and floodplain rehabilitation measures will riparian habitat conditions, providing improved habitat complexity, diversity, and increased extent of high-quality riparian habitat.	High

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Coon Creek Watershed Assessment

Sundance-Lakeview Farms Rehabilitation Site Enhancement

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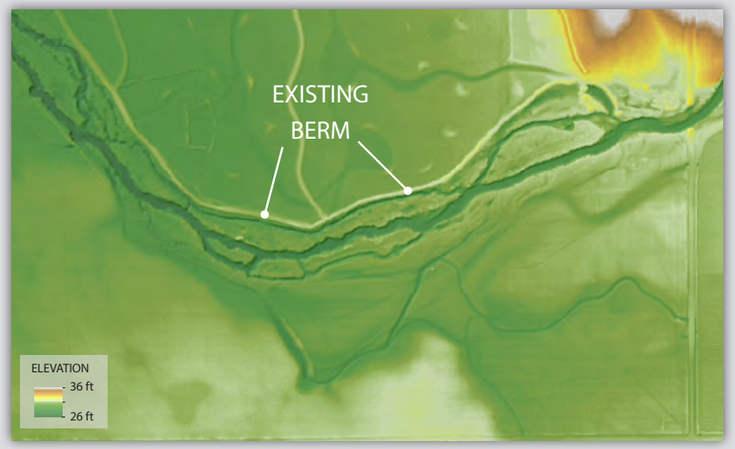
EXISTING CONDITIONS

Satellite imagery of the existing project area.



Existing topography in the project area.

PROPOSED CONDITIONS

Rendering of the proposed project area.

Coon Creek Watershed Assessment

Channel and Floodplain Rehabilitation Project - Middle Coon Creek

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Aerial view of the project area, looking east from Gladding Road. Photo by Scott Walls, cbec.

COON CREEK WATERSHED

Location

Coon Creek between Gladding Road and McCourtney Road

Existing Conditions

Immediately downstream of McCourtney Road, Coon Creek splits and follows two channel alignments that border the left and right valley walls. Channel incision generally ranges from moderate to severe. It is unclear if the channels were historically realigned along the valley walls for cattle grazing, other agriculture use, or for some other reason. Low-height berms also border some sections of Coon Creek, likely contributing to reduced floodplain connectivity. Inspection of LiDAR data shows multiple historic channel alignments (likely secondary or high flow channels) along the floodplain.

Project Description and Benefits

Rehabilitation of the stream channels and floodplain can address channel incision, increase floodplain connectivity and enhance floodplain and off-channel habitat quality. The installation of engineered large wood jams and/or bed level controls (e.g., Newbury Rock Riffles) can be used to aggrade the stream bed and encourage more frequent floodplain connectivity. Removal of berms will further enhance floodplain connectivity. Historic floodplain channel alignments can also be enhanced with grading to increase inundation frequency and habitat quality. The existing riparian corridor can also be widened.

Potential Constraints

The project will require land owner agreements and would need to be compatible with the hunting preserve land use. The project would also need to be compatible with existing conservation easements and any post-project requirements from past efforts driven by mitigation funds.

Estimated Project Cost Range

$100,000 to >$1,000,000

Timeline

3 to 6 years

Priority

High

Project is conceptual only and assumes the support of all land owners, land managers and stakeholders.

Typical channel conditions along Coon Creek in the project area. Photo by Jai Singh, cbec.

Berm along creek in the project area. Photo by Jai Singh, cbec.

PROJECT BENEFITS

Benefit	Comments	Value
Geomorphic / Physical Processes	Rehabilitation measures will further improve the physical process regime by increasing floodplain connectivity and enhancing the stream's ability to sustain and create off-channel habitat quality and complexity.	High
Hydrology	Depending on project design, the enhanced floodplain connectivity and conversion of the site to a passively managed system may increase retention of floodwaters, eliminate groundwater pumping needs, and increase groundwater recharge.	High
Water Quality	The further rehabilitated floodplain and riparian corridor and enhanced floodplain connectivity may increase the capture of fine sediment and contaminants.	High
Salmonid Habitat	The additional high flow channel and floodplain rehabilitation measures will enhance aquatic and wetland habitat conditions, providing improved habitat complexity, diversity and duration of seasonal availability for salmon.	Moderate
Riparian Habitat	The additional high flow channel and floodplain rehabilitation measures will riparian habitat conditions, providing improved habitat complexity, diversity, and increased extent of high-quality riparian habitat.	High

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Coon Creek Watershed Assessment

Channel and Floodplain Rehabilitation Project - Middle Coon Creek

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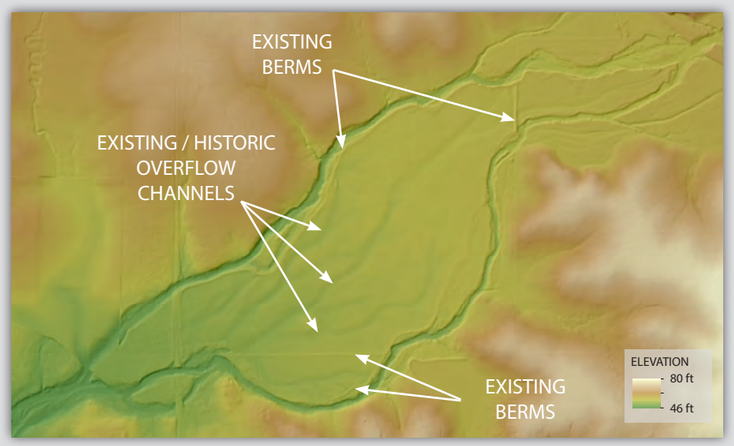
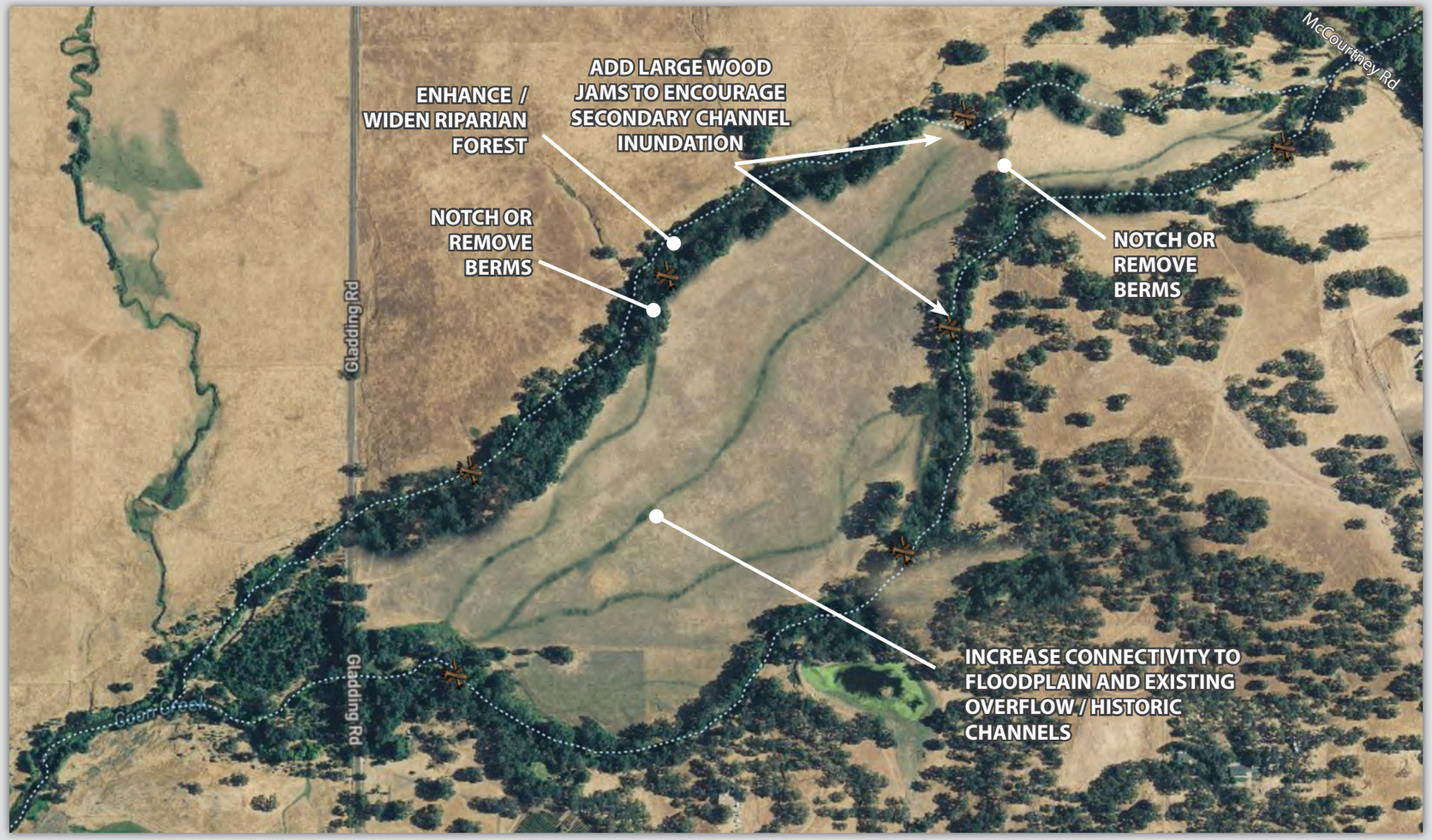
EXISTING CONDITIONS

Satellite imagery of the existing project area.



Existing topography in the project area.

PROPOSED CONDITIONS



Render of proposed project area.

0 250 500 1,000 1,500 2,000 Feet

Coon Creek Watershed Assessment

Doty Ravine South at Head Diversion Dam Retrofit

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Wicket-gate dam installed during diversion season. Photo by Jai Singh, cbec.

Location: Doty Ravine

Existing Conditions

NID operates a wicket-gate dam and diversion on Doty Ravine to divert flows into the Doty South Canal. The dam and downstream rock ramp serve as a partial barrier to both adult and juvenile salmonids during low flow conditions. Once the wicket gates are raised for the irrigation season (April 15th to Oct 15th), downstream fish passage for juveniles is limited to flow events that overtop the gates. The unscreened diversion likely entrains both rearing and emigrating juveniles in the Doty South Canal.

Project Description and Benefits

A fish screen could be installed at or immediately upstream of the diversion inlet to eliminate entrainment and mortality risks of the diversion. In conjunction, a small and low-cost fish passage ladder such as an Alaska Steeppass ladder could be installed along the side of the channel to provide both upstream and downstream passage for adults and juveniles. Alternatively, the dam's downstream rock ramp could be retrofitted or redesigned altogether to improve passage and/or the wicket-gate dam could be replaced with an adjustable weir or dam to provide occasional downstream passage of juveniles after the irrigation season commences.

Potential Constraints

Any changes to the dam and diversion would need to be compatible with NID operations. A fish passage ladder would require that continuous flows be passed downstream to enable passage while the diversion is operating during the irrigation season.

Estimated Project Cost Range

$100,000 to >$1,000,000

Timeline

3 to 7 years

Priority

High

Project is conceptual only and assumes the support of all land owners, land managers and stakeholders.

Rock ramp on downstream side of diversion structure. Photo by Jai Singh, cbec.

Upstream side of diversion structure and intake. Photo by Jai Singh, cbec.

PROJECT BENEFITS

Benefit	Comments	Value
Geomorphic / Physical Processes	Installation of the fish screen and fish ladder would likely have minimal effect on physical processes. However, retrofitting or replacing the dam and/or the downstream rock ramp could have a more significant impact on physical processes along Doty Ravine.	Low
Hydrology	Installing a fish ladder and providing consistent flows for passage purposes will result in an increase in Doty Ravine's base flow downstream of the dam during the irrigation season.	Low
Salmonid Habitat	The fish screen would greatly reduce or eliminate the unintended entrainment of rearing and emigrating juveniles in Doty Ravine. The fish passage ladder and bypass flows could also facilitate upstream and downstream fish passage for both adult and juvenile salmonids. In addition to providing more consistent access to upstream habitat, juvenile salmon rearing in late spring or summer would have improved access to the colder water temperatures associated with NID flow conveyance along Doty Ravine upstream of the dam.	High
Riparian Habitat	Installation of the fish screen and fish ladder would have minimal impacts on existing riparian habitat, and selected re-planting or enhancement of existing riparian vegetation (e.g., removal of nonnative Himalayan blackberry) could be integrated into fish passage improvements.	Low

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Coon Creek Watershed Assessment

Doty Ravine South at Head Diversion Dam Retrofit

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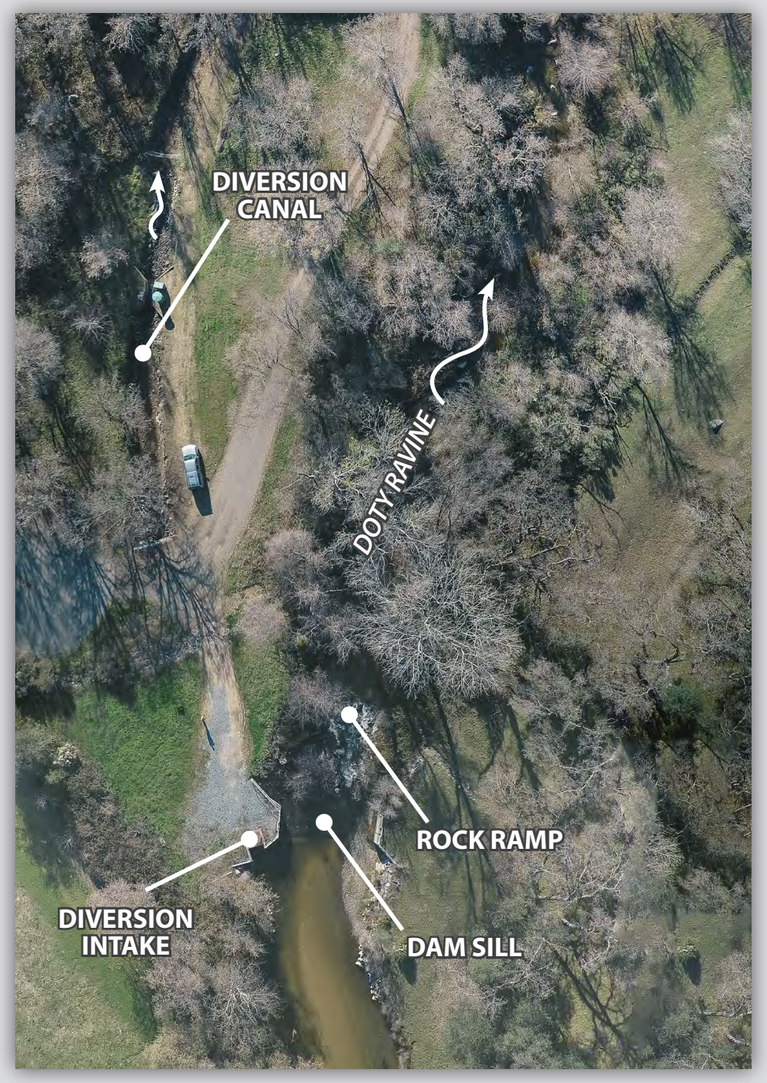
EXISTING CONDITIONS



Aerial photo mosaic of the project area. Photos by Scott Walls, cbec.

PROPOSED CONDITIONS

Aerial photo of the diversion intake, dam sill, and renderings of the proposed enhancements for fish passage and emigration. Photo by Scott Walls, cbec.

Coon Creek Watershed Assessment

Garden Bar Road Culvert Replacement

Downstream side of Garden Bar Rd culvert with large drop. Photo by Scott Walls, cbec.

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COON CREEK WATERSHED

Location

Doty Ravine at Garden Bar Road Bridge over Doty Ravine

Existing Conditions

The creek crossing consists of a perched culvert that is likely impassable for anadromous fish during most, if not all, flow conditions. Fish passage is likely inhibited by the height of the culvert outlet above the downstream pool water surface and velocities in the culvert during higher flows. The bridge is aging and the combination of its narrow width and a sharp curve in the road leading to the southern approach make it somewhat hazardous for vehicular traffic. The culvert is also likely undersized for passing large flood flows, acts as a hydraulic constriction point, and causes a large scour pool downstream of the bridge.

Project Description and Benefits

The existing bridge can be replaced with an open-span bridge or bottomless culvert that allows for a more natural stream bed and provides unimpeded fish passage. Fish friendly grade control structures and channel reprofiling measures would need to be implemented to prevent upward migration of a head cut. The project would enhance longitudinal connectivity of physical processes, alleviate an artificial hydraulic constriction, improve downstream aquatic habitat and provide access to several miles of potential spawning and rearing habitat for anadromous salmonids.

Estimated Project Cost Range

$100,000 to >$1,000,000

Timeline

2 to 5 years

Priority

High

Project is conceptual only and assumes the support of all land owners, land managers and stakeholders.

Downstream end of perched culvert at Garden Bar Road. Photo by Jai Singh.

Scour pool and erosion in Doty Ravine downstream of Garden Bar Road. Photo by Scott Walls, cbec.

PROJECT BENEFITS

Benefit	Comments	Value
Geomorphic / Physical Processes	By addressing a hydraulic constriction, the project will enhance longitudinal connectivity of physical processes such as sediment transport and storage. Depending on the project design, it will also improve geomorphic conditions of the stream channel immediately upstream and downstream of the crossing.	Moderate
Hydrology	The removal of a hydraulic constriction will likely shift reach-scale hydrologic conditions during high flow events to a more natural state.	Low
Salmonid Habitat	The project will enhance or restore anadromous fish access to several miles of habitat upstream of the culvert. This reach of Doty Ravine provides cooler water temperatures longer into the spring and summer, relative to most other stream reaches in the watershed, due to conveyance practices by NID. The project will also enhance aquatic habitat, particularly downstream of the bridge.	High
Riparian Habitat	Installation of the fish screen and fish ladder would have minimal impacts on existing riparian habitat, and selected re-planting or enhancement of existing riparian vegetation (e.g., removal of nonnative Himalayan blackberry) could be integrated into fish passage improvements.	Low

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Coon Creek Watershed Assessment

Garden Bar Road Culvert Replacement

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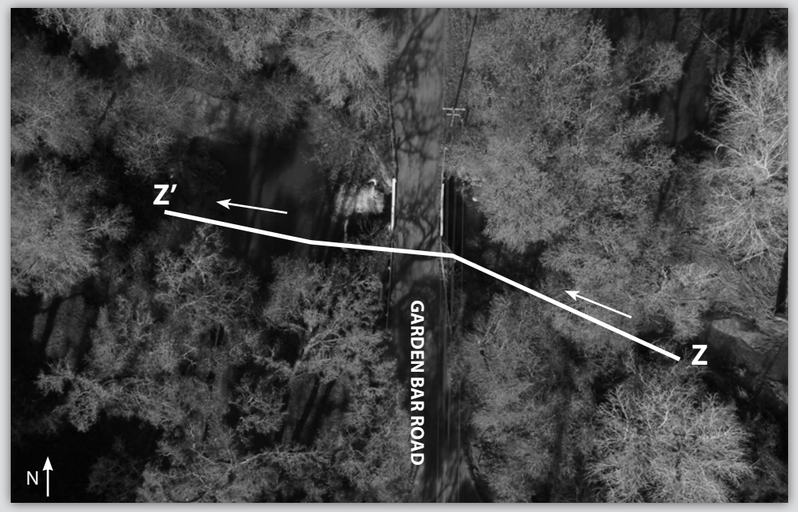
GARDEN BAR ROAD CULVERT FISH PASSAGE ENHANCEMENT OPTIONS

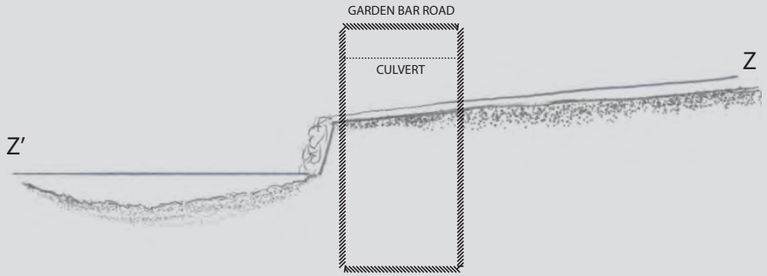
Existing Perched Culvert

Rendering of Natural Bottomed Arched Culvert

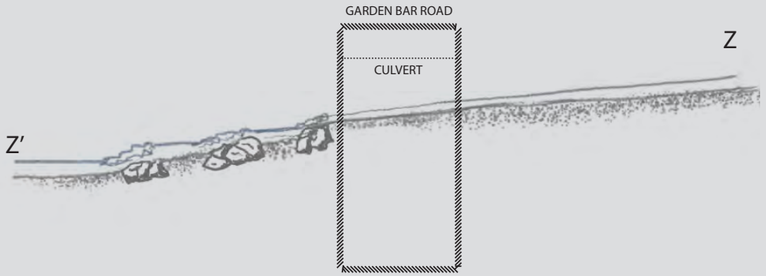
Rendering of Open-Span Bridge with Fish Passage Baffles



Aerial View of Doty Ravine at Garden Bar Road Crossing. Photo by Scott Walls, cbec.



Conceptual Drawing of Existing Longitudinal Profiles Z-Z' of Doty Ravine at Garden Bar Road Crossing



Conceptual Drawing of Proposed Longitudinal Profile Z-Z' after fish passage improvements of Doty Ravine at Garden Bar Road Crossing

8.3 RECOMMENDED STUDIES

This watershed assessment significantly advanced the state of knowledge for the watershed with respect to many focus areas including hydrology, physical processes, water quality, aquatic and riparian habitat, anadromous fisheries, human disturbances and rehabilitation opportunities. In addition to developing recommendations for specific rehabilitation strategies and management actions, the assessment also identifies additional studies and data sets that could be developed to further enhance knowledge of the watershed and inform future rehabilitation projects and management changes.

Hydrology

Monitor Stream Flows Year-Round

The development of a long-term stream flow data set at one or more monitoring locations in the watershed would be highly informative for understanding peak flow dynamics within the watershed as well as future decision making around flow management and rehabilitation opportunities. The development of these data sets could leverage the existing low-flow monitoring station operated by SSWD on Coon Creek immediately upstream of the Sutter County boundary and Line 1 Canal at a concrete weir. This data set is only maintained during the irrigation season and has an upper limit to accuracy at approximately 42 cfs. Stage data is also collected at three locations throughout the watershed (see Contrail Gages in Figure 22) and it is possible that stage-discharge rating curves could be developed at these locations if the channel geometry is both suitable and relatively stable. This would involve collecting a series of event-based flow (or discharge) measurements using standard hydrogaphic techniques and correlating these to measured stage levels to develop stage-discharge relationship (or curve). Alternatively, other sites could be used, particularly where an existing hydraulic (natural or artificial) control structure already exists. A range of instrumentation platforms and rating curve development techniques can be used to generate a flow data set, depending on site conditions and time and budget constraints.

Conduct Flow Management Alternatives Feasibility Study

An assessment should be conducted to evaluate the feasibility of altering flow management practices in the watershed to provide greater environmental benefit while maintaining human needs. To do this, we recommend building off the assessment of flow management conducted as part of this effort to further characterize the timing, magnitude and inter-annual variability of water conveyance, diversion and abstraction in Coon Creek and Doty Ravine. This effort could involve measuring stream flows at multiple locations along Coon Creek and Doty Ravine on multiple occurrences (or continuously) to help quantify flow conditions and flow management effects. This study could then explore some or all of the seven concepts described above in Section 8.1.2. It should also explore water conservation measures such as rainwater catchment and off-channel storage of winter runoff to provide opportunities to delay water extraction or diversion and should explored as components of a feasibility study. This work would need to be conducted alongside an ecological benefits and consequences study to assess the expected effects of flow management modifications on salmonids and other aquatic and riparian species.

Physical Processes

Conduct Field-Based Geomorphic Assessment of Coon Creek and Doty Ravine Confluence

A field-based geomorphic assessment (or fluvial audit) of Coon Creek and Doty Ravine could not be conducted along stream reaches near the confluence of Coon Creek and Doty Ravine due to a lack of private property access. This includes Coon Creek between Old Hwy 65 and Gladding Road and Doty Ravine between the Coon Creek confluence and Manzanita Cemetery Road. If the County is able to coordinate access with the landowner in the future, it would be highly beneficial to conduct a ground-based fluvial audit assessment of these reaches to characterize physical processes, assess channel conditions and land use pressures, and identify rehabilitation and management opportunities.

Water Quality

This assessment developed a highly informative short- to medium-term data set representing a fairly comprehensive set of water quality parameters. In the future, the development of a longer-term, more systematic water quality data set could help to better characterize variability in water quality conditions (particularly temperature) and inform longer-term trends in water quality. To establish such a dataset, water quality monitoring should be performed regularly throughout the watershed. Ideally, long-term monitoring activities should be conducted at the same site(s), on a regular schedule, and for a consistent set of analytes. The highest priority for future efforts is continued regular monitoring of water quality parameters and constituents such as those measured in this assessment. Continued monitoring will allow stakeholders to understand long-term water quality trends and will likely lead to an improved understanding of sources and potential impacts of pollutants. Additional, more-targeted efforts that could be performed include the following:

Continued Stream Temperature Monitoring

Continued monitoring of stream temperatures at a select subset of the 20 locations monitored during this assessment (Figure 30) would help characterize inter-annual variability in the temperature regime as well as habitat conditions and thermal suitability for anadromous fish. The seven monitoring locations depicted in Figure 45 would constitute the highest priority sites for continued temperature monitoring efforts targeting thermal suitability for anadromous fish (with the exception of Coon Upper 5 which is above expected barriers to anadromy).

Canal Temperature Monitoring

Temperature monitoring of canal water diverted into the Coon Creek stream network could be conducted to understand the effect of canal inflows on stream temperatures. Temperature sensors could be placed within relevant canals (e.g., Line 1 Canal, Combie Ophir Canal, etc.) with priority given to canals that contribute the greatest volumes of water to stream channels. This temperature monitoring effort could help inform future feasibility studies regarding flow management modifications as described in Section 8.1.2.

Sediment Mercury Concentrations

If mercury is present in the watershed, streambed sediments are expected to be the major reservoir. Microbial reactions in sediments are responsible for production of methyl mercury (it's most toxic form), and measuring mercury concentrations would allow stakeholders to evaluate whether this element poses a risk to human or environmental health in the watershed.

Further Metals Testing

To better understand the potential impacts of heavy metals on aquatic species, further testing could be performed to determine what fraction of metals are present in the dissolved form and what fraction are associated with sediment. Metals measurements made in sediment pore water are expected to be most representative of "bioavailable" metals concentrations.

Further Microbial Testing

Results of the microbial testing carried out in this assessment generally demonstrated concentrations above the upper reporting limit of the employed testing methodology. Additional testing with higher reporting limits may help stakeholders identify the sources of these organisms and understand the magnitude of the risk they pose.

Fish Tissue Testing (Bioassays)

Collecting samples of important fisheries species, as feasible, and measuring constituents of concern would enable stakeholders to understand whether contaminants are bioaccumulating in the watershed and whether fish consumption is a human health concern. Contaminants that may be present in fish tissue include mercury, arsenic, and organic chemicals such as pesticides or PCBs. Because concentrations of these species in fish tissues are typically elevated compared to their concentrations in water, tissue measurements are a more sensitive tool for assessing risk posed by these chemicals and trends in their concentrations over time.

Additional Anadromous Fish Surveys

The fish surveys conducted for this watershed assessment provided valuable information on species assemblages, habitat conditions and availability, distribution of anadromous spawning and rearing, and the timing of juvenile emigration. However, the results of these surveys provide only a snapshot of these attributes, and more intensive surveys are needed to answer specific questions about how and when anadromous salmonids use the Coon Creek watershed. One particular area of concern is the timing of juvenile emigration. We demonstrated that at least some juvenile Chinook salmon can remain in the watershed as late as early June, but we were unable to determine what proportion of the population this represents, or the timing of peak emigration. We recommend conducting downstream migration trapping for juvenile salmonids for several months in spring, possibly from late March through June. Many established methods are available and could be effectively implemented in Coon Creek, including a pipe trap, fyke net, rotary screw trap, or inclined plane trap. Ideally, trapping would be conducted over several years to determine interannual variability in the timing and magnitude of juvenile salmonid production.

The timing of emigration is particularly important in the context of the timing of water conveyance and extraction for agricultural production. We recommend conducting a thorough analysis of the timing and magnitude to water conveyance, diversion and extraction in Coon Creek and Doty Ravine. The feasibility of altering the timing and magnitude of these flow manipulations to minimize impacts to juvenile salmonids should be explored. Water conservation measures such as rainwater catchment and off-stream storage of winter runoff provide opportunities to delay water extraction or diversion and should explored as components of a feasibility study.

Sensitive Species Surveys

Salmonids are not the only sensitive species that occur, or potentially occur, in Coon Creek and Doty Ravine. Additional studies to understand the use of the watershed and its stream by other sensitive species, such as California red-legged frogs, foothill yellow-legged frogs, giant garter snakes (in the lower watershed), various species of migratory birds (e.g., tri-colored blackbirds and California black rails), and Western pond turtles, should be pursued to develop a more comprehensive understanding of the benefits that restoration actions in the watershed could provide.

9 CONCLUSIONS AND RECOMMENDATIONS

Starting in the late 1800s and continuing to the present day, the Coon Creek watershed has experienced a wide range of disturbances including channel realignment and modification, land development and land cover change, agricultural encroachment, urbanization, flow management, and water quality effects. Physical disturbances to the stream system are most pronounced in the middle and lower watershed as well as in the upper headwaters near Auburn. Extensive channel realignment appears to have occurred historically along Coon Creek from McCourtney Road continuing downstream. Disturbances to the channel and floodplain become steadily more pronounced as the stream flows west and agricultural activities intensify, with the greatest impact resulting from interception of Coon Creek by the East Side Canal and the complete disconnection of the lowermost reach. These physical disturbances are accompanied by degradation of aquatic and riparian habitat as well as declines in the quantity, quality and seasonal availability of floodplain habitat.

Flows in Coon Creek and its tributaries are heavily influenced today by conveyance and delivery practices during the irrigation season which typically extends from April 15th to October 15th. Water agencies operating in the basin convey imported water along a complex network of canals and stream channels to facilitate deliveries, largely for irrigation purposes. As a result, as Coon Creek and Doty Ravine descend from east to west, they experience several cycles of flow augmentation followed by partial or complete diversion of stream flow. In addition to these spatial discontinuities in flow, irrigation deliveries and diversions can also drive high levels of temporal variability in stream flows on a daily and weekly basis during the irrigation season.

Despite these effects, fall-run Chinook salmon actively use the stream reaches accessible to anadromy, specifically Coon Creek below Lower Hidden Falls and Doty Ravine below the Garden Bar Road culvert. It is unclear whether Central Valley steelhead currently inhabit the watershed during the freshwater portion of their life history. Temperatures are generally suitable for anadromous fish between November and April, and become stressful to lethal from mid-May onward. Flow management also drive spatial and temporal discontinuities in the temperature regime, as well as creating locally cooler reaches where irrigation flows are conveyed along the stream channel. Unscreened diversions, seasonal dams and other irrigation infrastructure likely result in the mortality of some portion of the Coon Creek anadromous fish population, particularly during juvenile rearing and emigration life stages.

Despite the historic and ongoing disturbances to the Coon Creek watershed, it remains one of the least developed Sierra foothill watersheds in Placer County and has the potential for significant physical and ecological uplift. This assessment identified a portfolio of basin-level rehabilitation and management strategies, site-specific restoration projects, and considerations for future management efforts and studies. Of specific emphasis are projects aimed at improving the success of salmonid rearing and emigration life stages. The installation of fish screens and passage improvements at the Doty South at Head Diversion Dam and Coppin Dam on the East Side Canal would address two major lethal entrainment points that likely affect anadromous fish populations. Retrofitting or replacing the Garden Bar Road culvert on Doty Ravine would address a prominent passage barrier for salmon and provide

access to additional spawning habitat. Screening other pumps and diversions throughout the watershed is also recommended.

Channel and floodplain rehabilitation measures can be pursued to enhance physical processes and the condition of the stream and floodplain in the middle and lower watershed. Recommended strategies include floodplain grading to increase topographic complexity and to enhance or create secondary channel alignments. Degraded stream reaches can also be improved through channel form rehabilitation, reconnection of historic meander bends, channel re-profiling and placement of large woody material. These efforts would all serve to improve floodplain connectivity, and, particularly in the lower watershed, would improve the quality and availability of floodplain rearing habitat for juvenile salmonids. Another option for improving the quality, quantity and duration of availability of floodplain rearing habitat for juvenile salmonids is implementing multi-purpose floodplain management of rice fields in the lower watershed. Inundated rice fields can be used to achieve tremendous growth rates in rearing juveniles in winter and spring months while still being used for rice cultivation during the growing season.

Other high-priority rehabilitation strategies including enhancing the riparian corridor, particularly in the lower and middle watershed where there the riparian buffer width is minimal along many reaches. Efforts should aim to increase the width of the riparian buffer, improve longitudinal connectivity of the riparian corridor, increase the presence of large woody vegetation and reduce the coverage of invasive species. Cattle exclusion measures would also be significantly beneficial in reducing livestock disturbances to the stream channel along several reaches in the middle watershed. Altering current flow management practices to lessen the temporal and spatial variability of stream flows would likely benefit aquatic habitat conditions. However, this report does not recommend specific actions due to the complexity of today's flow management activities (and the resulting benefits and detriments for a broad array of species) and the lack of stream flow data. Instead, numerous considerations and concepts regarding flow management are presented that require further exploration.

As with the vast majority of environmental rehabilitation efforts, the successful implementation of the opportunities identified for the Coon Creek watershed will hinge on the effective partnership of relevant stakeholders. Many of the proposed projects are located on stream reaches flowing through large parcels of private property. Flow management practices of water resource agencies also significantly influence the conditions of the stream network. Meaningful collaboration of government agencies, land owners, non-profits, water resource agencies and other organizations can result in creative solutions that improve the health and resilience of the watershed's natural resources while also maintaining other land use objectives.

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Notes:

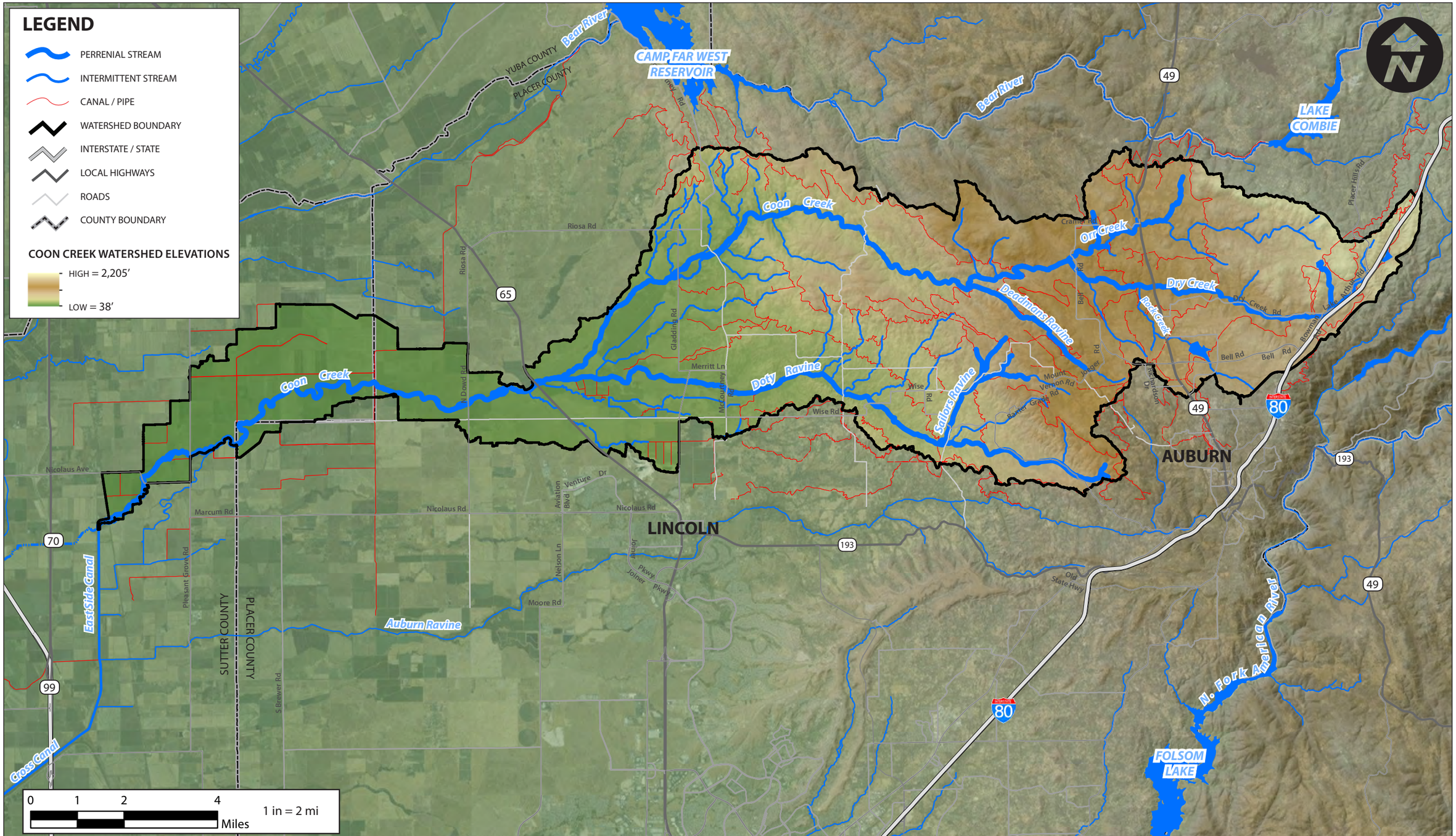
Coon Creek Watershed Assessment

Watershed Location Map

Project No. 14-1024

Created By: SPW

Figure 1



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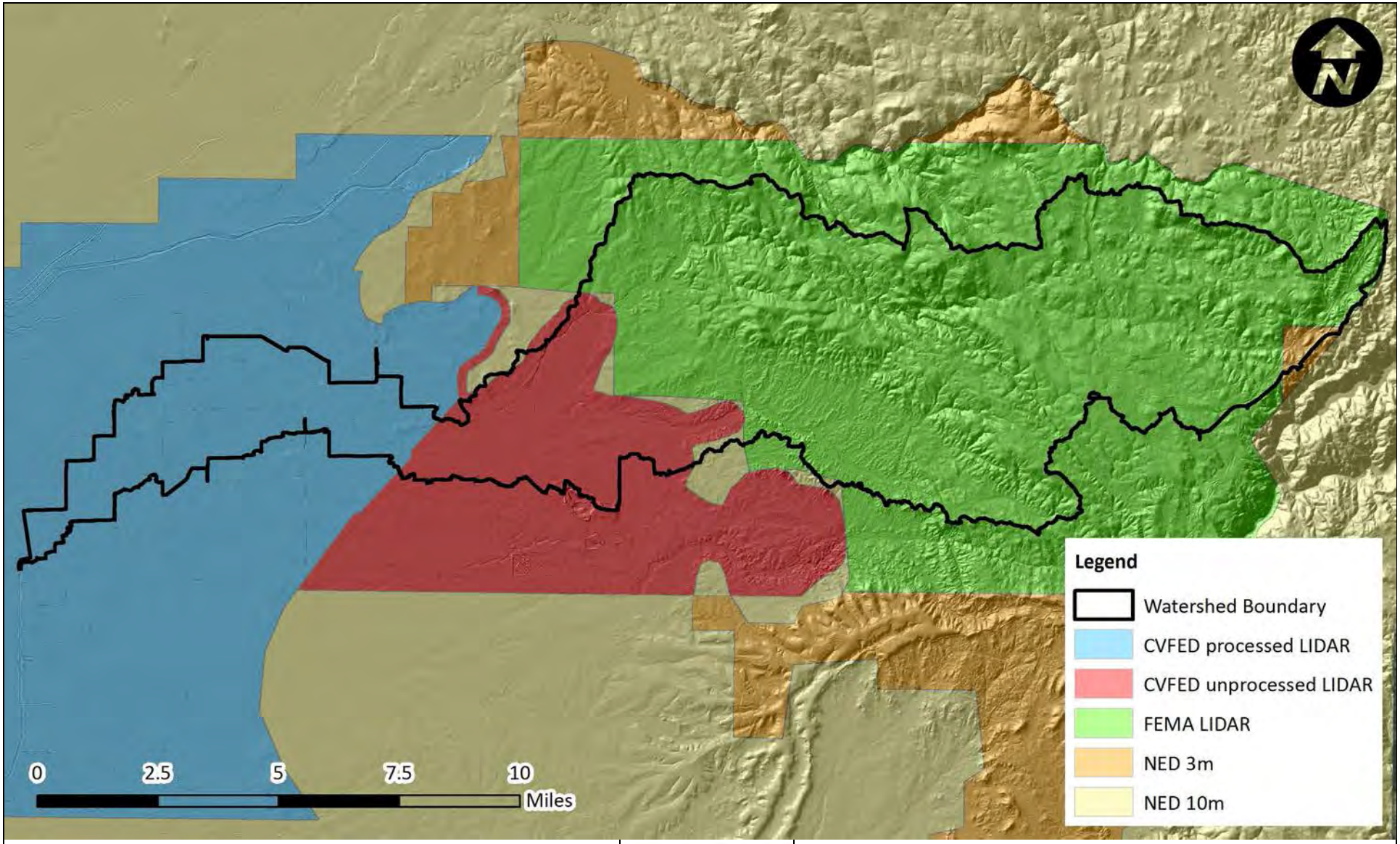
Coon Creek Watershed Assessment

Watershed Overview and DEM

Project No. 14-1024	Created By: SPW	**Figure 2**



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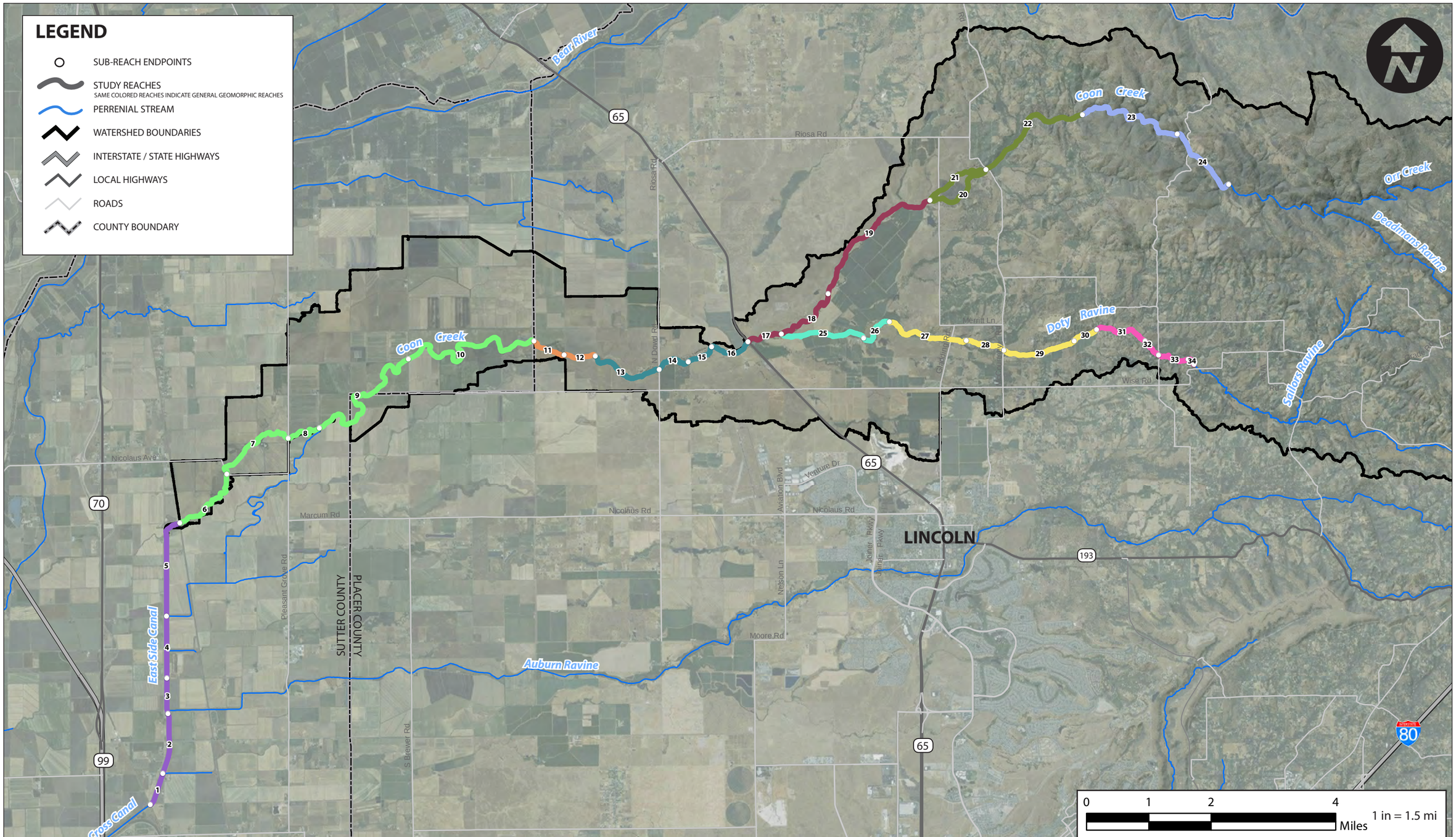
Coon Creek Watershed Assessment

LiDAR and Elevation Data Sets

Project No. 14-1024	Created By: WJL	**Figure 3**



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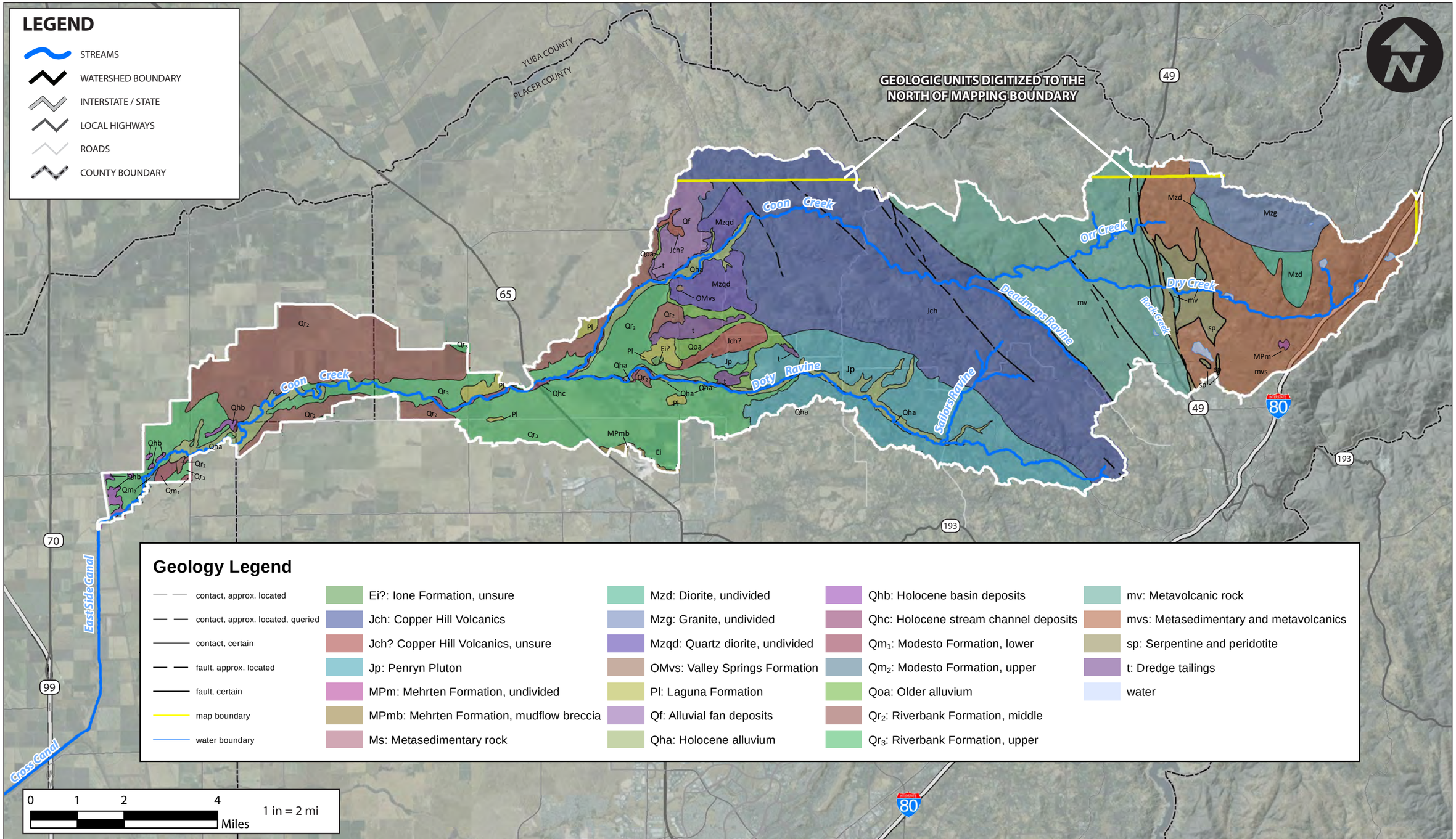
Coon Creek Watershed Assessment

Identification of Geomorphic Sub Reaches

Project No. 14-1024	Created By: SPW	**Figure 4**



Notes: Geology mapping from California Geological Survey's Preliminary Geologic Map of the Sacramento 30' x 60' Quadrangle, California', prepared by Carlos I. Gutierrez (2011).
Areas to the north and east of the dark yellow boundaries were manually digitized from the Chico (1992) and Sacramento (1981) 1:250,000 geologic maps, respectively.

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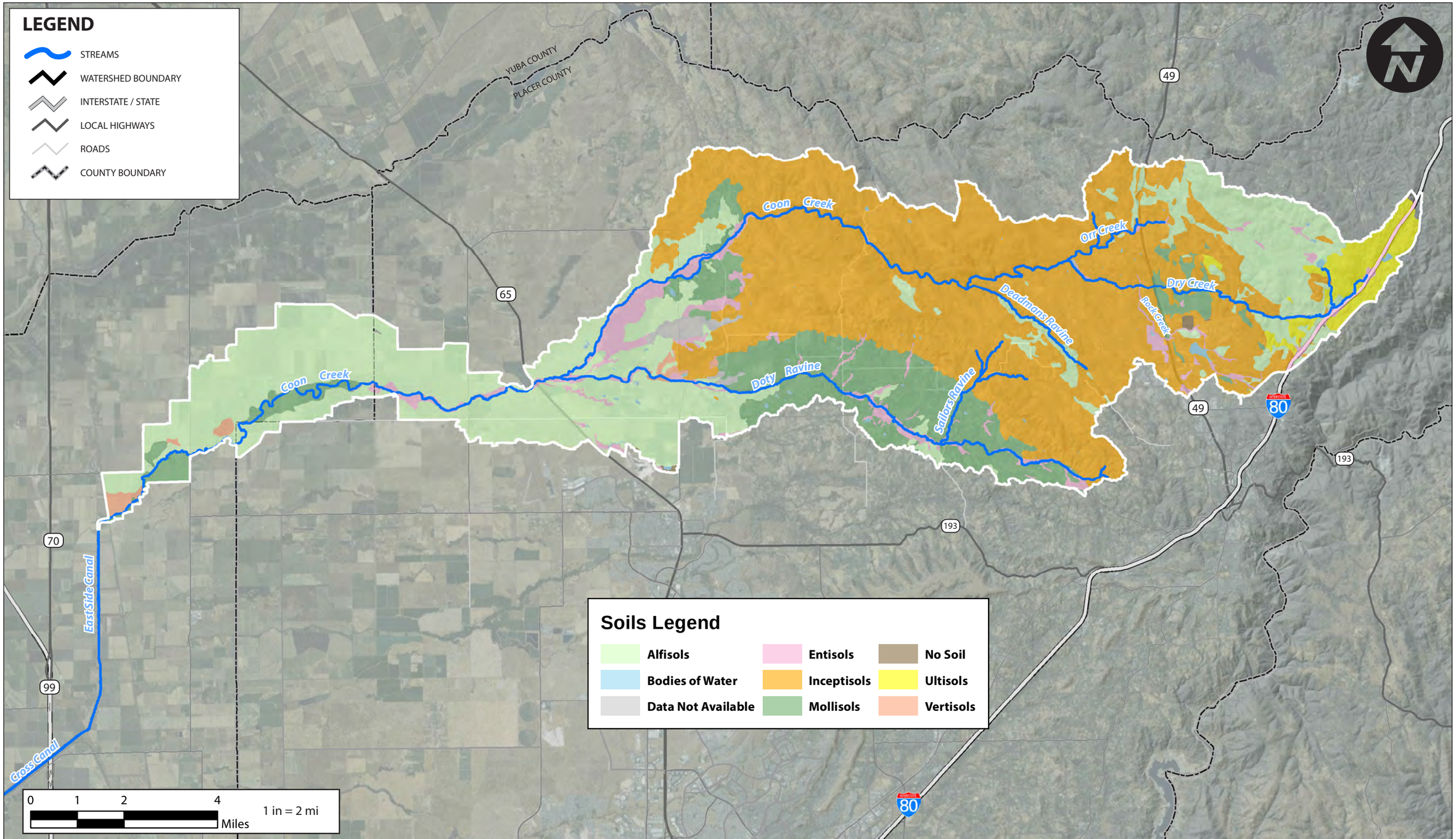
Coon Creek Watershed Assessment

Geology Map

Project No. 14-1024	Created By: SPW	**Figure 5**



Notes: Geology mapping from California Geological Survey's Preliminary Geologic Map of the Sacramento 30' x 60' Quadrangle, California', prepared by Carlos I. Gutierrez (2011).
Areas to the north and east of the dark yellow boundaries were manually digitized from the Chico (1992) and Sacramento (1981) 1:250,000 geologic maps, respectively.

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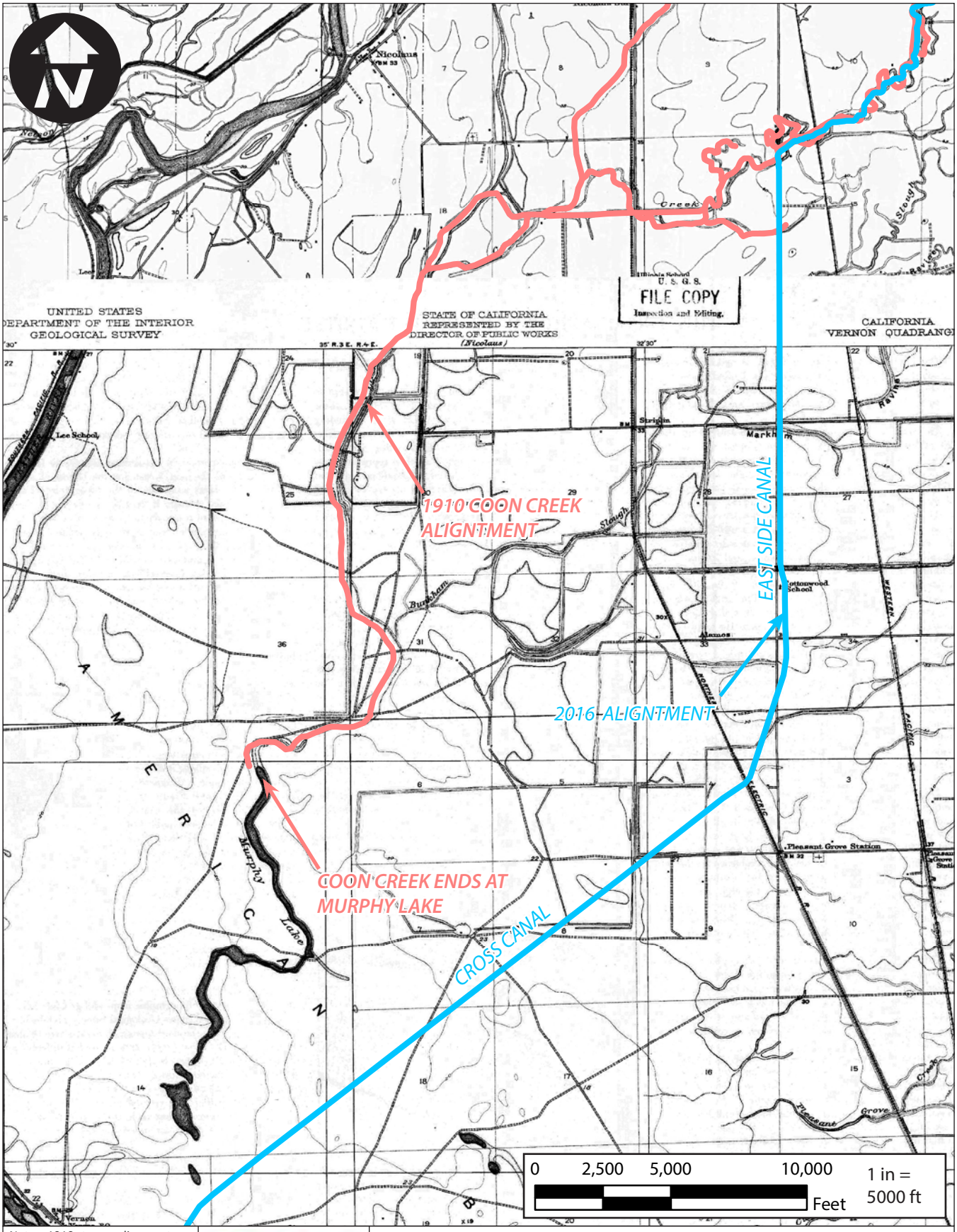
Coon Creek Watershed Assessment

Geology Map

Project No. 14-1024	Created By: SPW	**Figure 6**



Notes: 1910 stream alignment derived from USGS Quadrangle Maps; Stream alignment had already been altered substantially by this time.

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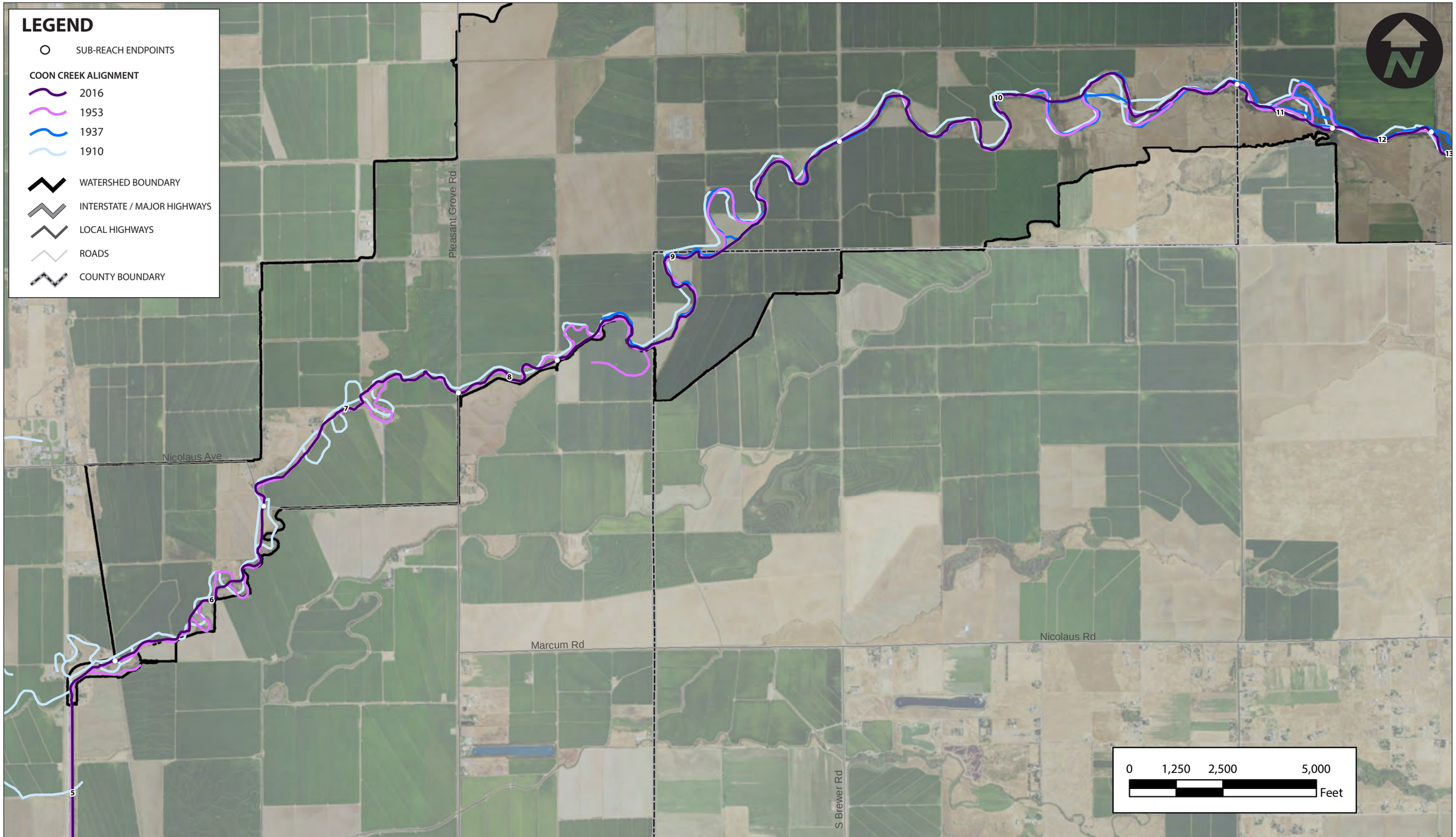
Coon Creek Watershed Assessment

Historic Channel Alignments - Lower Historic Coon Creek

Project No. 14-1024 | Created By: SPW | **Figure 7**



Notes: 1910 stream alignment derived from USGS Quadrangle Maps; Stream alignment had already been altered substantially by this time.

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Coon Creek Watershed Assessment

Historic Channel Alignments - Lower Watershed

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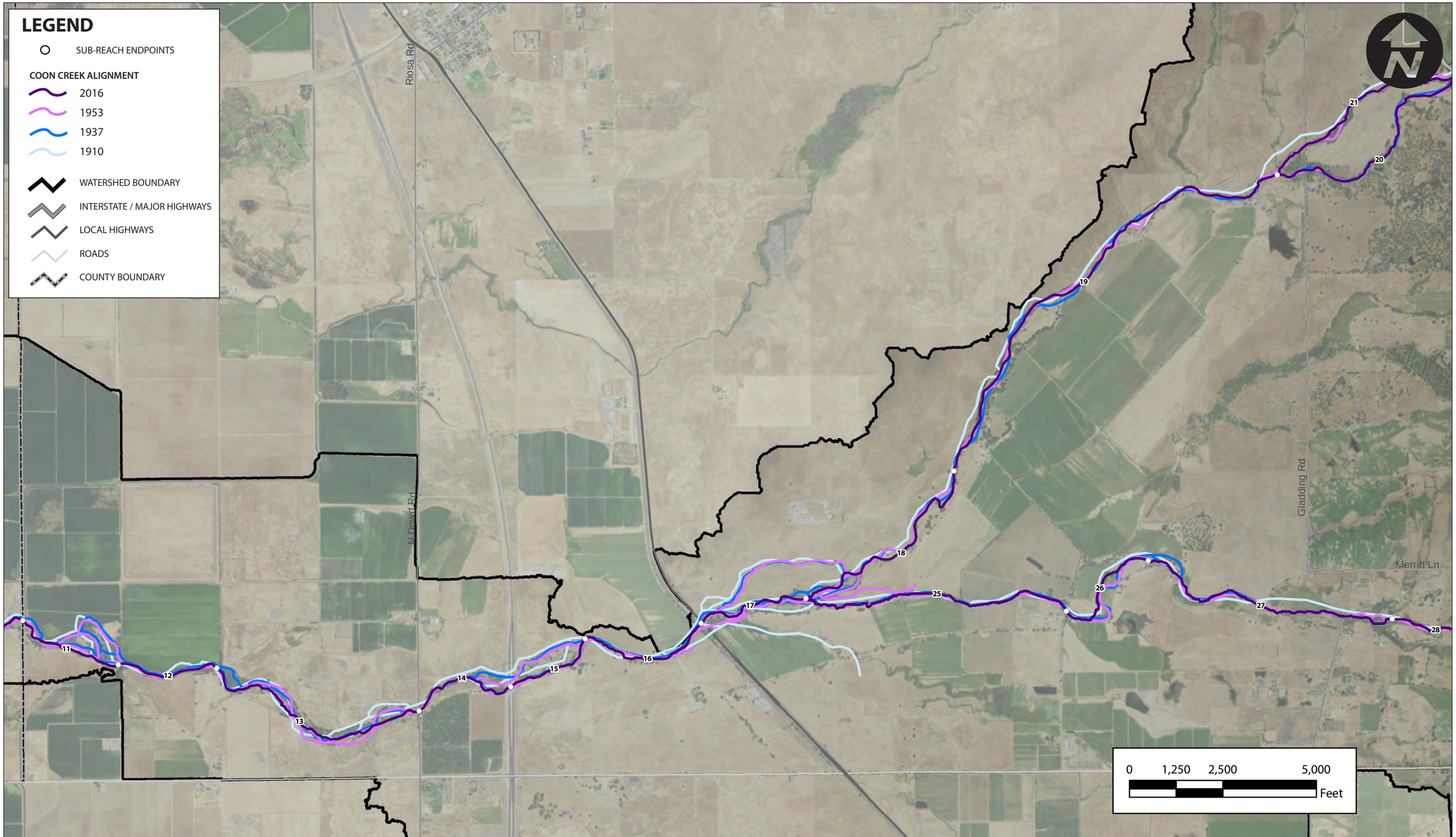

Notes: 1910 stream alignment derived from USGS Quadrangle Maps; Stream alignment had already been altered substantially by this time.

Coon Creek Watershed Assessment

Historic Channel Alignments - Lower to Middle Watershed

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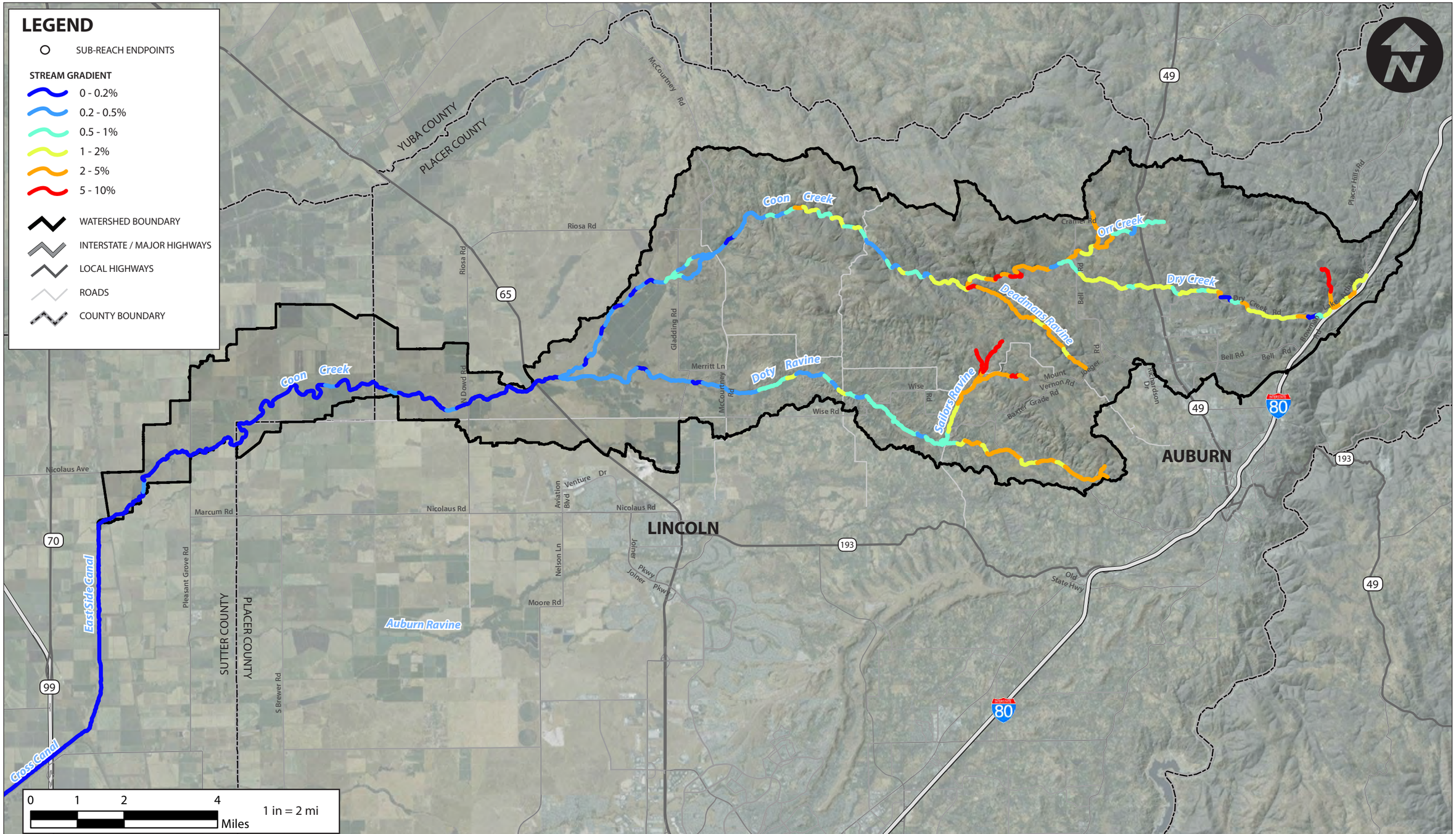

Notes: Stream gradient calculated from composite elevation data set

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Coon Creek Watershed Assessment

Stream Gradient

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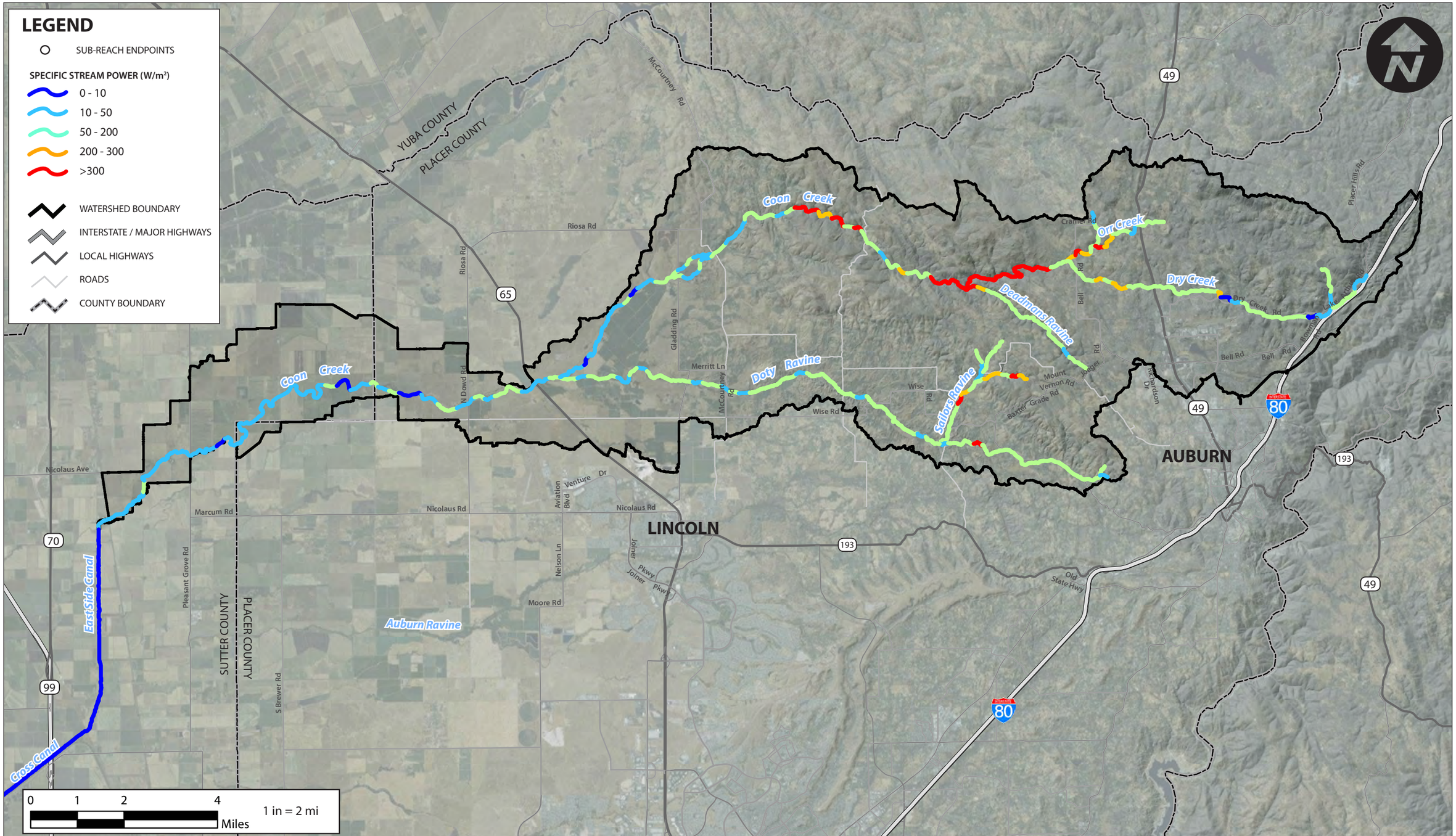

Notes: Stream gradient calculated from composite elevation data set

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Coon Creek Watershed Assessment

Specific Stream Power

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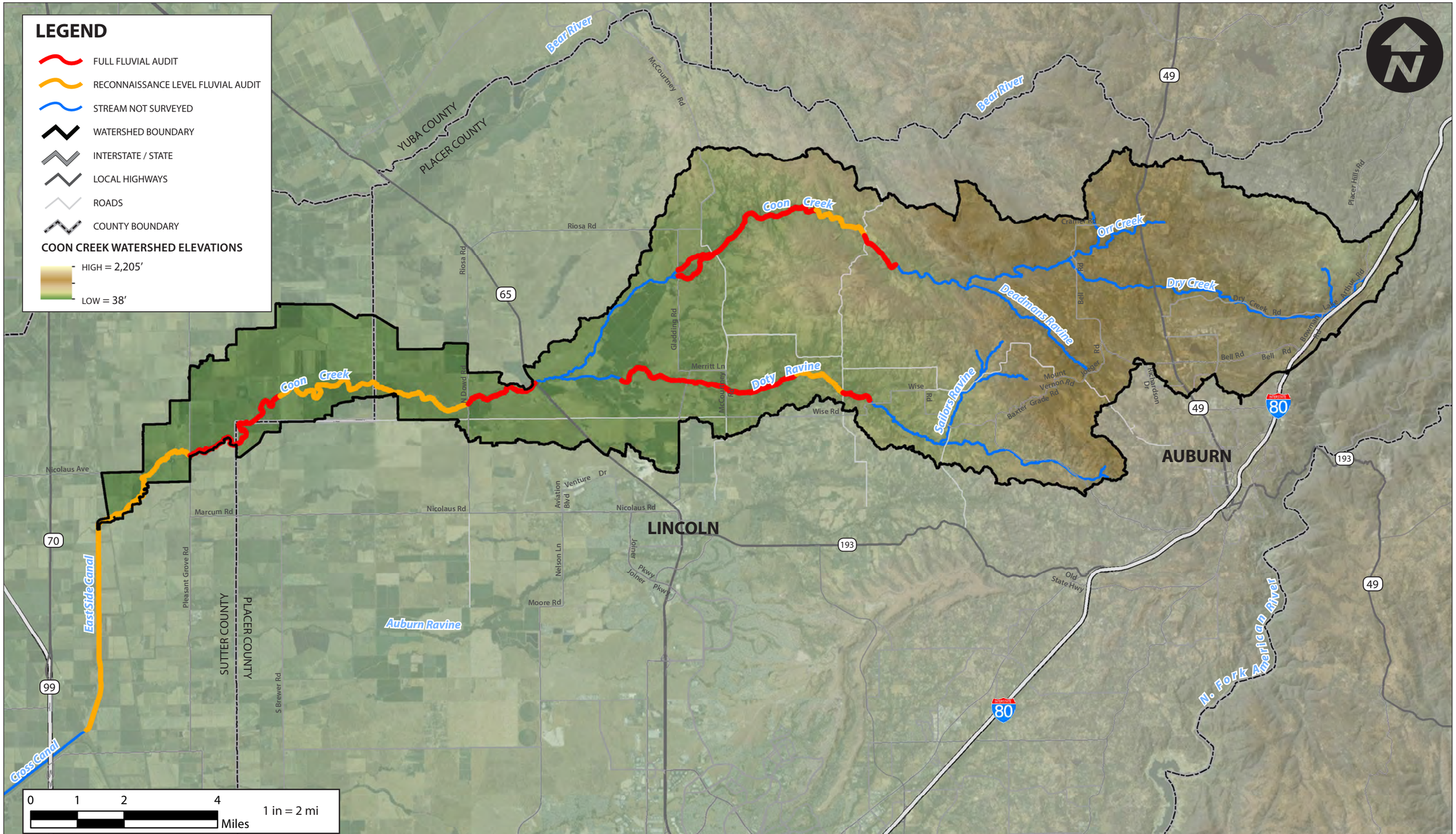

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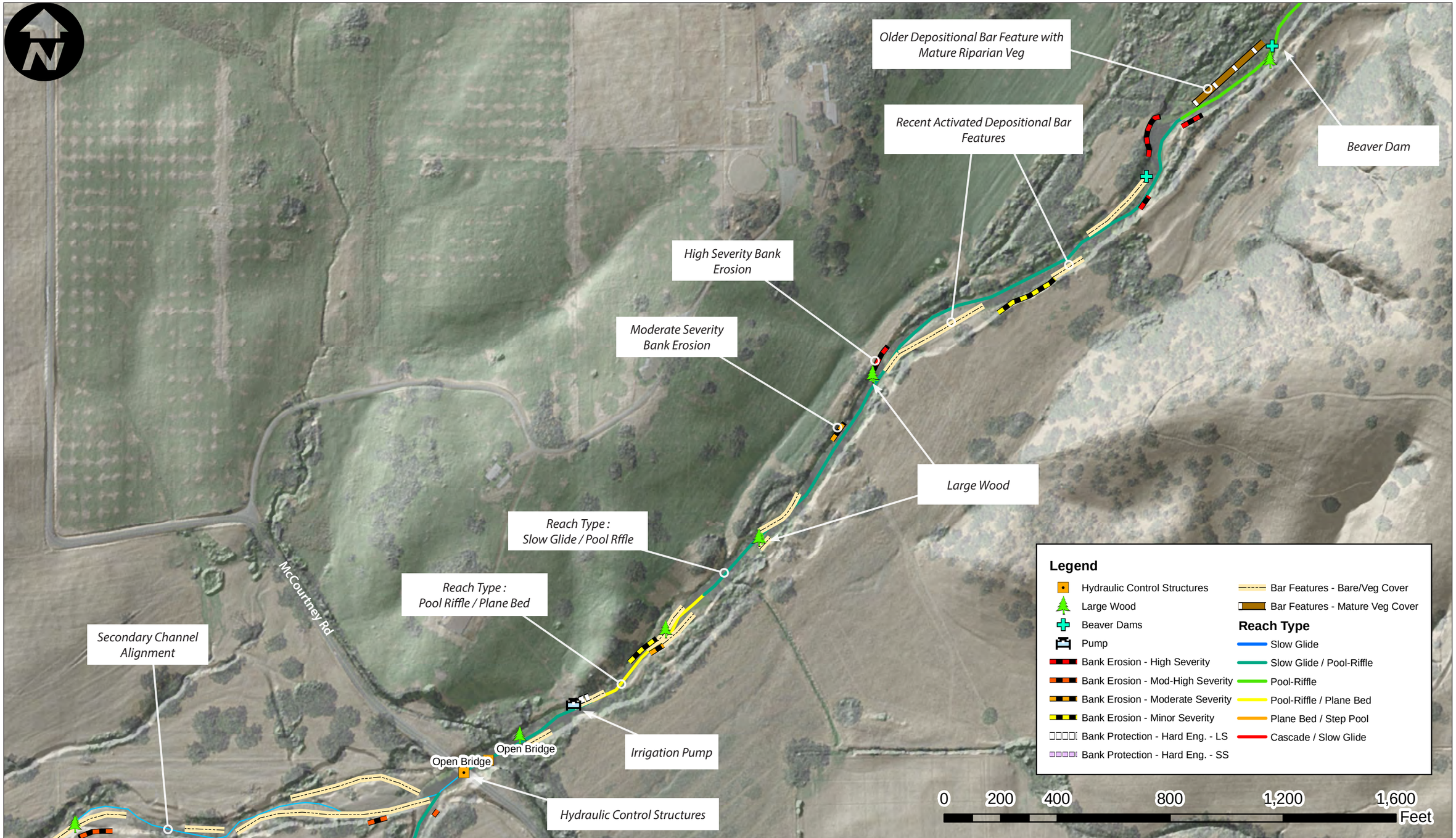
Coon Creek Watershed Assessment

Fluvial Audit Coverage

Project No. 14-1024	Created By: SPW	**Figure 12**



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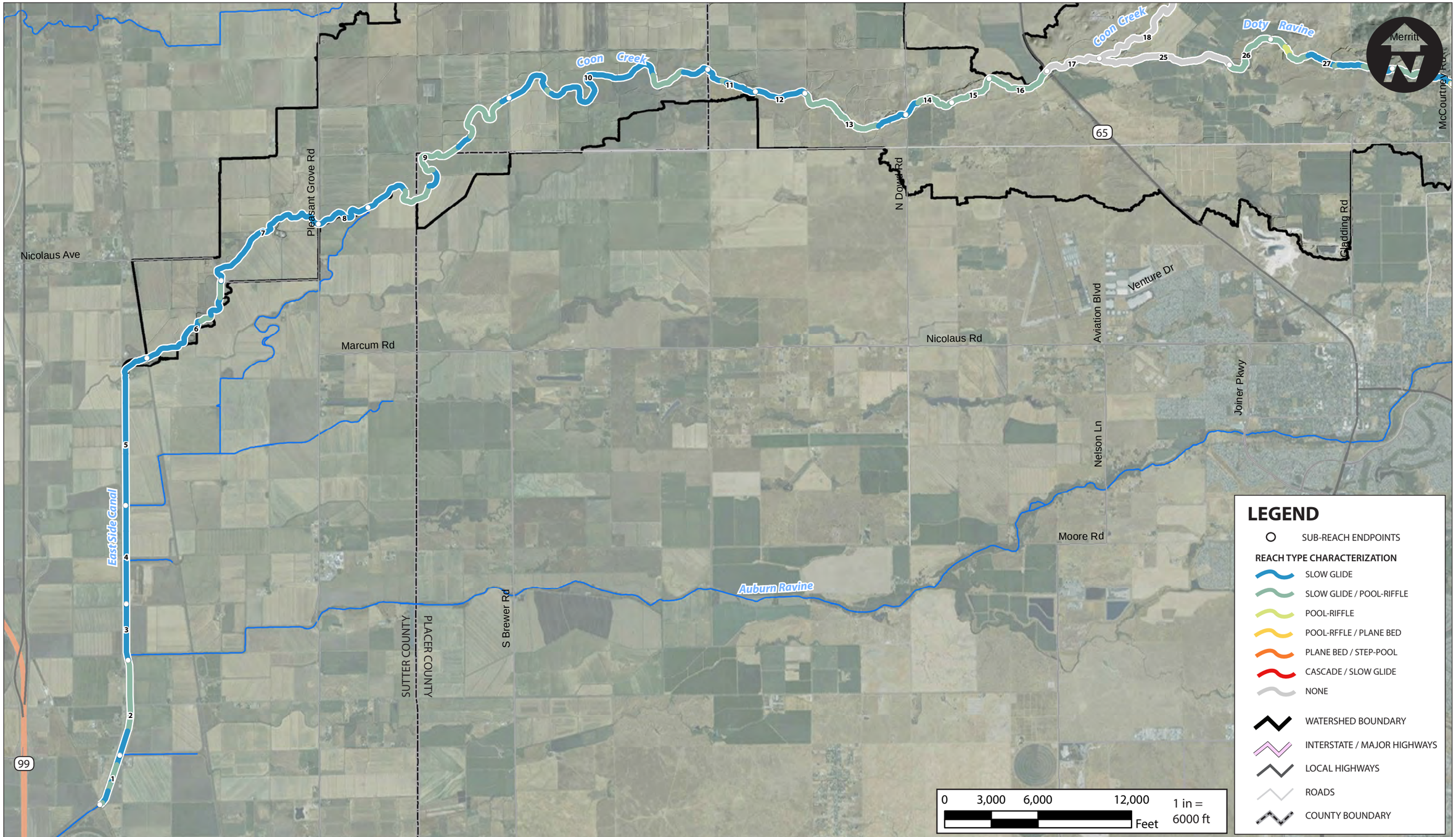
Coon Creek Watershed Assessment

Example Fluvial Audit Data

Project No. 14-1024	Created By: SPW	**Figure 13**



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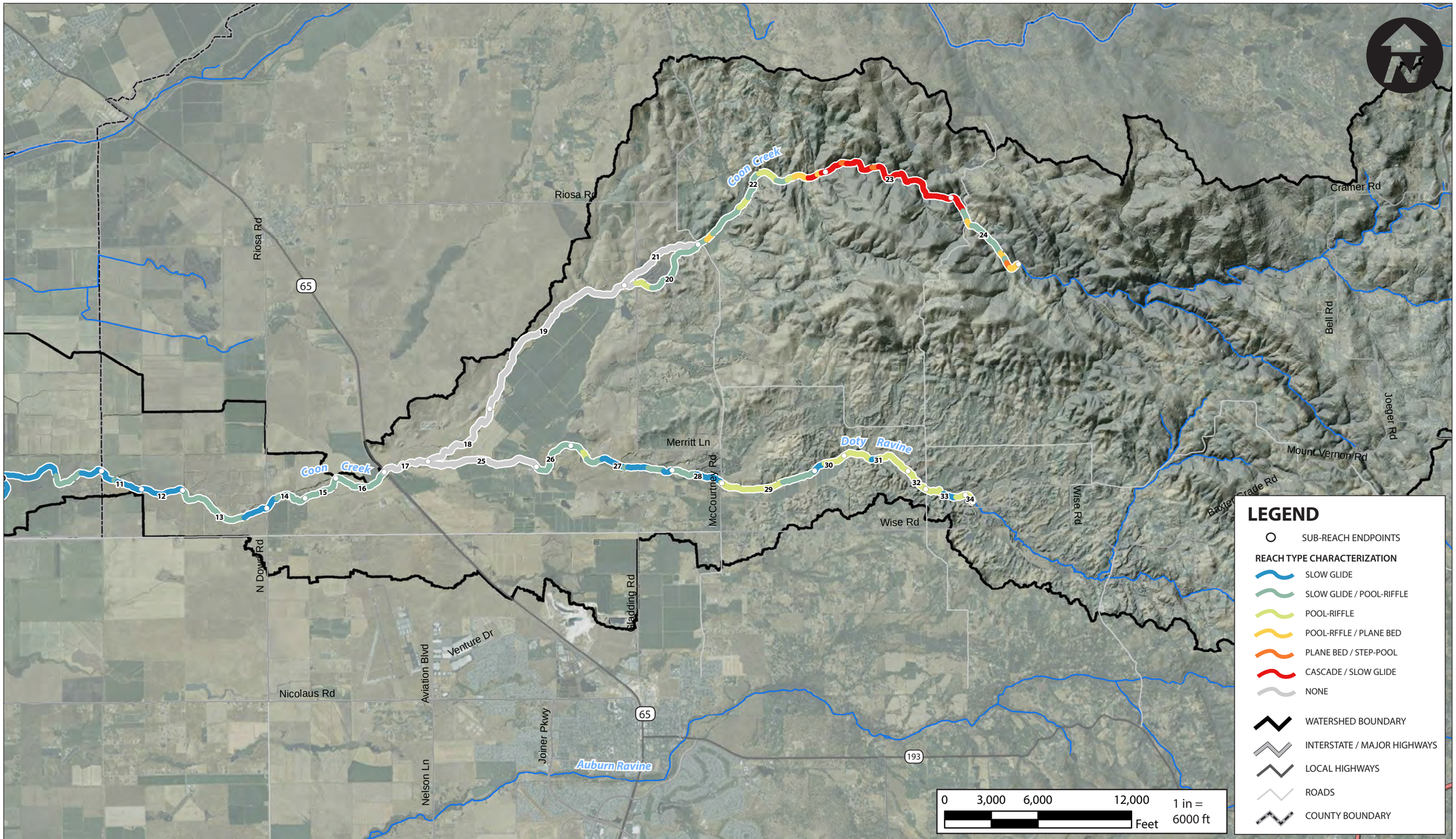
Coon Creek Watershed Assessment

Reach Type Characterization - Lower Watershed

Project No. 14-1024	Created By: SPW	**Figure 14**



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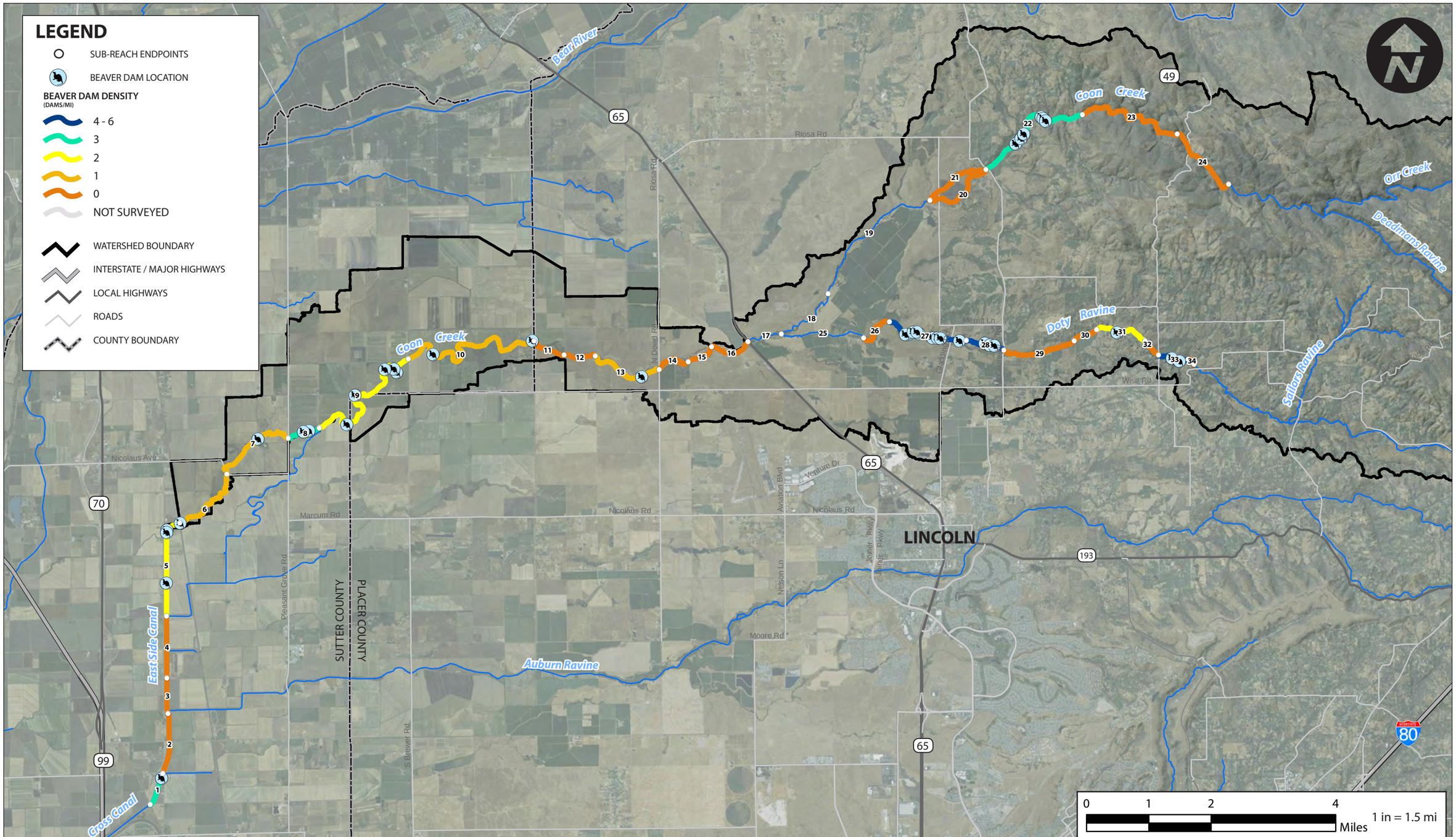
Coon Creek Watershed Assessment

Reach Type Characterization - Middle Watershed

Project No. 14-1024	Created By: SPW	**Figure 15**



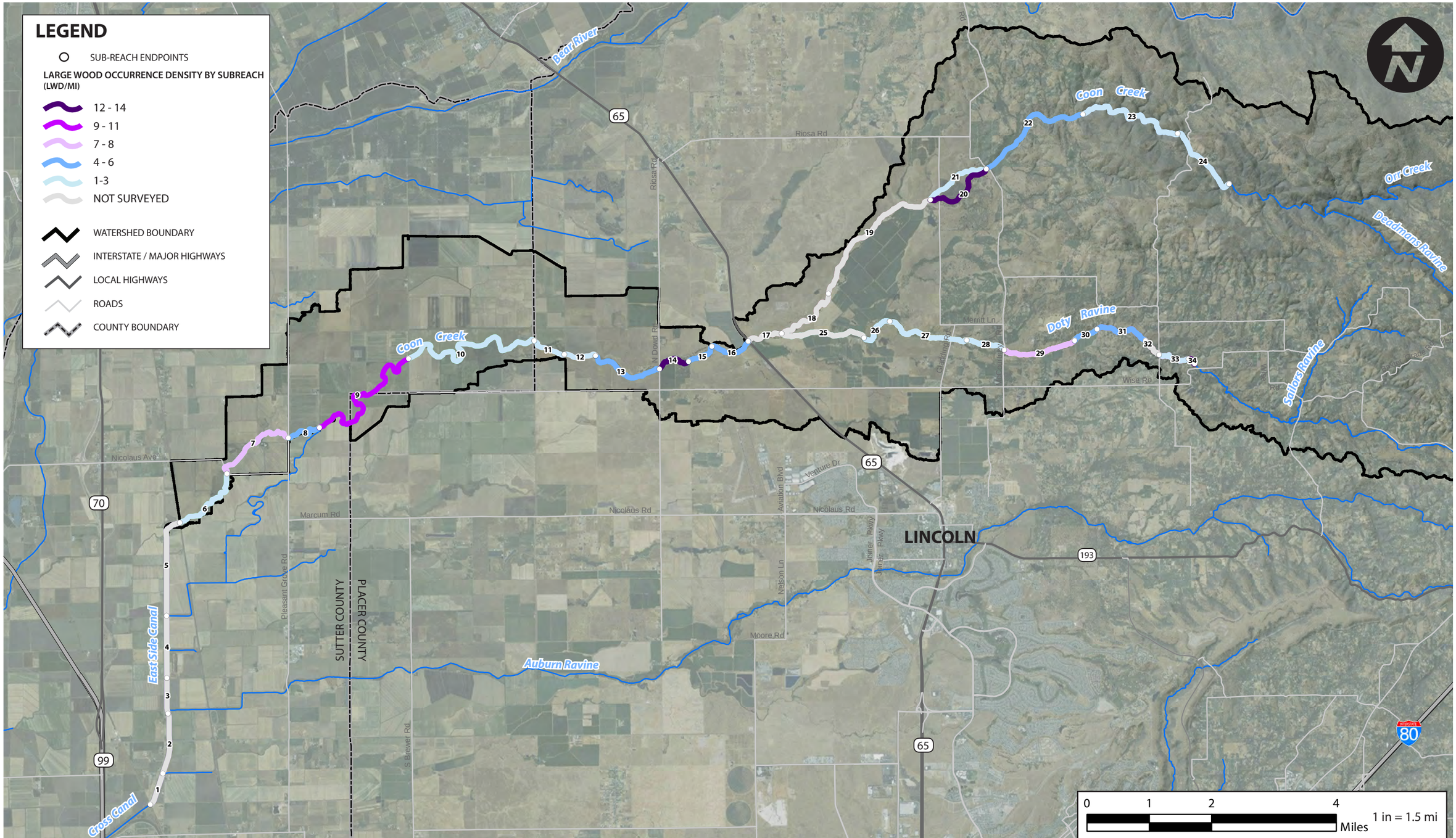
Notes:

cbec

Coon Creek Watershed Assessment

Beaver Dam Density

Project No. 14-1024 | Created By: SPW | **Figure 16**



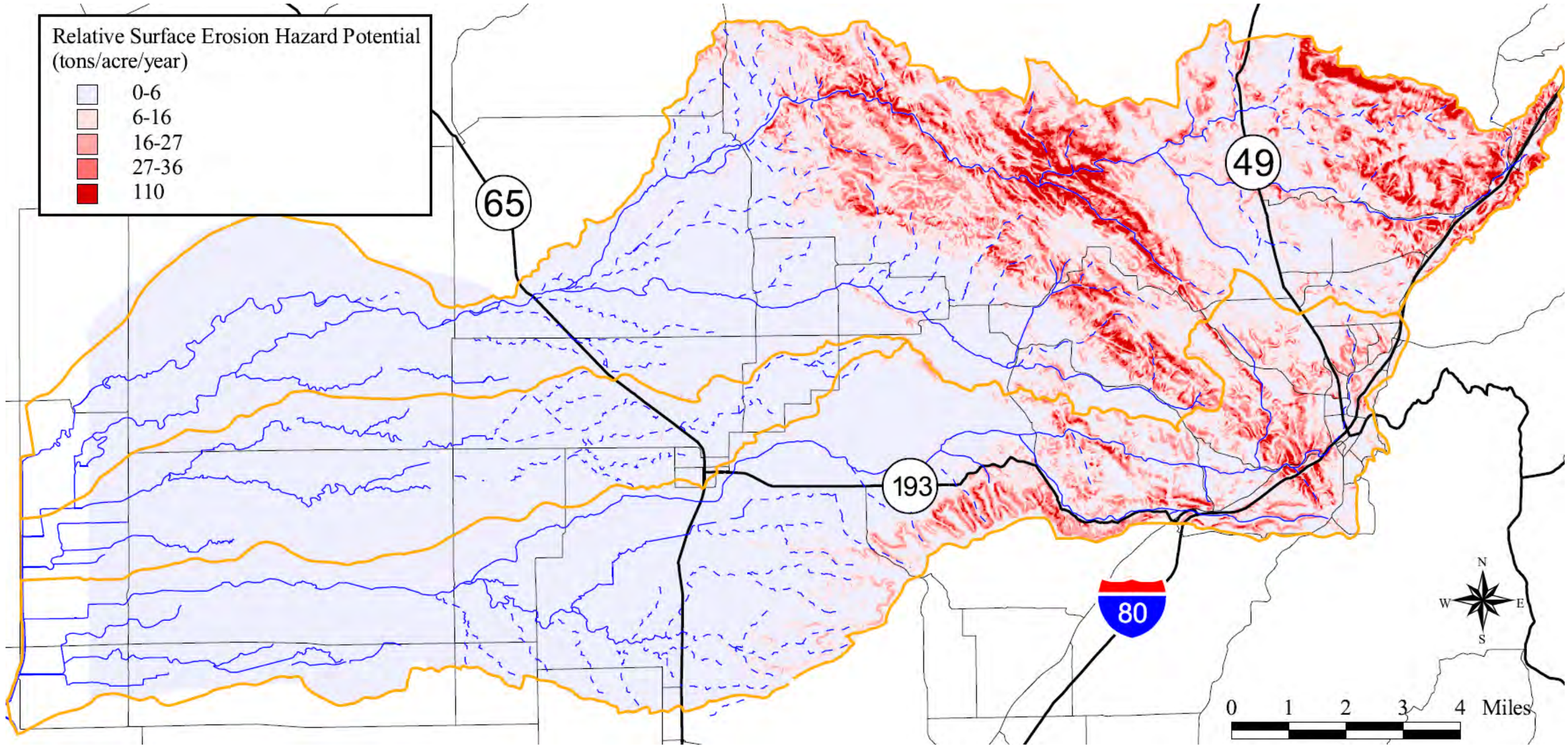
Notes:

cbec

Coon Creek Watershed Assessment

Large Wood Occurrence Density

Project No. 14-1024 | Created By: SPW | **Figure 17**



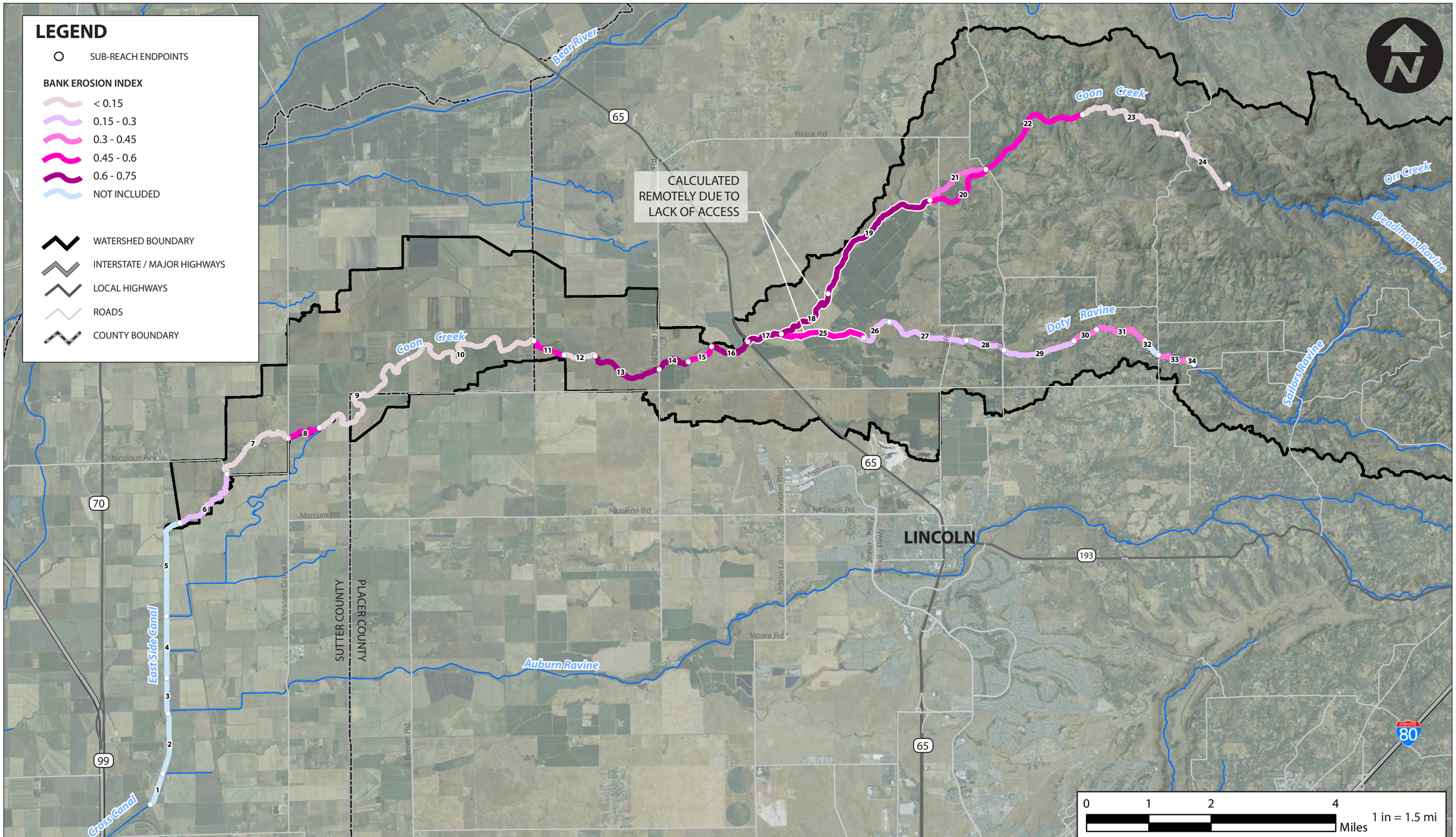
Note: Figure from Auburn Ravine / Coon Creek Ecosystem Restoration Plan (AR/CC ERP) developed for Placer County Planning Department in 2003 by unknown author. Figure is listed as Figure 5-1 in the AR/CC ERP.

cbec eco engineering

Coon Creek Watershed Assessment

Relative Surface Erosion Hazard Potential

Project No. 14-1024	Created By:: Uknown	**Figure 18**



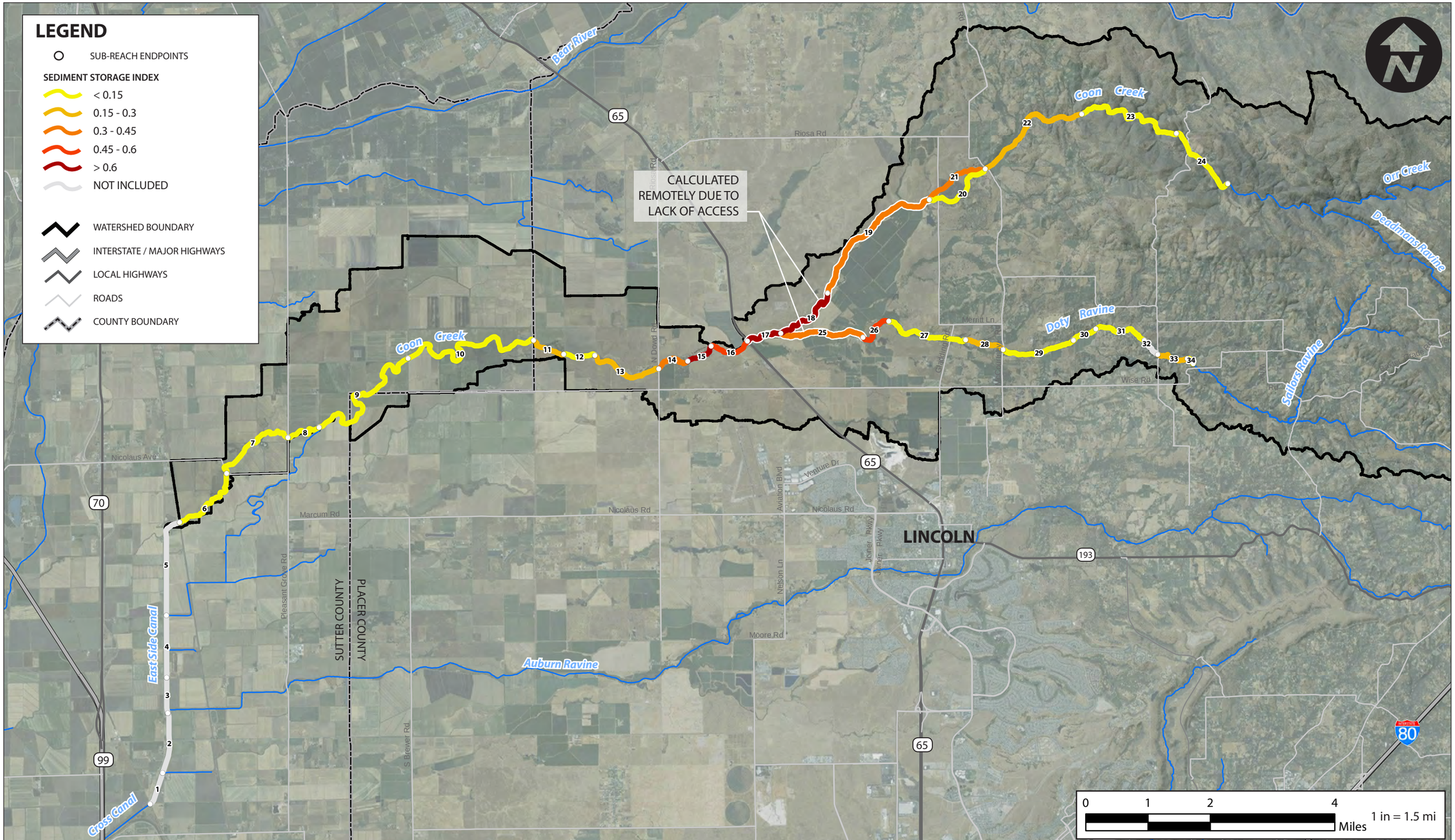
Notes: Index values for sub-reaches 17, 18, 19 and 25 were calculated using aerial imagery and LiDAR only as ground access was not provided for field assessment.

cbec

Coon Creek Watershed Assessment

Bank Erosion Index

Project No. 14-1024	Created By: SPW	**Figure 19**



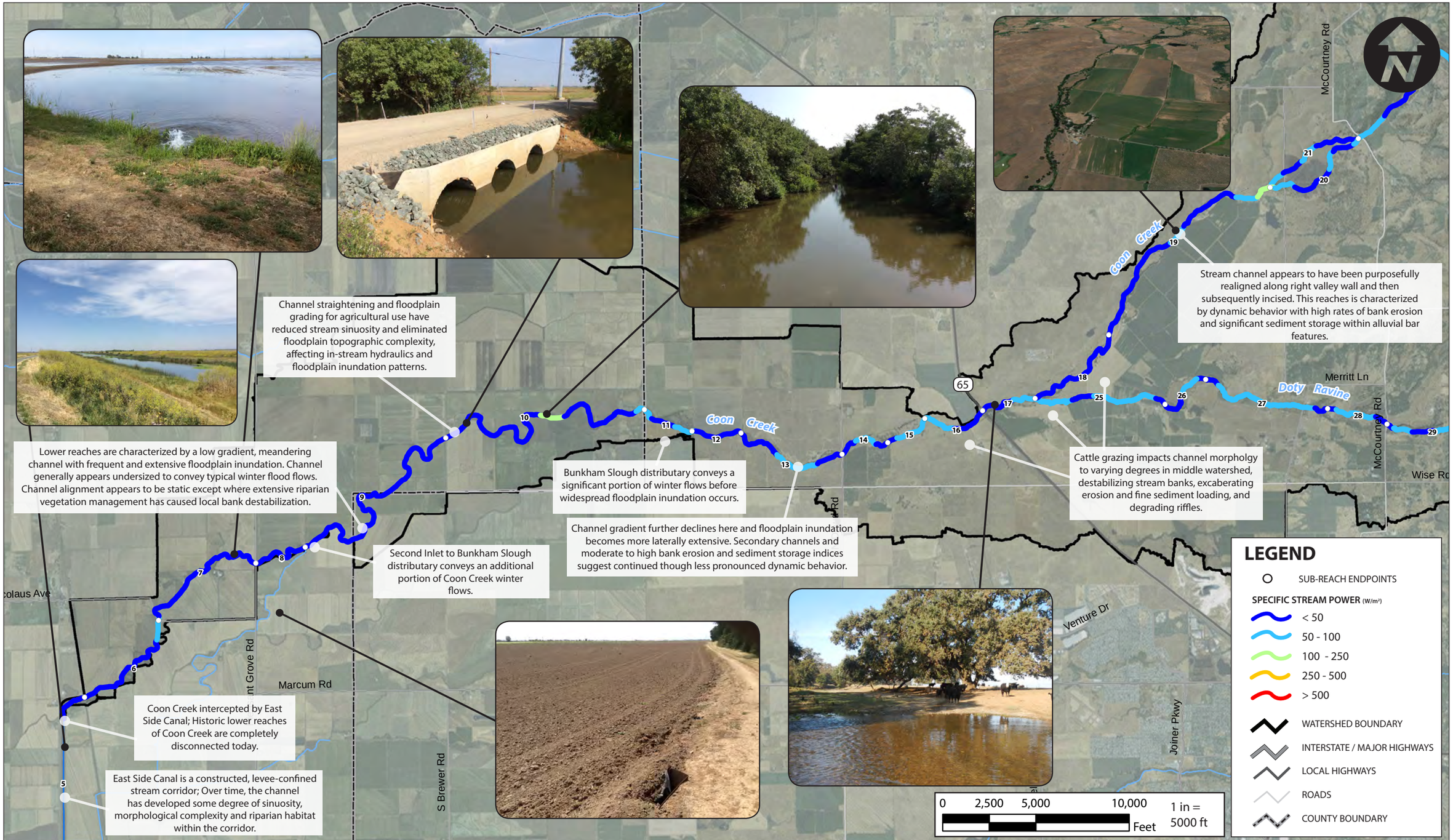
Notes: Index values for sub-reaches 17, 18, 19 and 25 were calculated using aerial imagery and LiDAR only as ground access was not provided for field assessment.

cbec

Coon Creek Watershed Assessment

Sediment Storage Index

Project No. 14-1024	Created By: SPW	**Figure 20**



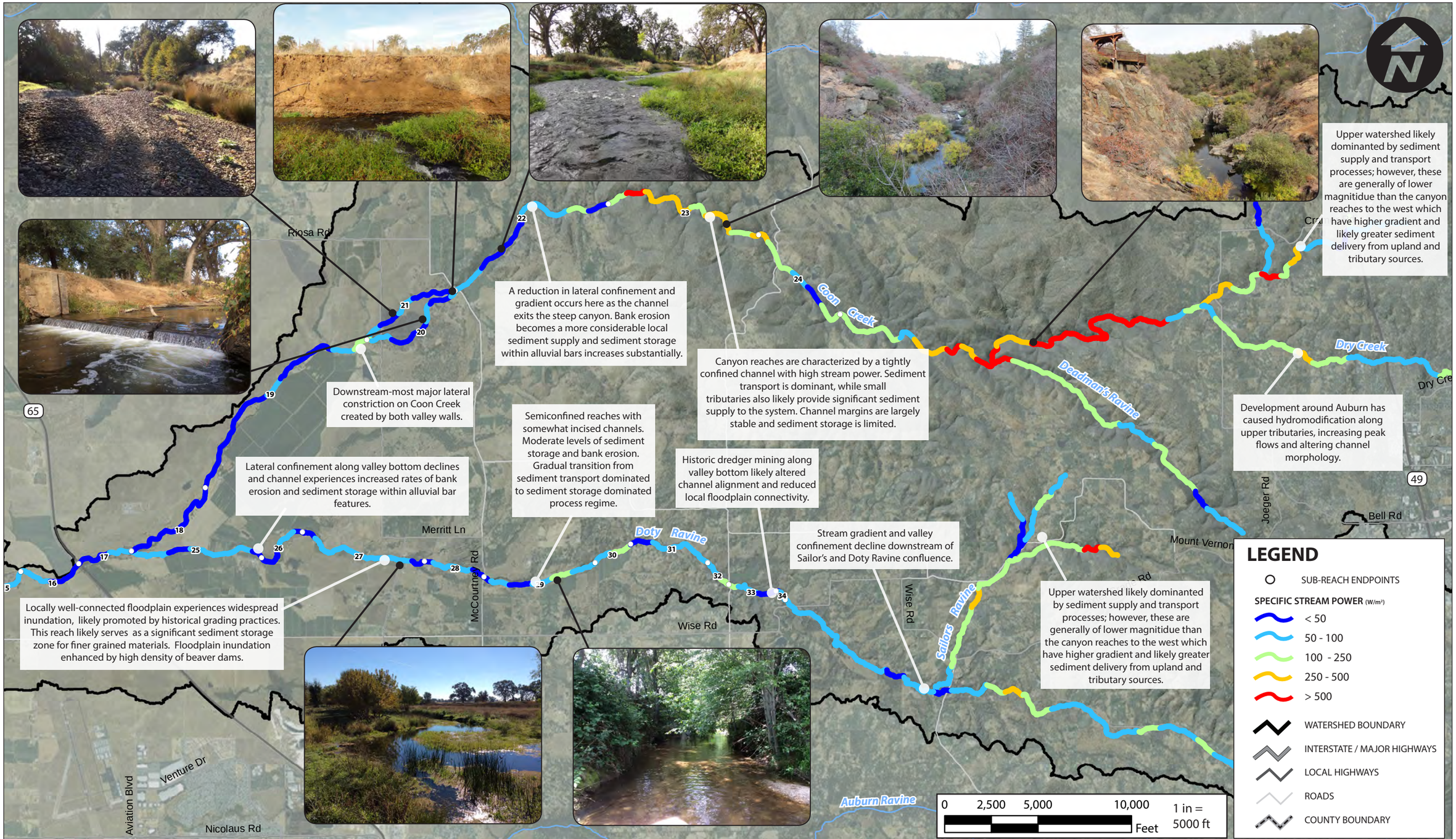
Notes:

cbec

Coon Creek Watershed Assessment

Geomorphic Process Regime - Lower Watershed

Project No. 14-1024	Created By: SPW	**Figure 21**



Notes:

cbec

Coon Creek Watershed Assessment

Geomorphic Process Regime - Middle Watershed

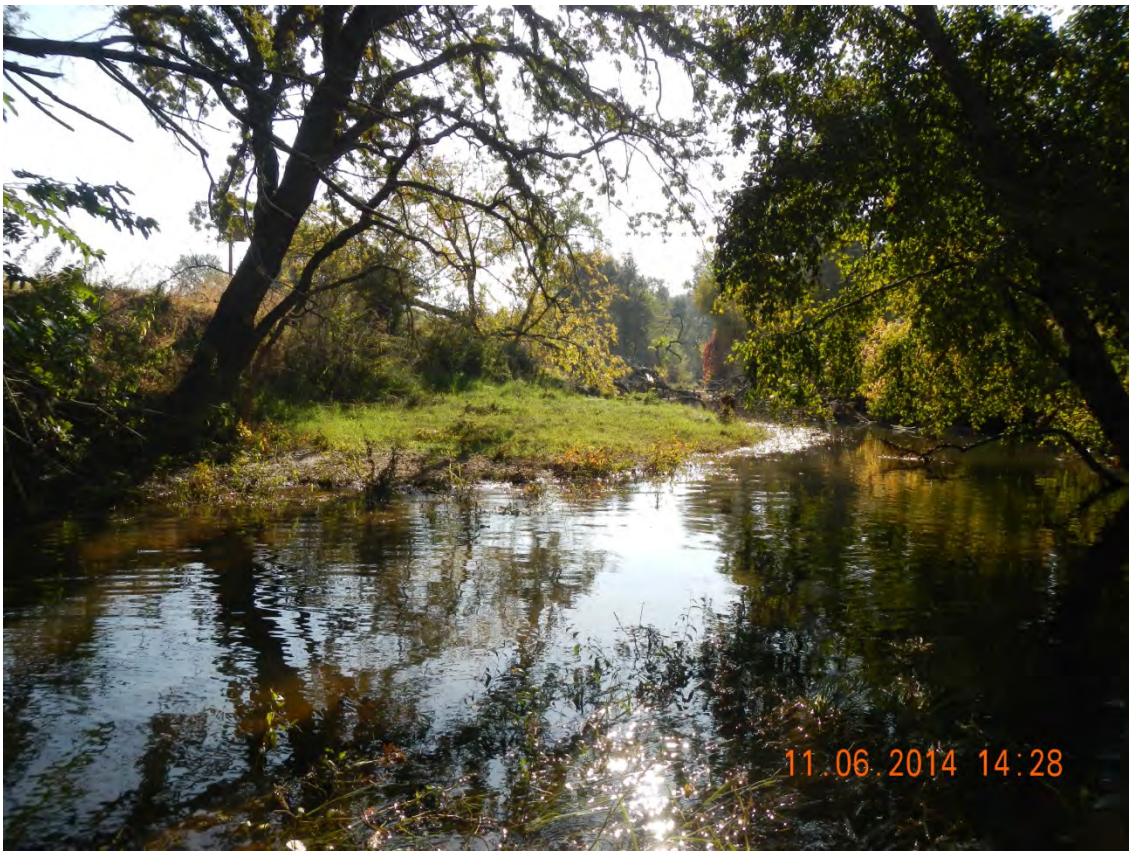
Project No. 14-1024 | Created By: SPW | **Figure 22**

Notes:		*Coon Creek Watershed Assessment*		
		East Side Canal		
		Project No. 14-1024	Created By: JDS	**Figure 23**

Notes: Reach 9 aerial view (above) and ground-based photo (below)	cbec eco engineering	*Coon Creek Watershed Assessment* **Lower Coon Creek - Reach 9**		
		Project No. 14-1024	Created By: JDS	**Figure 24**

Notes: Reach 8 (above) and Reach 10 (below)	cbec eco engineering	*Coon Creek Watershed Assessment* **Lower Coon Creek - Reach 8 and Reach 10**		
		Project No. 14-1024	Created By: JDS	**Figure 25**

Notes: Reach 11 (above) and Reach 12 (below)	cbec eco engineering	*Coon Creek Watershed Assessment* **Coon Creek - Reaches 11 and 12**		
		Project No. 14-1024	Created By: JDS	**Figure 26**

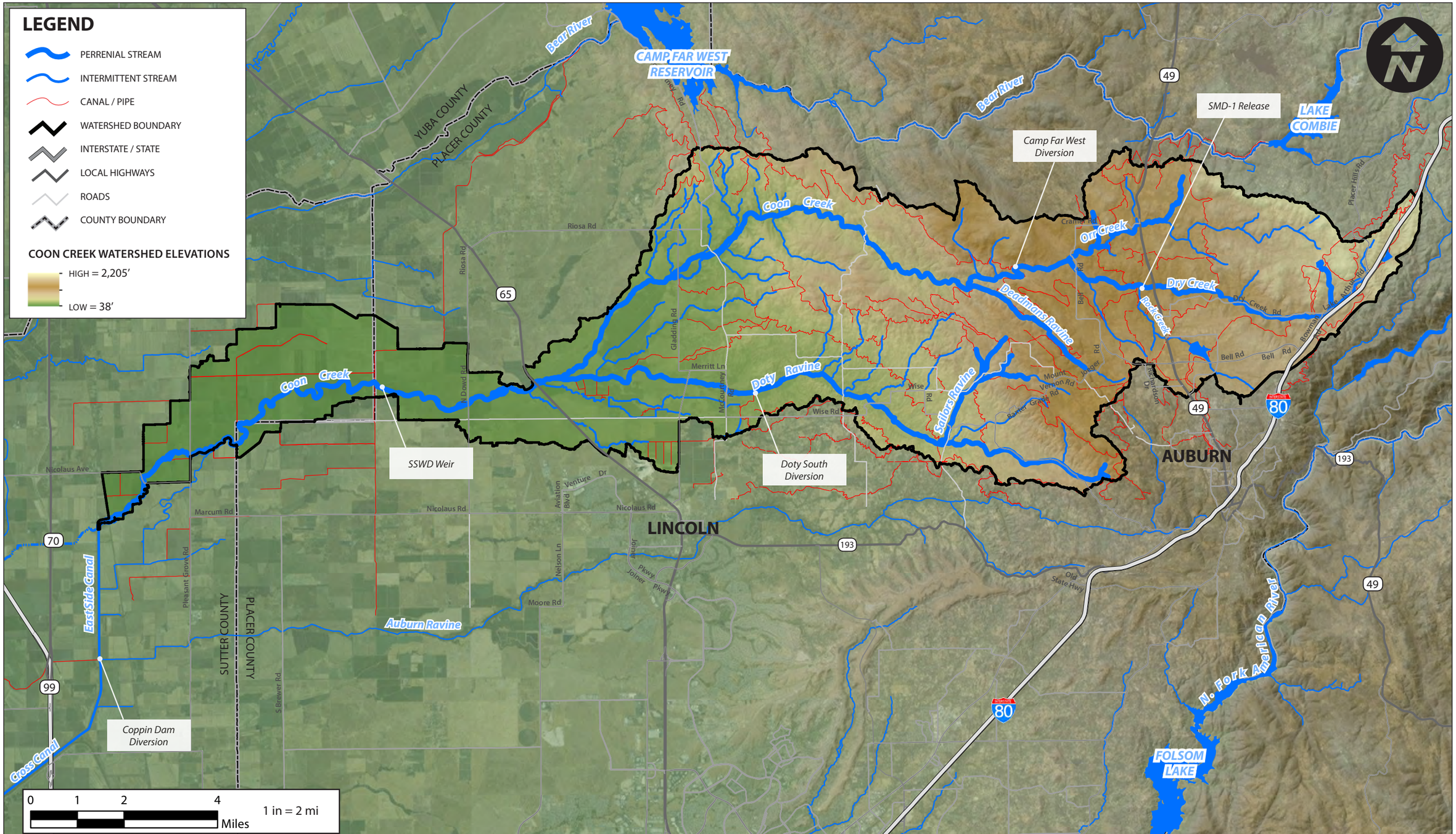


Notes: Reach 14 (above) and Reach 16 (below)	cbec eco engineering	*Coon Creek Watershed Assessment* **Coon Creek - Reaches 14 and 16**		
		Project No. 14-1024	Created By: JDS	**Figure 27**

Notes: Reach 20 above Gladding Road (above) and Reach 22 above McCourtney Road (below)	cbec eco engineering	*Coon Creek Watershed Assessment* **Coon Creek - Reaches 20 and 22**		
		Project No. 14-1024	Created By: JDS	**Figure 28**

Notes: Reach 23	cbec eco engineering	*Coon Creek Watershed Assessment* **Coon Creek - Lower Canyon Reach**		
		Project No. 14-1024	Created By: JDS	**Figure 29**

Notes: Coon Creek at Taylor Ranch (above) and Hidden Falls Regional Park (below)	cbec eco engineering	*Coon Creek Watershed Assessment* **Coon Creek - Upper Canyon Reaches**		
		Project No. 14-1024	Created By: JDS	**Figure 30**



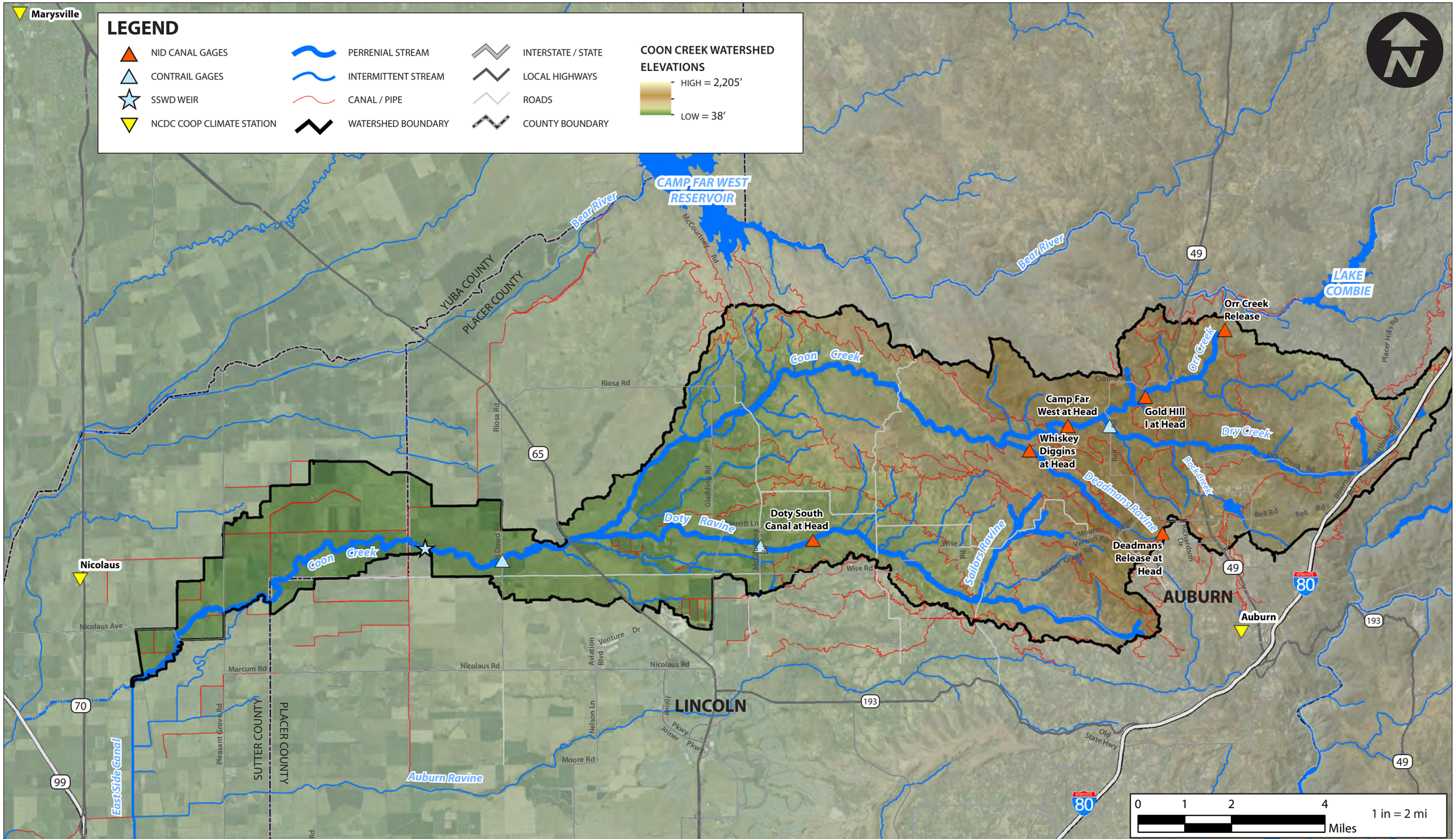
Notes:

cbec

Coon Creek Watershed Assessment

Coon Creek Hydrography Overview

Project No. 14-1024	Created By: SPW	**Figure 31**



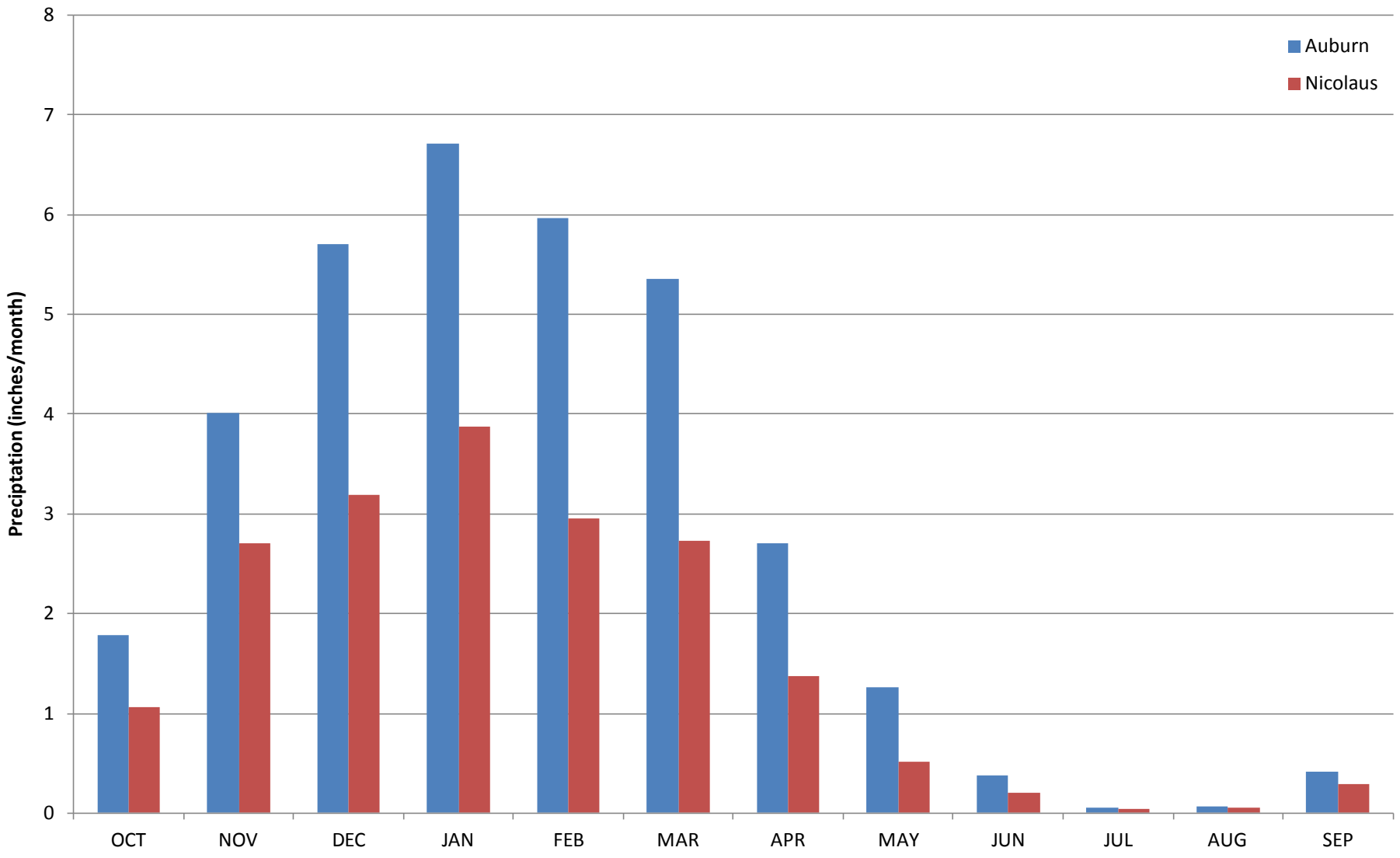
Notes:

cbec

Coon Creek Watershed Assessment

Coon Creek Hydrology Gaging and Climate Station Locations

Project No. 14-1024	Created By: SPW	**Figure 32**

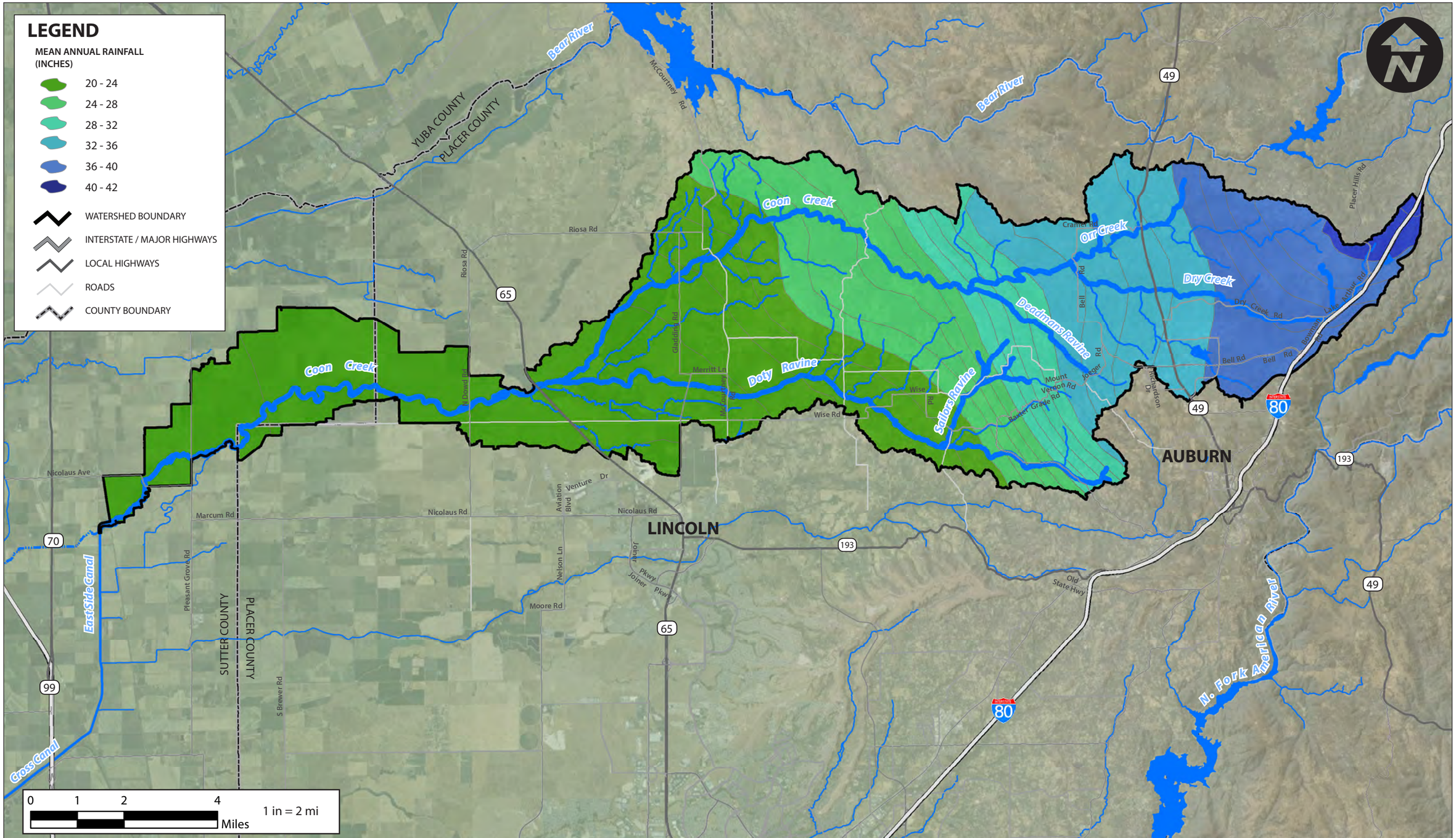


Notes: Plots derived from preciptiation data for the NCDC COOP monitoring stations in Auburn, CA (GHCND:USC00040383) and Nicolaus, CA (GHCND:) for time periods of 1914-2008 and 1962-2008, respectively.

Coon Creek Watershed Assessment

Average Monthly Precipitation

Project No. 14-1024	Created By: WJL	**Figure 33**



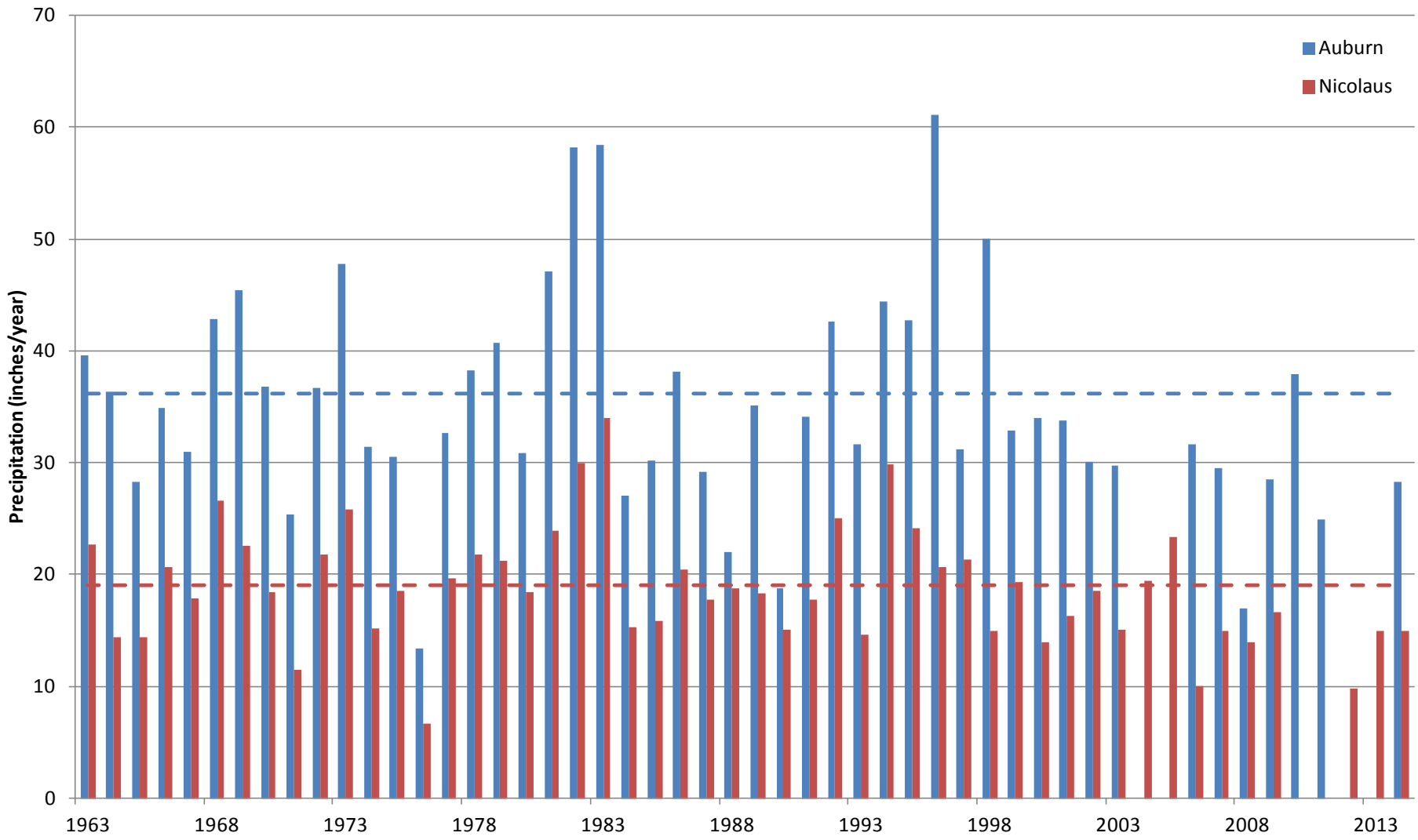
Notes: Spatial precipitation data from PRISM Climate Group of Oregon State and the USDA.

cbec

Coon Creek Watershed Assessment

Mean Annual Rainfall

Project No. 14-1024	Created By: SPW	**Figure 34**

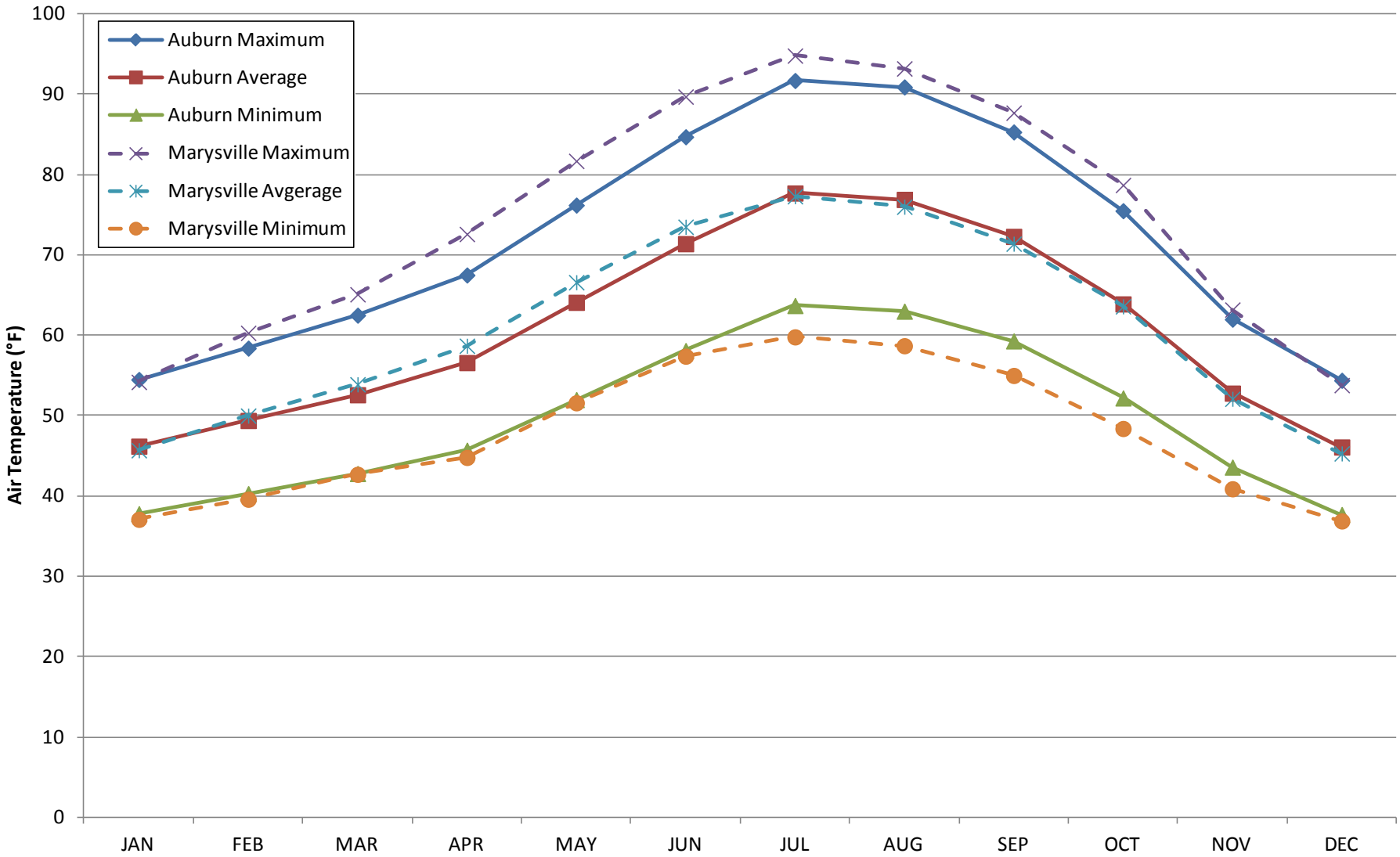


Notes: Plots derived from preciptiation data for the NCDC COOP monitoring stations in Auburn, CA (GHCND:USC00040383) and Nicolaus, CA (GHCND).

Coon Creek Watershed Assessment

Annual Precipitation for Auburn and Nicolaus

Project No. 14-1024	Created By: WJL	**Figure 35**



Notes: Plots derived from 30-year temperature normals from 1980 to 2010 for the NCDC COOP monitoring stations in Auburn, CA (GHCND:USC00040383) and Marysville, CA (GHCND:USW00093205).

Coon Creek Watershed Assessment

Average Monthly Air Temperatures

Project No. 14-1024	Created By: WJL	**Figure 36**

Notes: Camp Far West Diversion Dam (above) and canal inlet (below)

Coon Creek Watershed Assessment

Camp Far West Diversion Dam and Canal Inlet

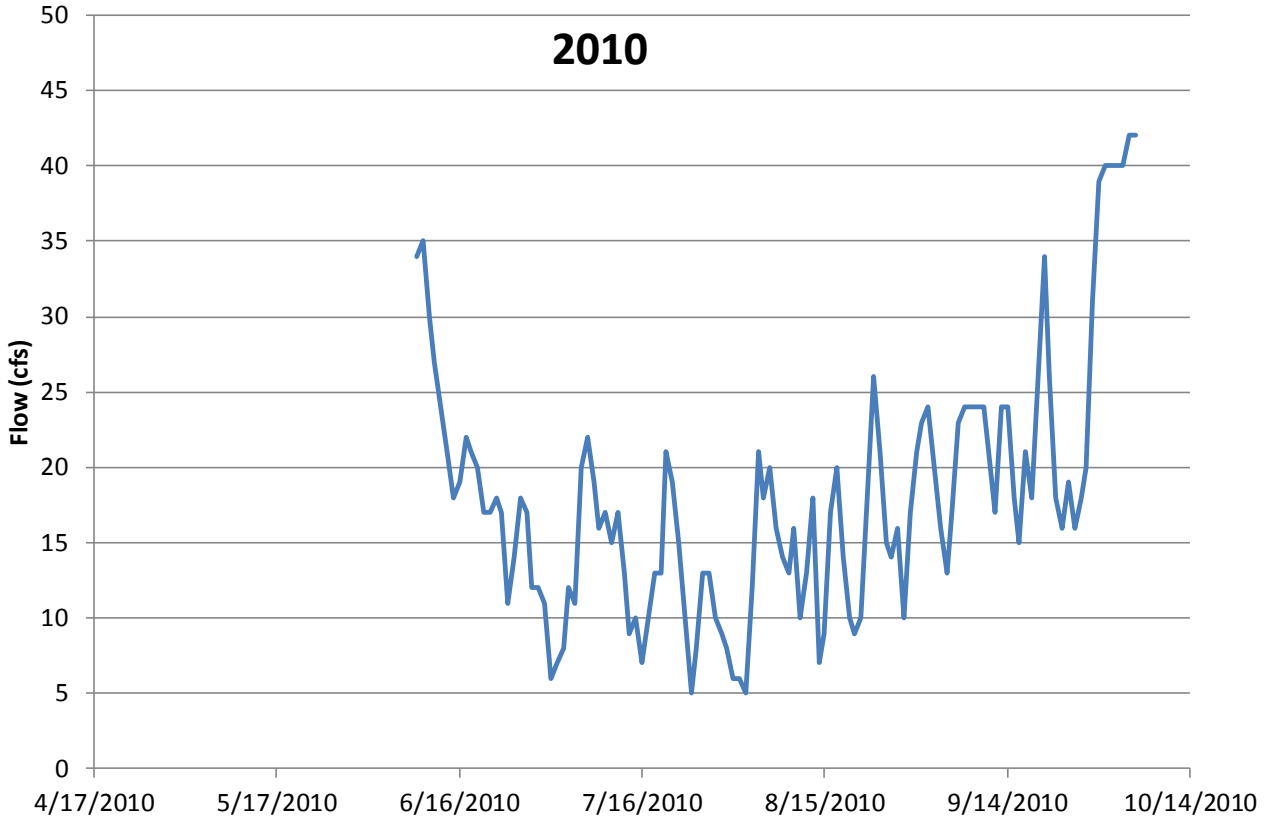
Project No. 14-1024	Created By: JDS	**Figure 37**

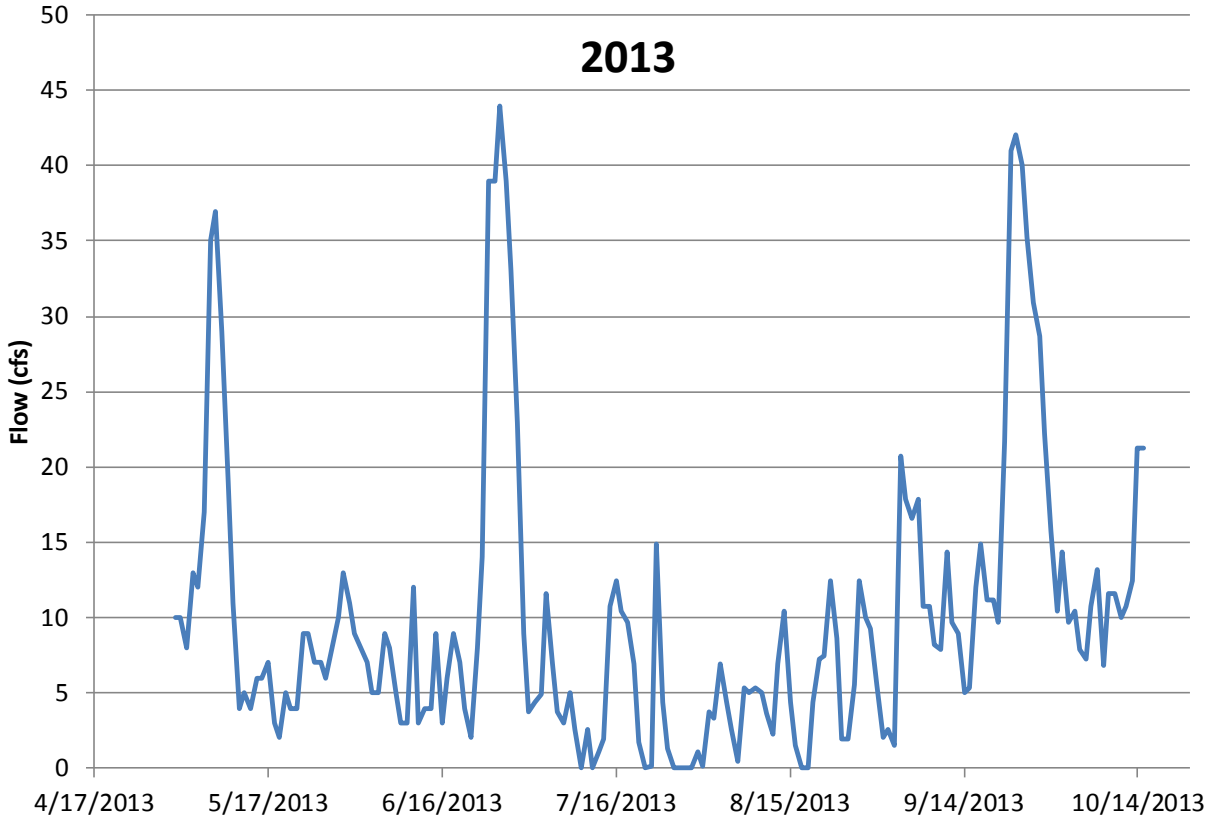
Notes: Wicket gate dam and diversion intake (above) and rock ramp below dam (below)

Coon Creek Watershed Assessment

Doty South at Head Diversion Dam

Project No. 14-1024	Created By: JDS	**Figure 38**



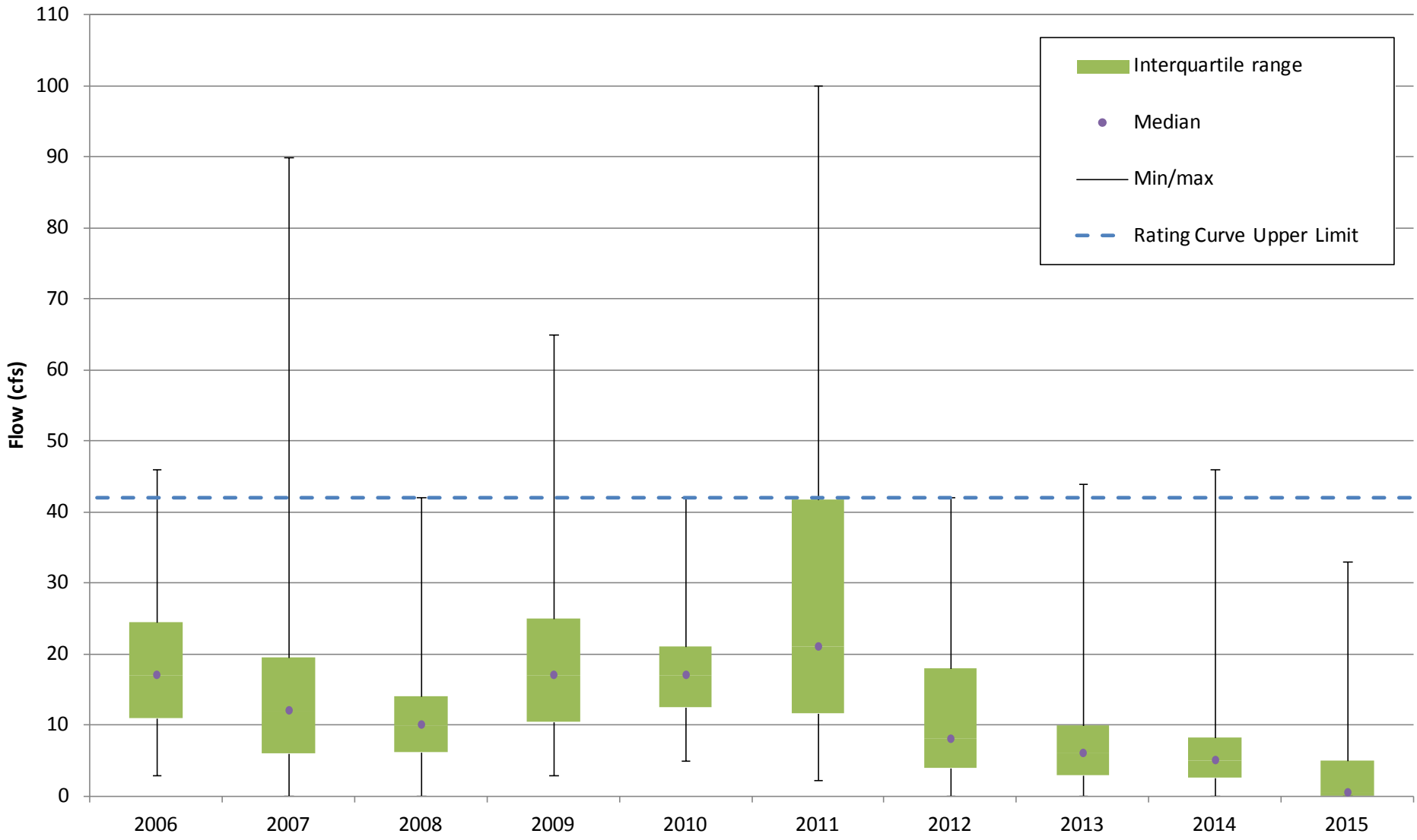


Notes: Data from SSWD weir located on Coon Creek just upstream of Placer-Sutter boundary.

Coon Creek Watershed Assessment

Coon Creek Flows at SSWD Weir in 2010 and 2013

Project No. 14-1024 | Created By: WJL | **Figure 39**

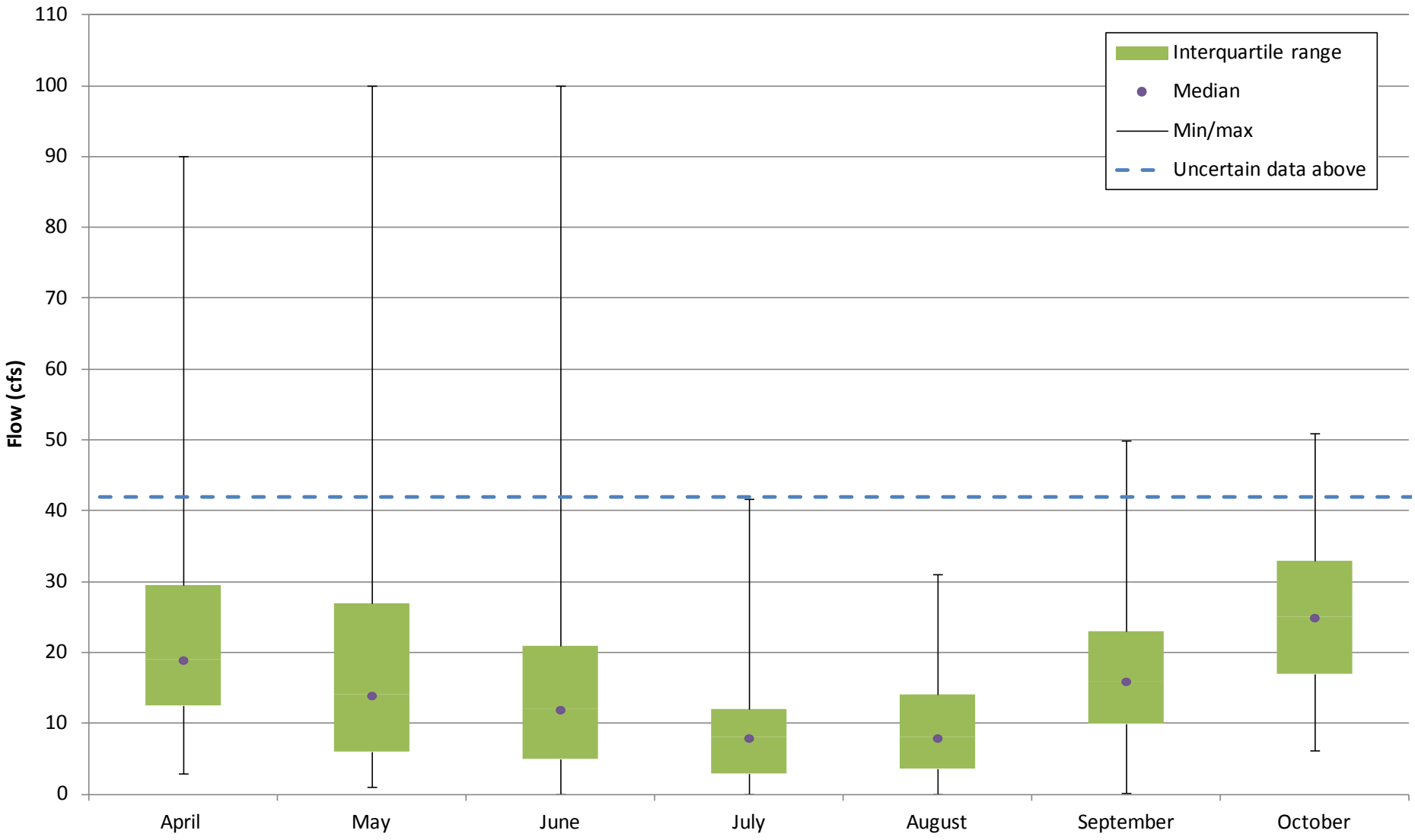


Notes: Data from SSWD weir located immediately upstream of Placer-Sutter County boundary on Coon Creek. Flows are recorded during the irrigation season only, which typically runs between April 15 and October 15 each year. Rating curve accuracy declines above 42 cfs.

Coon Creek Watershed Assessment

Coon Creek Annual Flow Range at SSWD Weir

Project No. 14-1024	Created By: NC	**Figure 40**



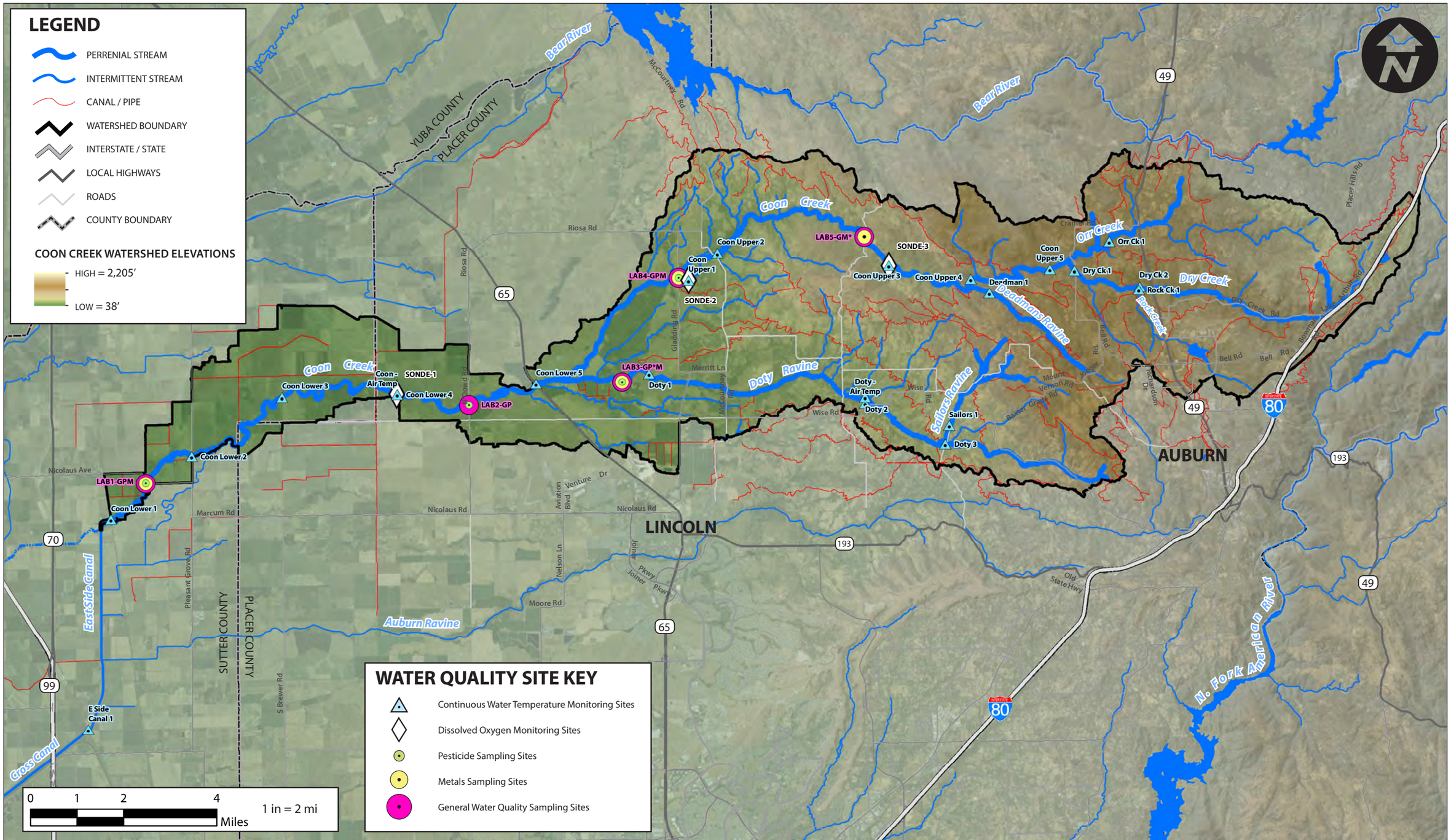
Notes: Data from SSWD weir located immediately upstream of Placer-Sutter County boundary on Coon Creek. Flows are recorded during the irrigation season only, which typically runs between April 15 and October 15 each year. Rating curve accuracy declines above 42 cfs.

Coon Creek Watershed Assessment

Coon Creek Monthly Flow Range at SSWD Weir

Project No. 14-1024	Created By: NC	**Figure 41**

Notes: Coppin Dam (above) and Auburn Extension Canal (below)	cbec eco engineering	*Coon Creek Watershed Assessment* **Coppin Dam and Auburn Extension Canal**		
		Project No. 14-1024	Created By: JDS	**Figure 42**



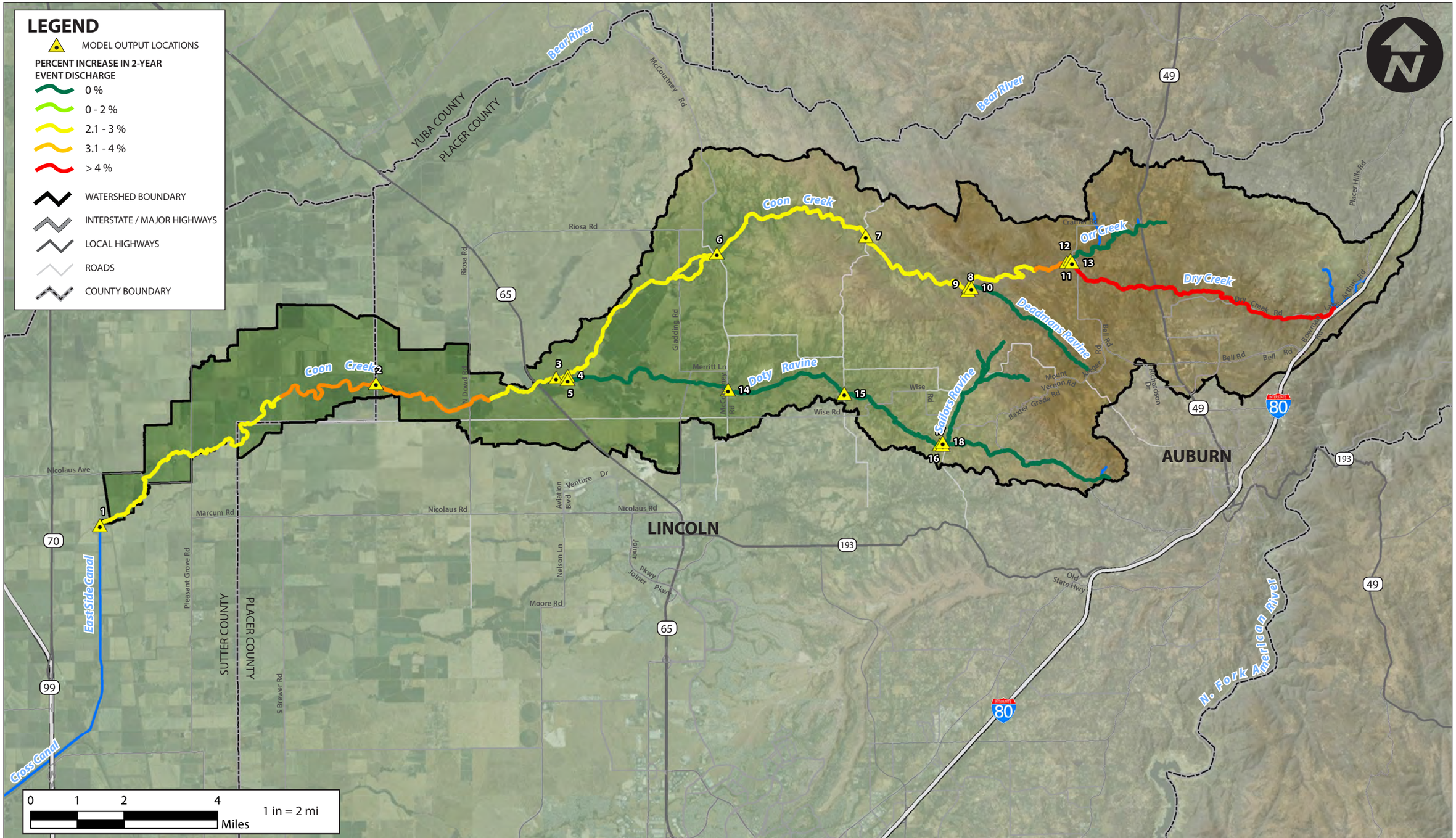
Notes: Metals analysis at LAB5 and pesticide analysis at LAB3 were only conducted in March 2016. Spring 2015 sonde deployments occurred only at Coon Lower 4 and Coon Upper 1, while the long-term dissolved oxygen monitoring in WY 2016 was conducted at Coon Lower 4, Coon Upper 1 and Coon Upper 3.

cbec

Coon Creek Watershed Assessment

Water Quality Monitoring Sites

Project No. 14-1024	Created By: SPW	**Figure 43**



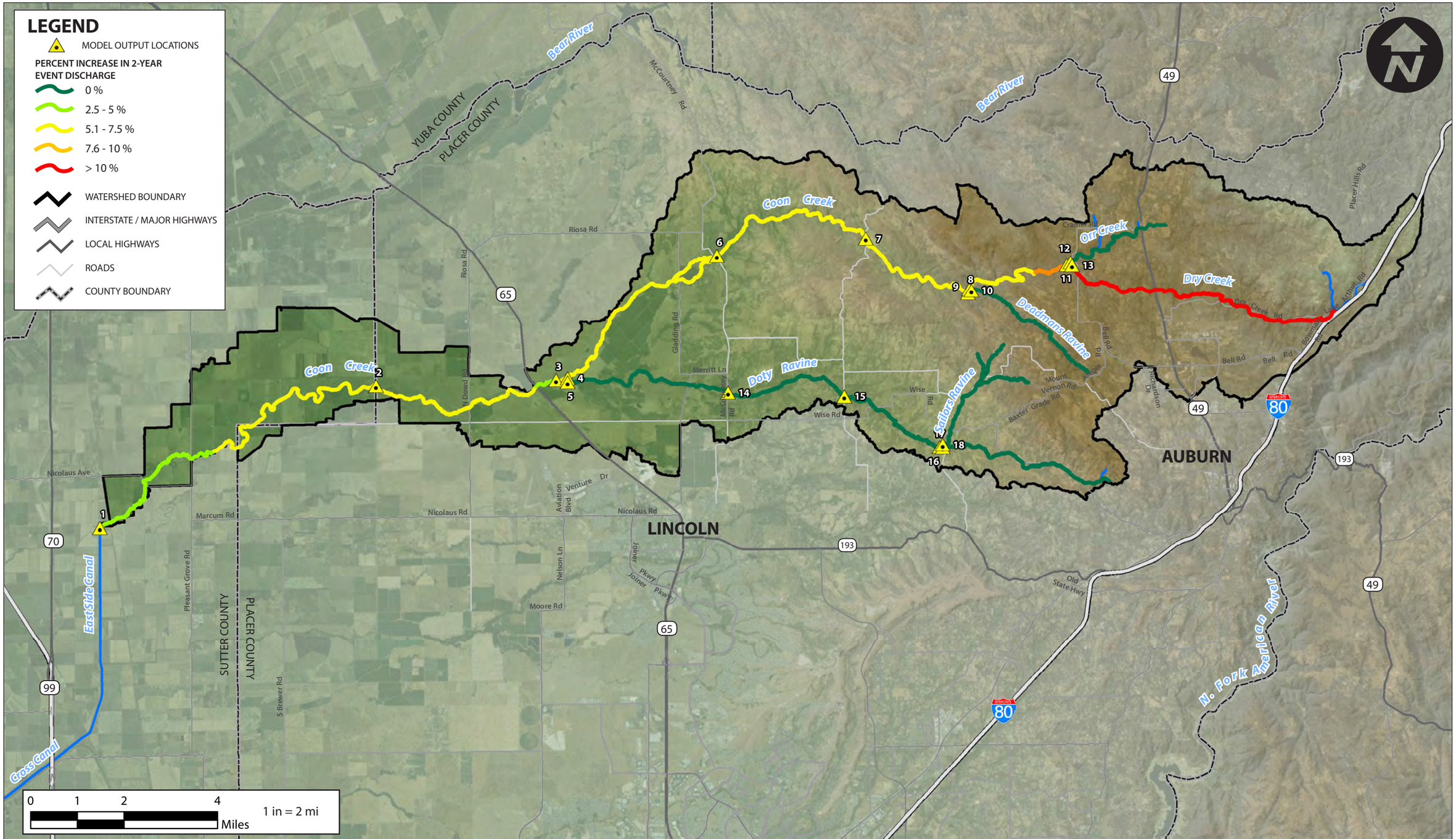
Notes: Percent increase in 2-year discharged derived from HEC-1 model results provided by Civil Engineering Solutions, Inc. Existing conditions are representative of 2007 conditions.

cbec

Coon Creek Watershed Assessment

Increase in 2-Year Event Discharge Between Existing and Pre-Disturbance Conditions

Project No. 14-1024	Created By: SPW	**Figure 44**



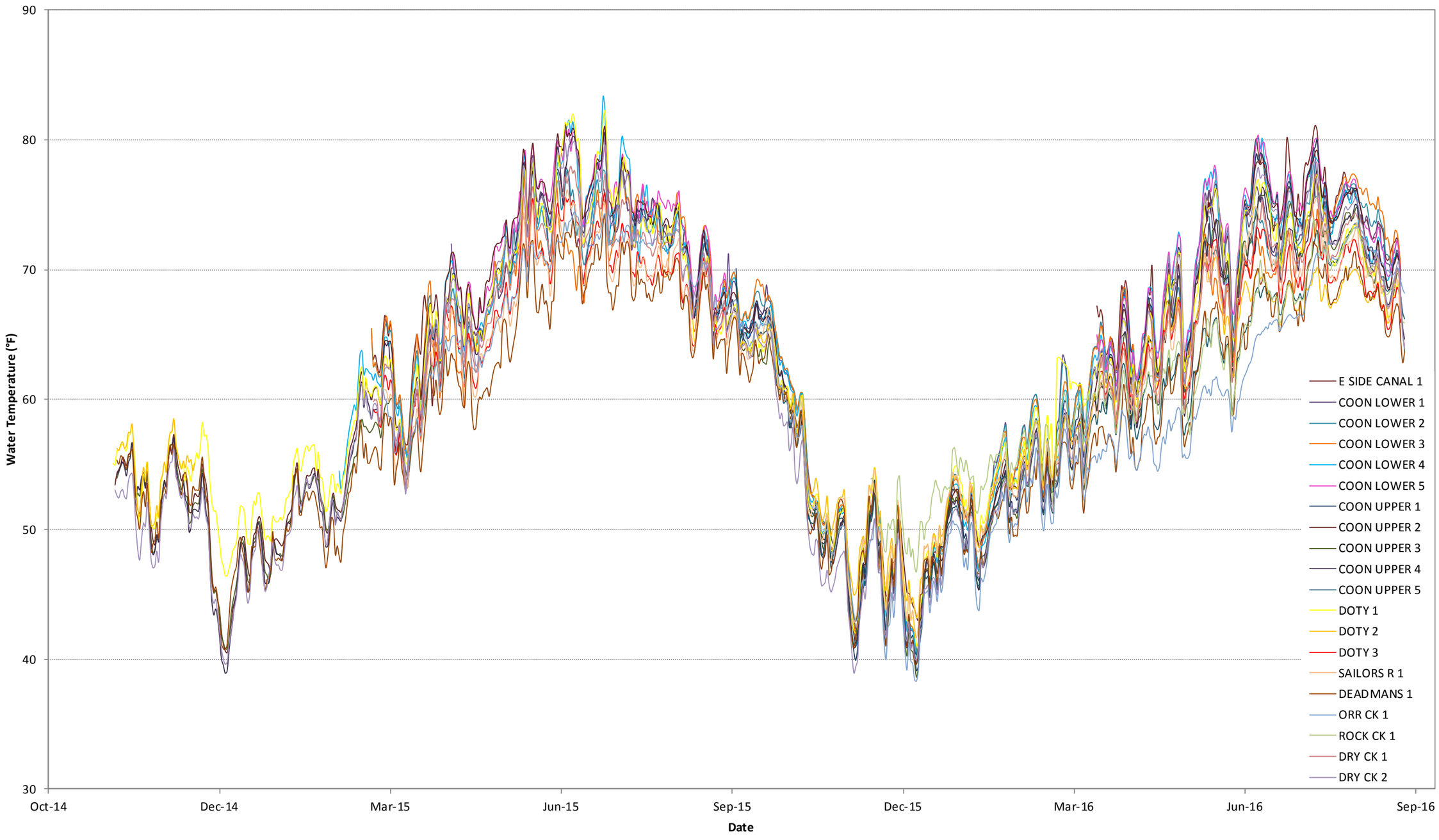
Notes: Percent increase in 2-year discharged derived from HEC-1 model results provided by Civil Engineering Solutions, Inc. Future fully developed conditions are based on Placer County and City of Lincoln general plans only. City of Auburn general plan information was not available in a digital format (pers. comm. Edgar Medina, Sept. 2016).

cbec

Coon Creek Watershed Assessment

Increase in 2-Year Event Discharge Between Future Fully Developed and Pre-Disturbance Conditions

Project No. 14-1024	Created By: SPW	**Figure 45**

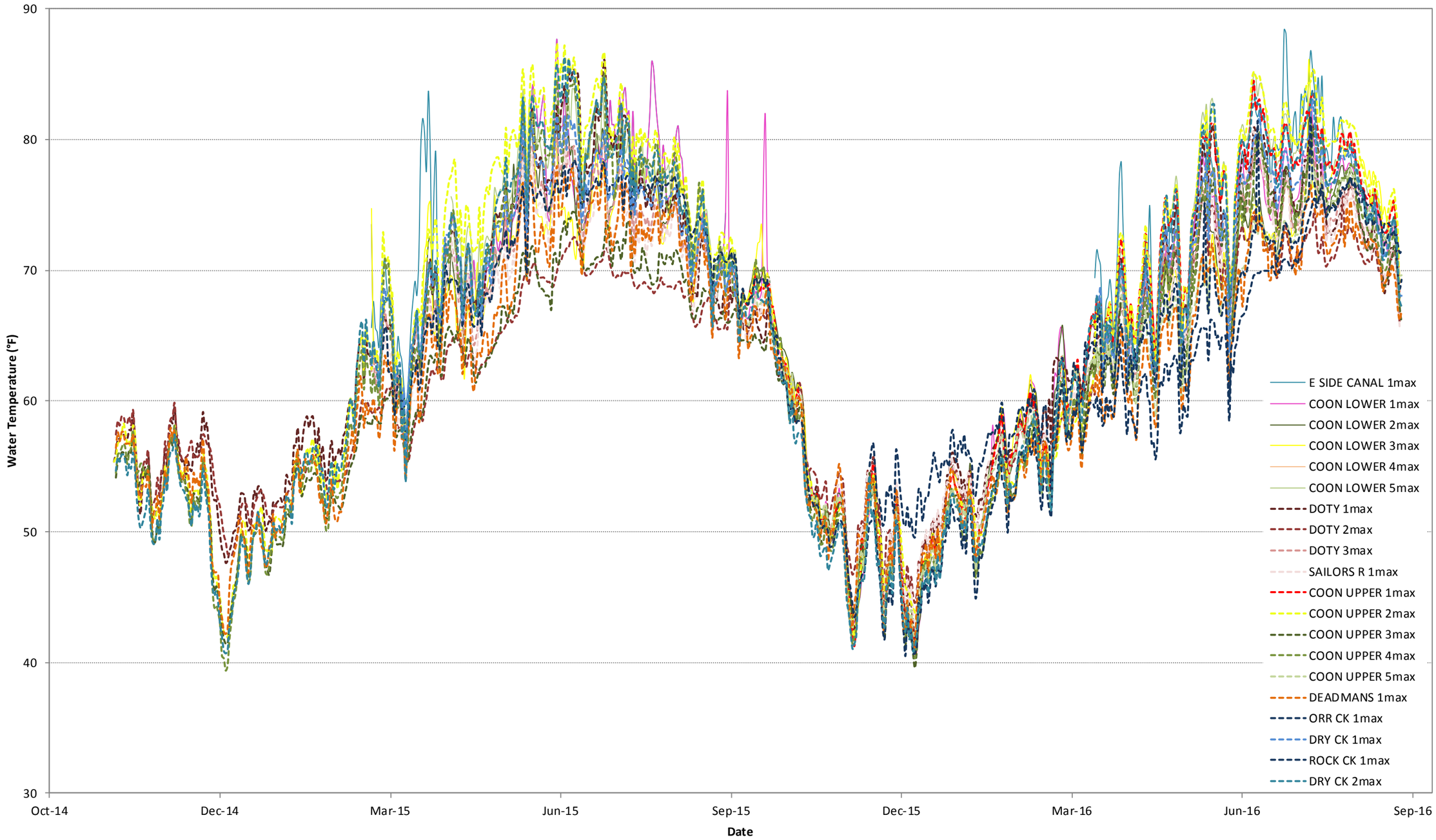


Notes:

Coon Creek Watershed Assessment

Daily Average Water Temperature at All Monitoring Sites

Project No. 14-1024	Created By: CMC	**Figure 46**

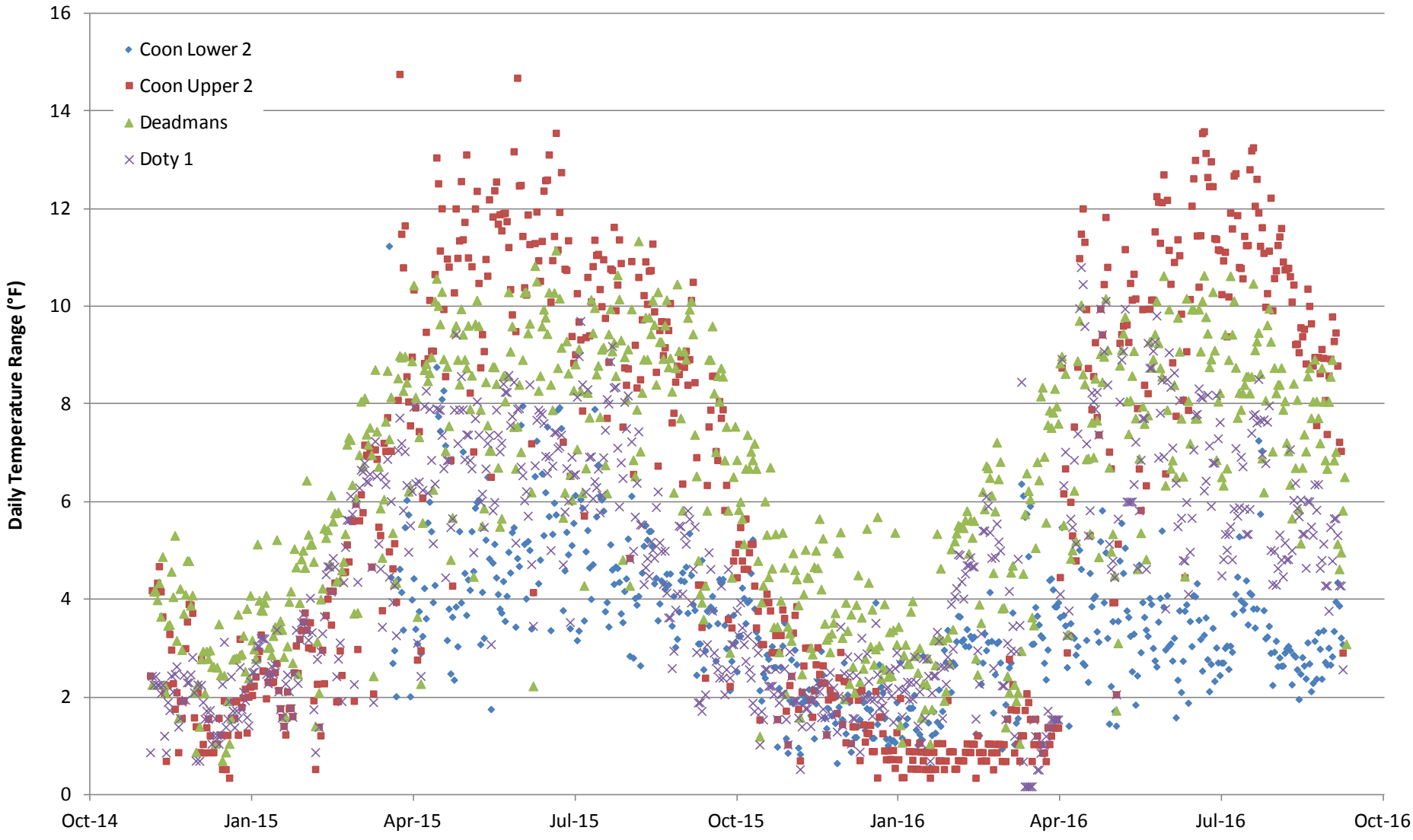


Notes: Occasional spikes in water temperature at individual sites may be driven by low to zero flow along monitored reach, which can result in isolated pools subject to rapid warming or direct exposure of sensors to air.

Coon Creek Watershed Assessment

Daily Maximum Water Temperatures at All Monitoring Sites

Project No. 14-1024	Created By: CMC	**Figure 47**



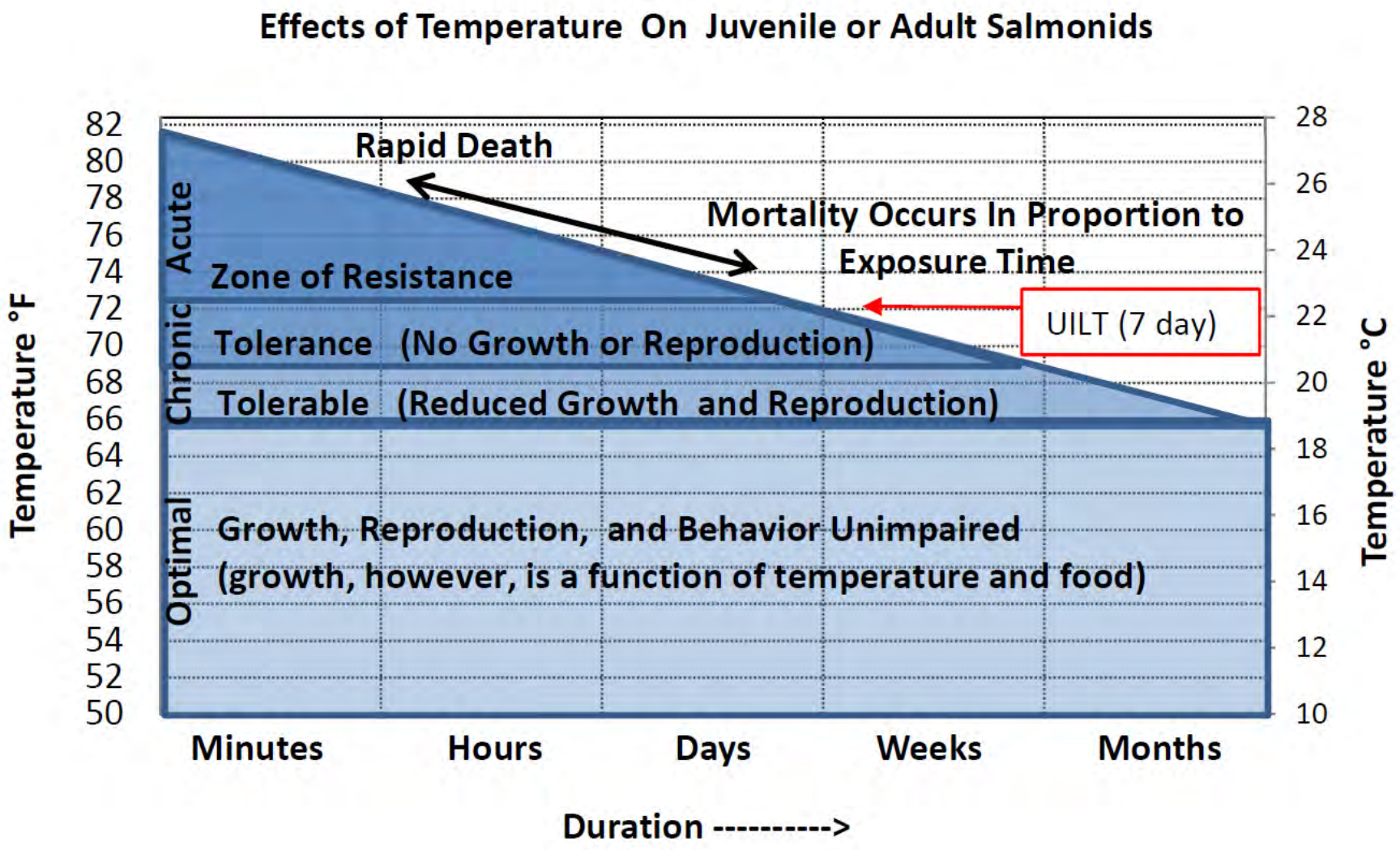
Notes:

cbec eco engineering

Coon Creek Watershed Assessment

Daily Temperature Range at Select Sites

Project No. 14-1024	Created By: JDS	**Figure 48**

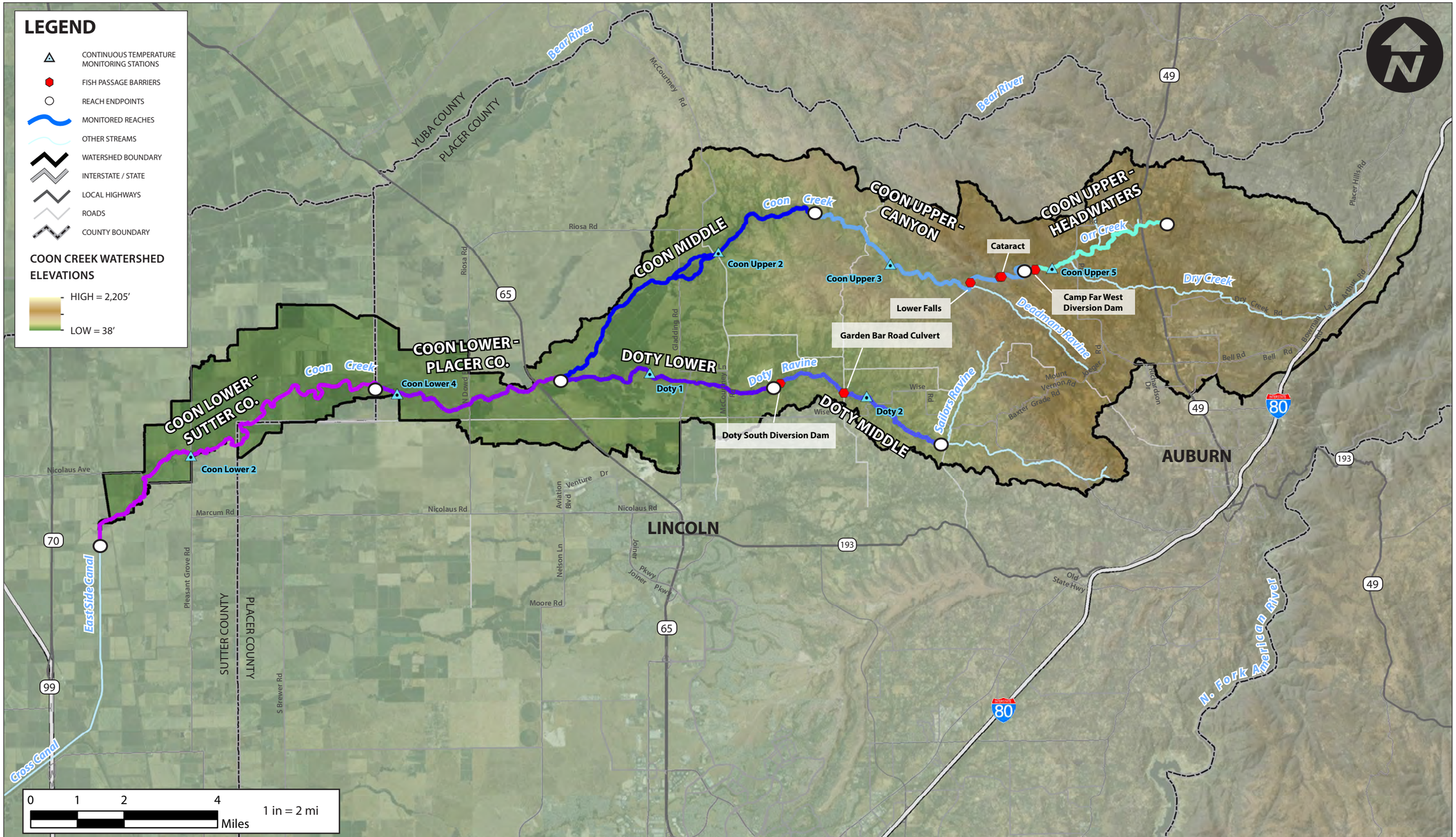


Notes: Figure excerpted from Water Temperature Considerations for Yuba River Basin Anadromous Salmonid Reintroductions (Bratovich et al. 2012). This figure is intended to explain the relationship between duration of exposure and water temperature in driving stress and mortality. The specific temperature thresholds indicated above differ from those used in the Coon Creek Watershed Assessment.

Coon Creek Watershed Assessment

Effects of Temperature and Exposure Duration on Salmonids

Project No. 14-1024	Created By: JDS	**Figure 49**



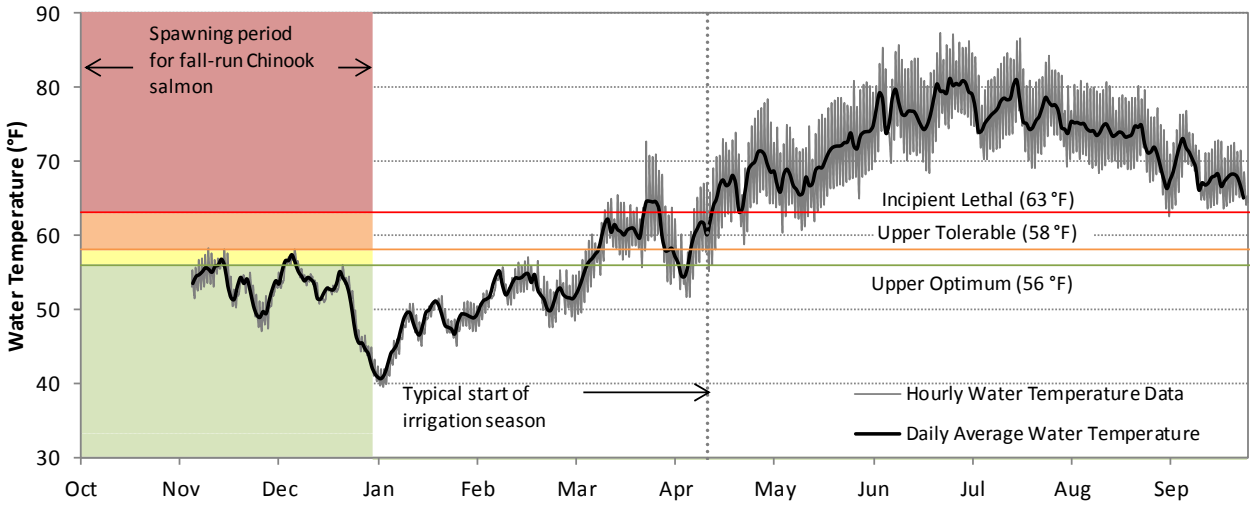
Notes: Only select passage barriers are shown. Other seasonal and partial barriers exist downstream.

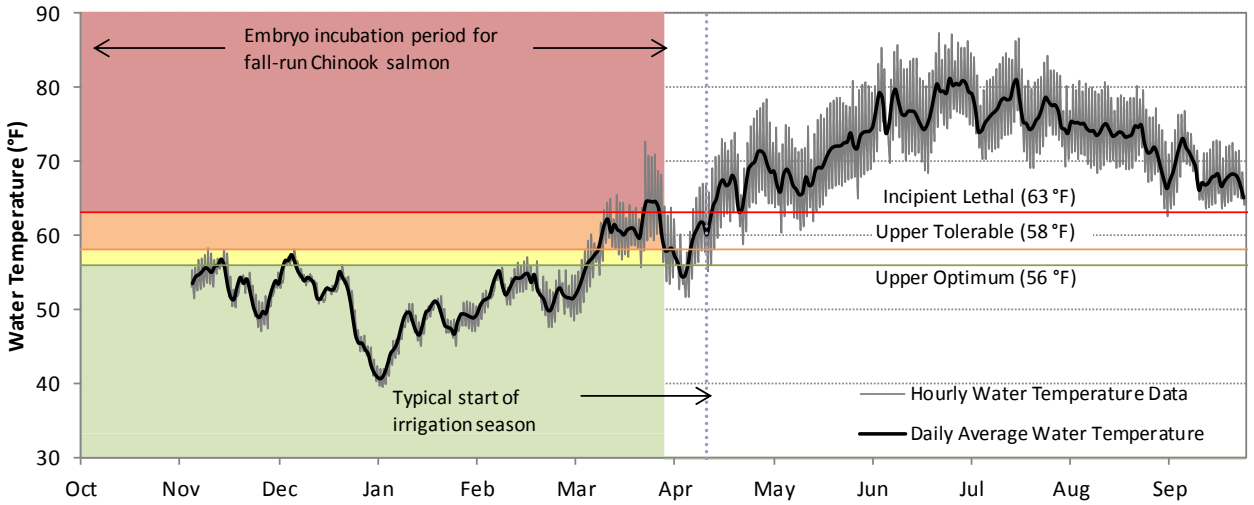
cbec

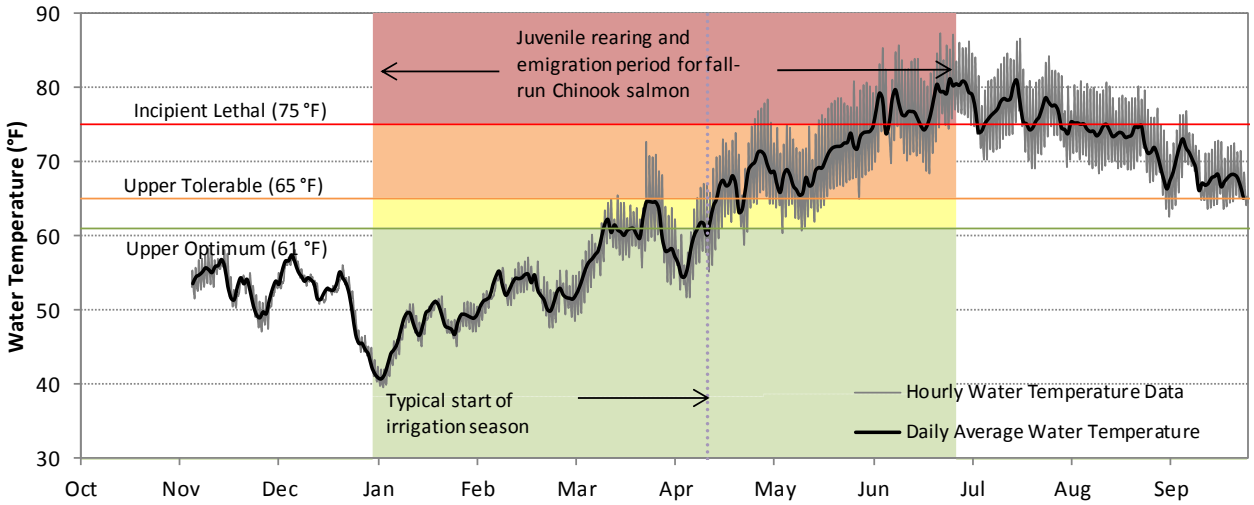
Coon Creek Watershed Assessment

Reach Delineation for Salmonid Thermal Suitability Assessment

Project No. 14-1024	Created By: SPW	**Figure 50**





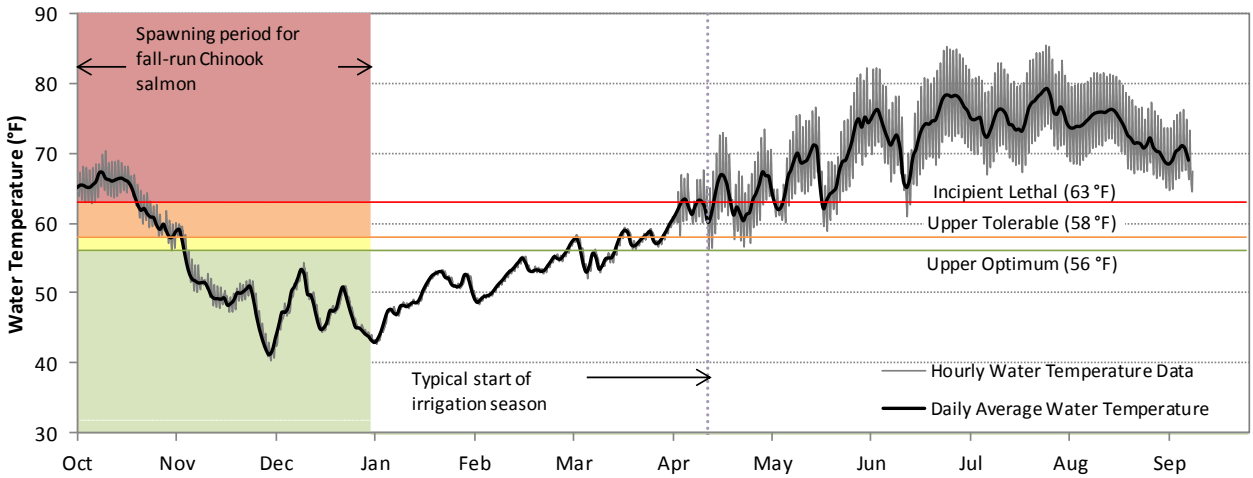


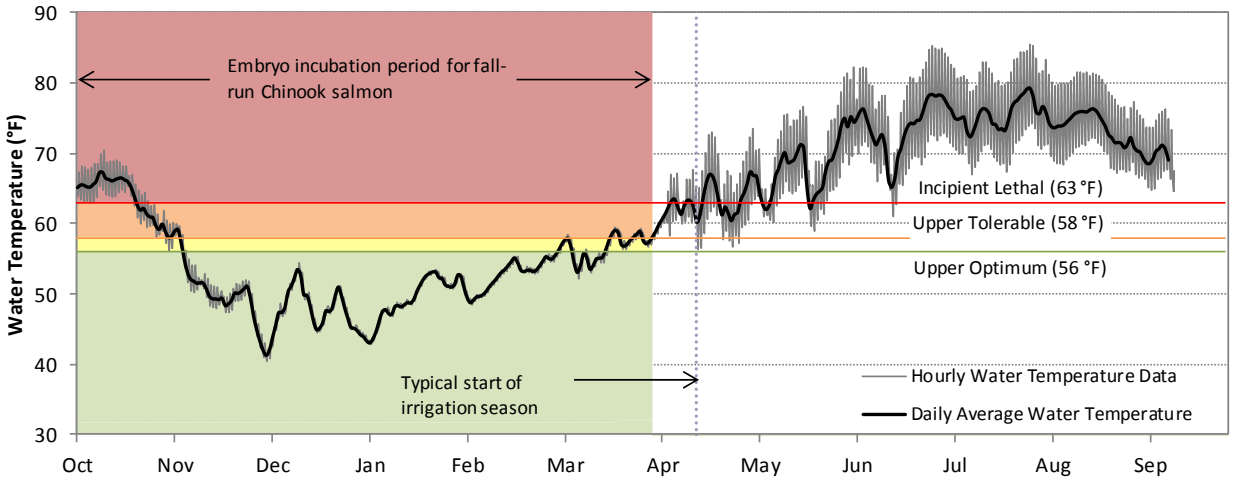
Notes: Data collection did not begin until November 2014

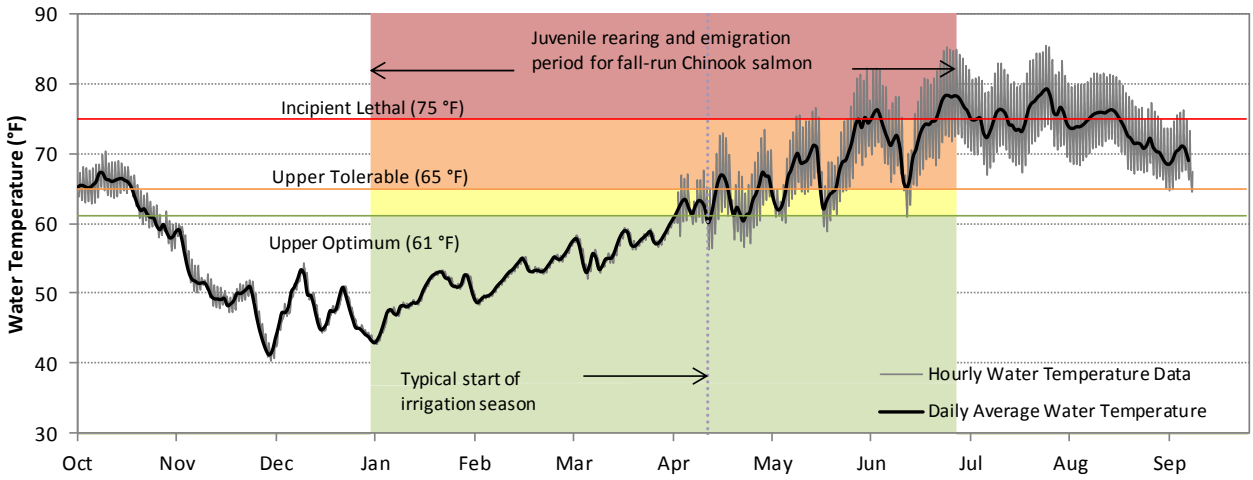
Coon Creek Watershed Assessment

Chinook Thermal Suitability - Coon Upper 2 - WY 2015

Project No. 14-1024	Created By: RR	**Figure 51**





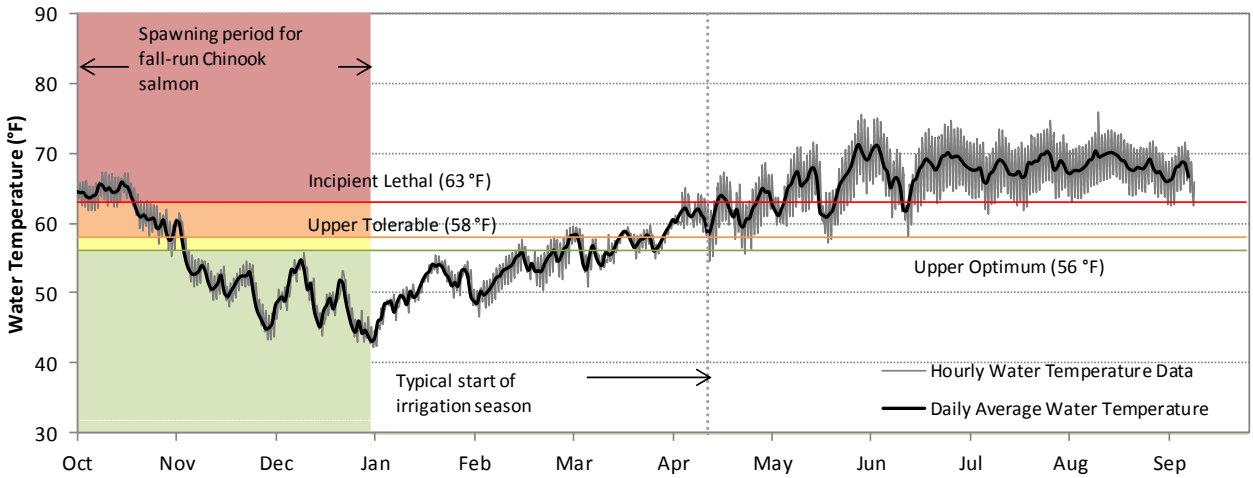


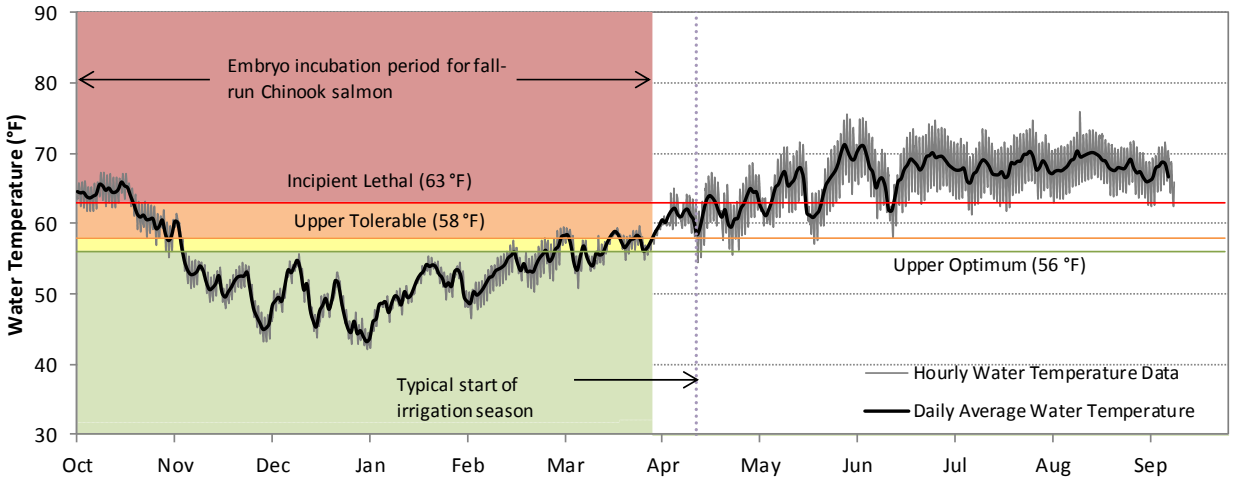
Notes:

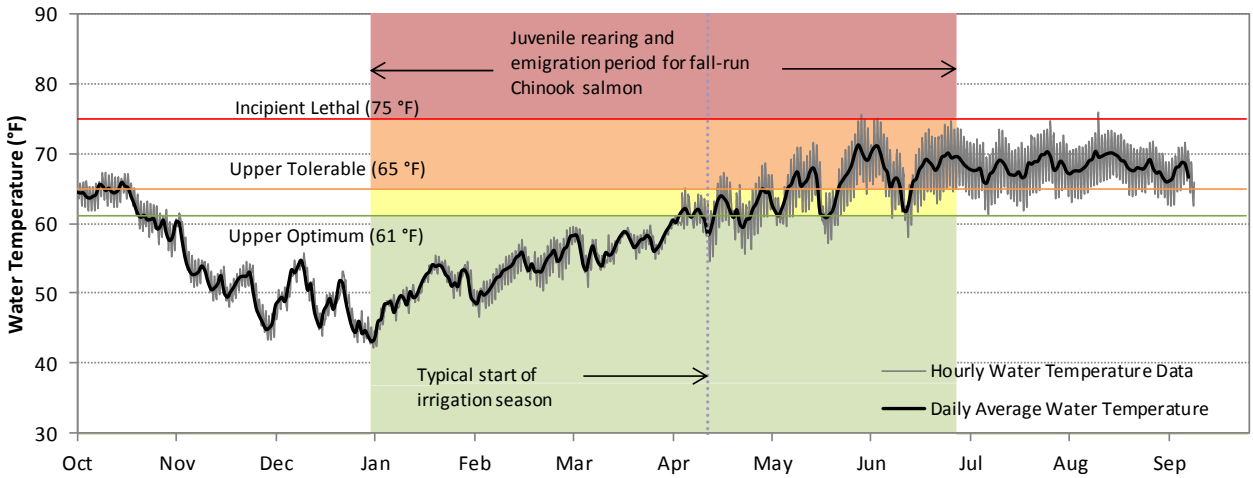
Coon Creek Watershed Assessment

Chinook Thermal Suitability - Coon Upper 2 - WY 2016

Project No. 14-1024	Created By: RR	**Figure 52**





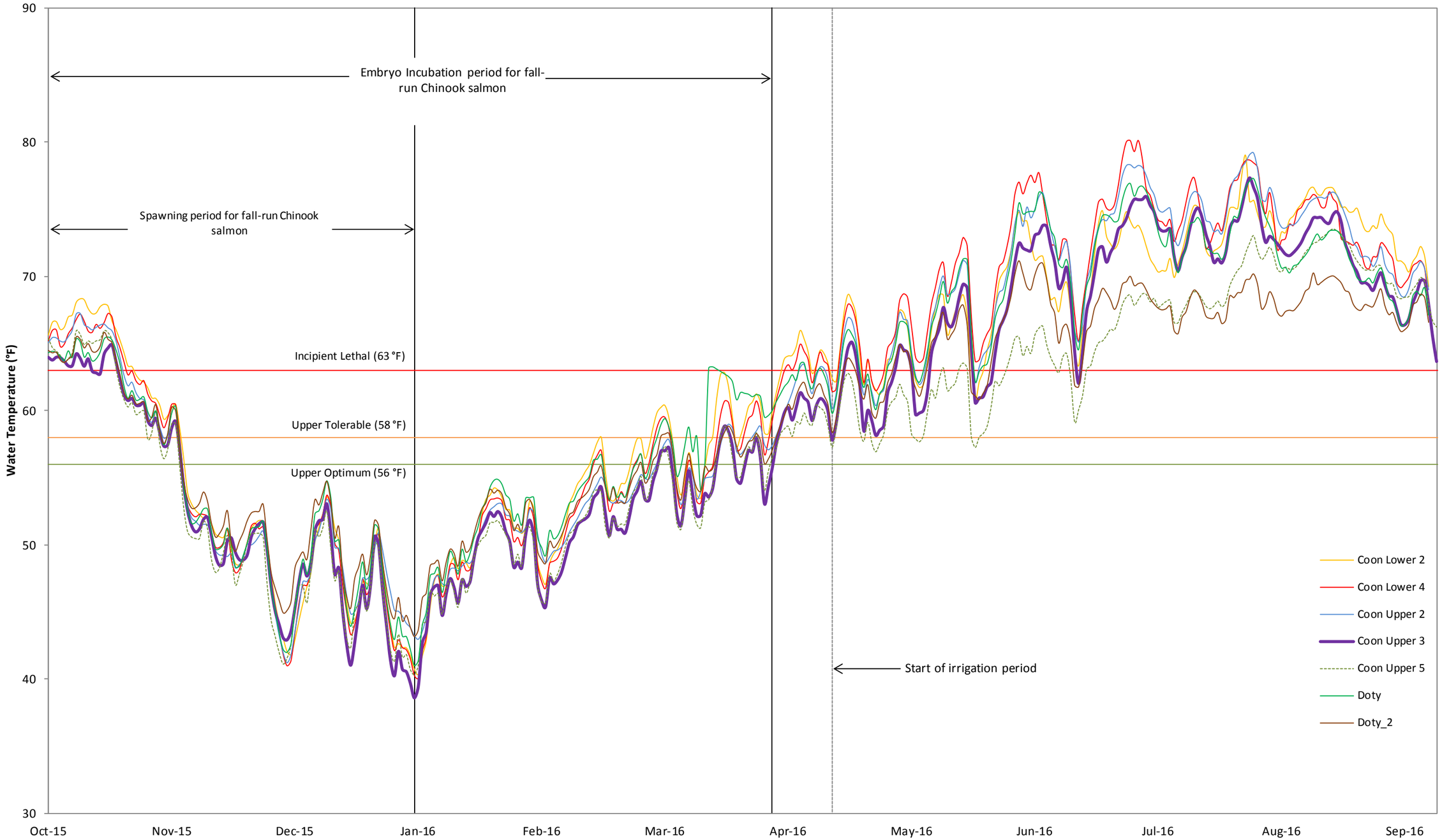


Notes:

Coon Creek Watershed Assessment

Chinook Thermal Suitability - Doty 2 - WY 2016

Project No. 14-1024	Created By: RR	**Figure 53**

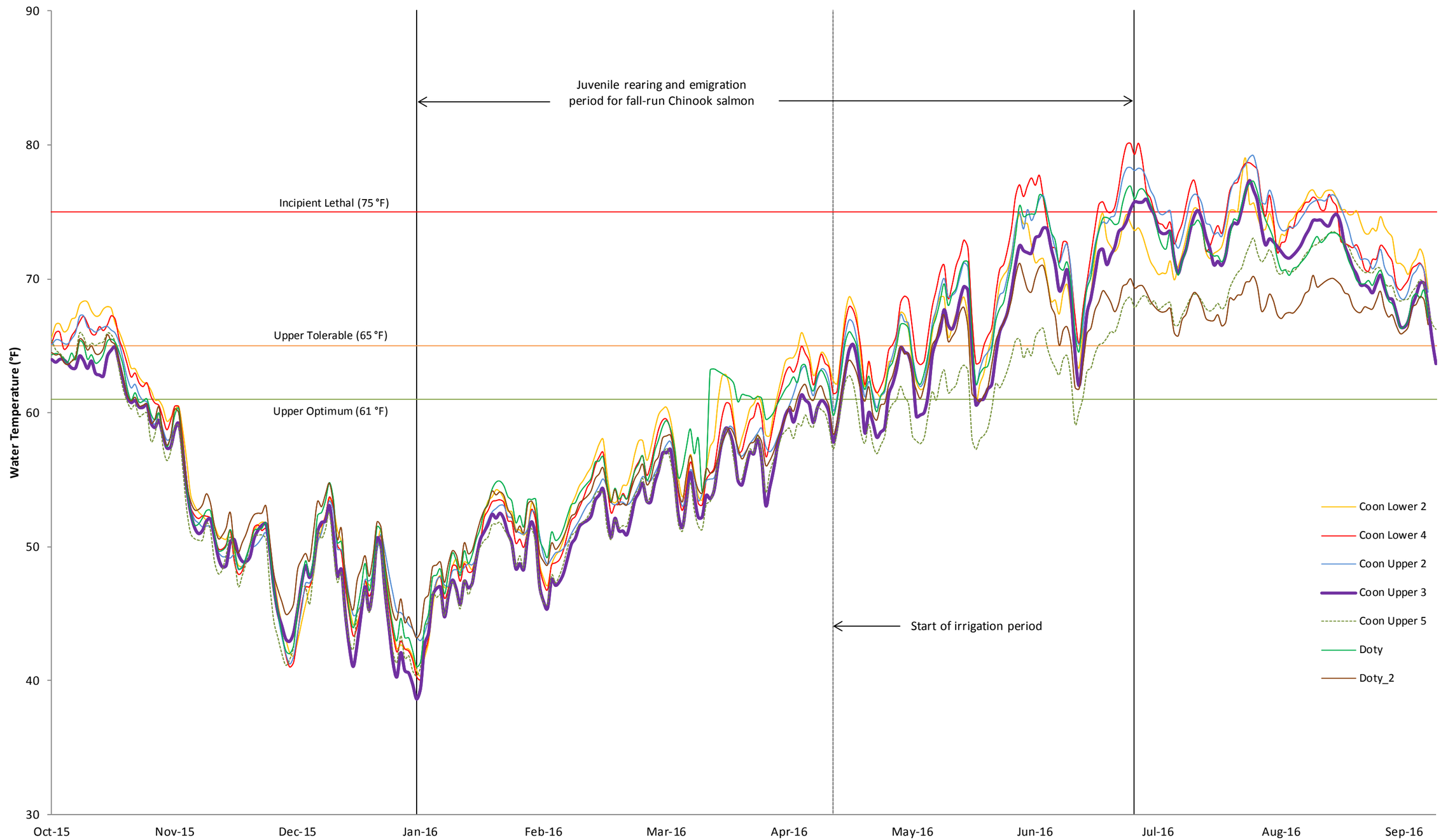


Notes: Water temperatures are daily average values.

Coon Creek Watershed Assessment

Chinook Spawning and Embryo Incubation Thermal Suitability - WY 2016

Project No. 14-1024	Created By: CMC	**Figure 54**

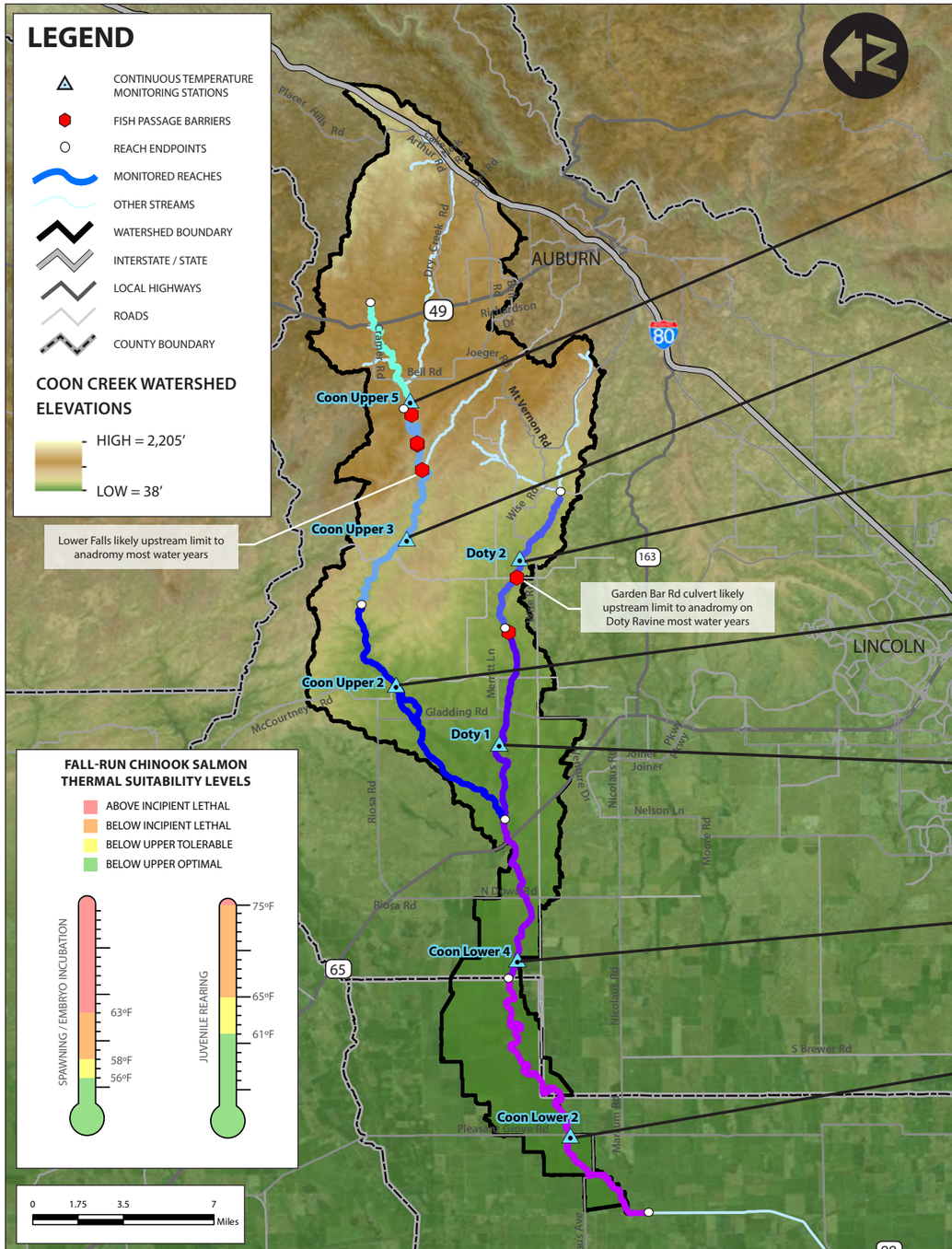


Notes: Water temperatures are daily average values.

Coon Creek Watershed Assessment

Juvenile Chinook Thermal Suitability at Representative Sites - WY 2016

Project No. 14-1024	Created By: CMC	**Figure 55**



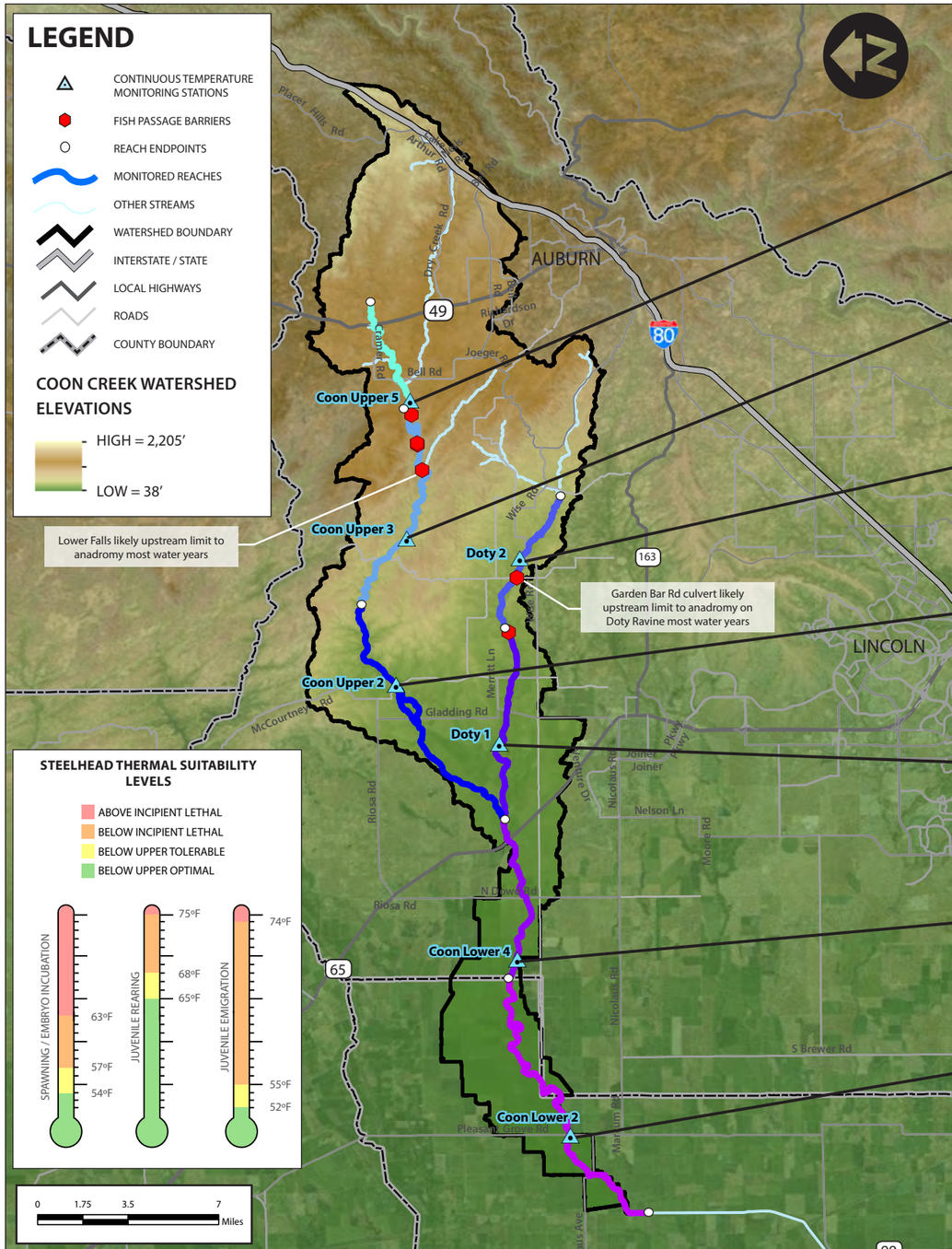
Fall-Run Chinook Salmon Thermal Suitability Based on Daily Average Stream Temperature in WY 2016

Notes: Thermal suitability temperature bars only extend as far the expected life stage typically extends.

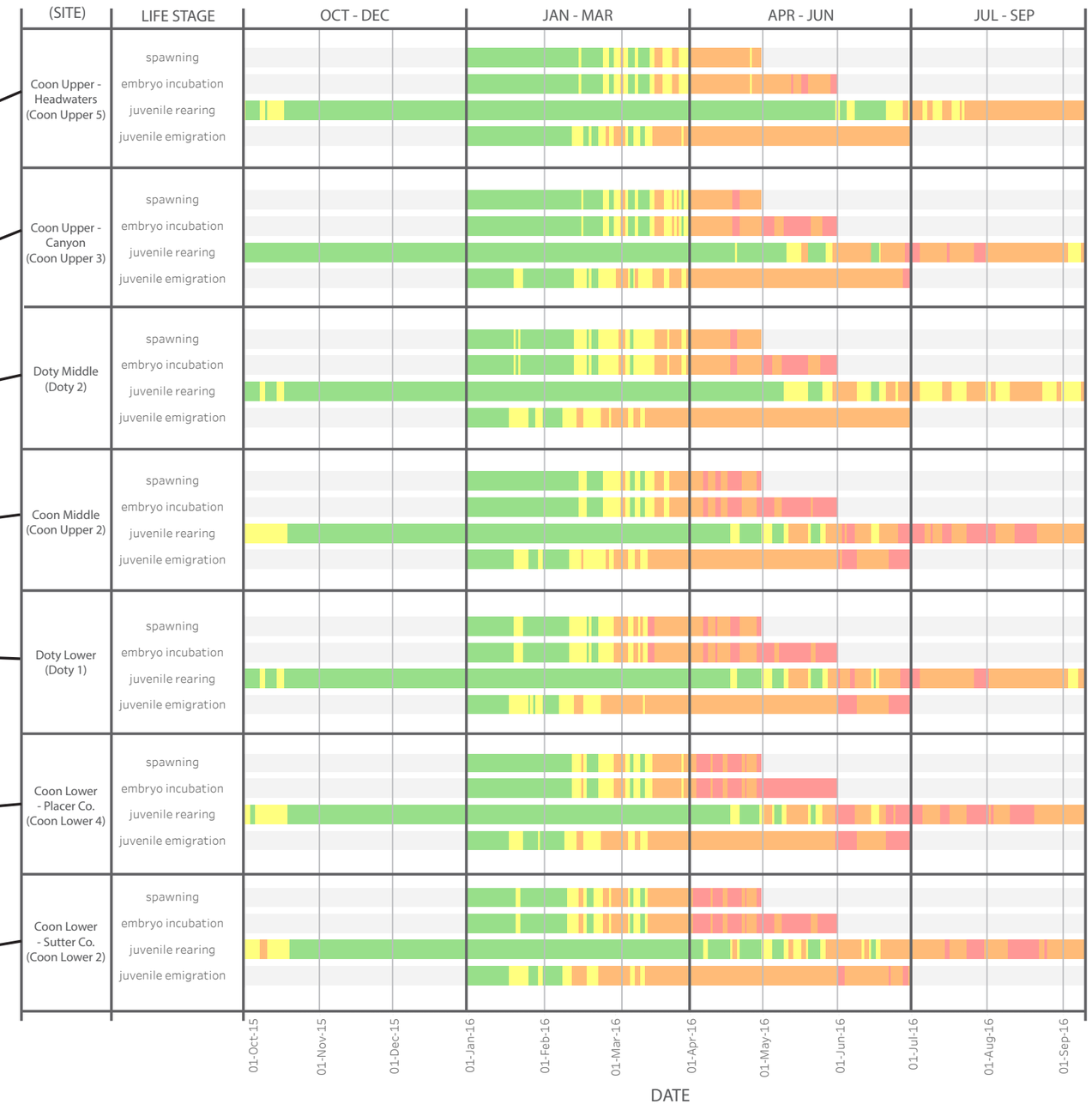
Coon Creek Watershed Assessment

Chinook Salmon Thermal Suitability by Life Stage - WY 2016

Project No. 14-1024	Created By: SPW	**Figure 56**



Steelhead Thermal Suitability Based on Daily Average Stream Temperature in WY 2016

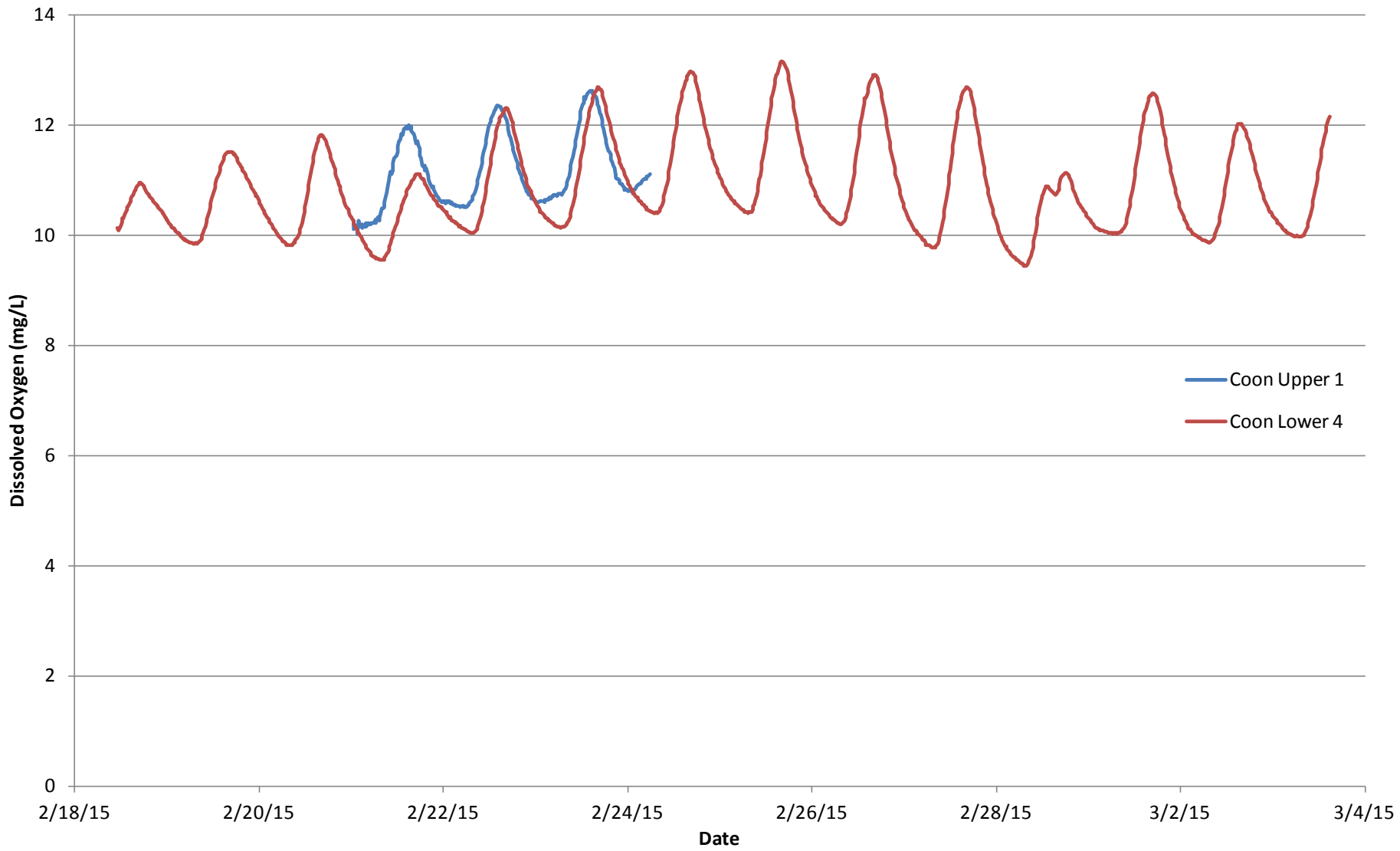


Notes: Thermal suitability temperature bars only extend as far the expected life stage typically extends.

Coon Creek Watershed Assessment

Steelhead Thermal Suitability by Life Stage - WY 2016

Project No. 14-1024	Created By: SPW	**Figure 57**

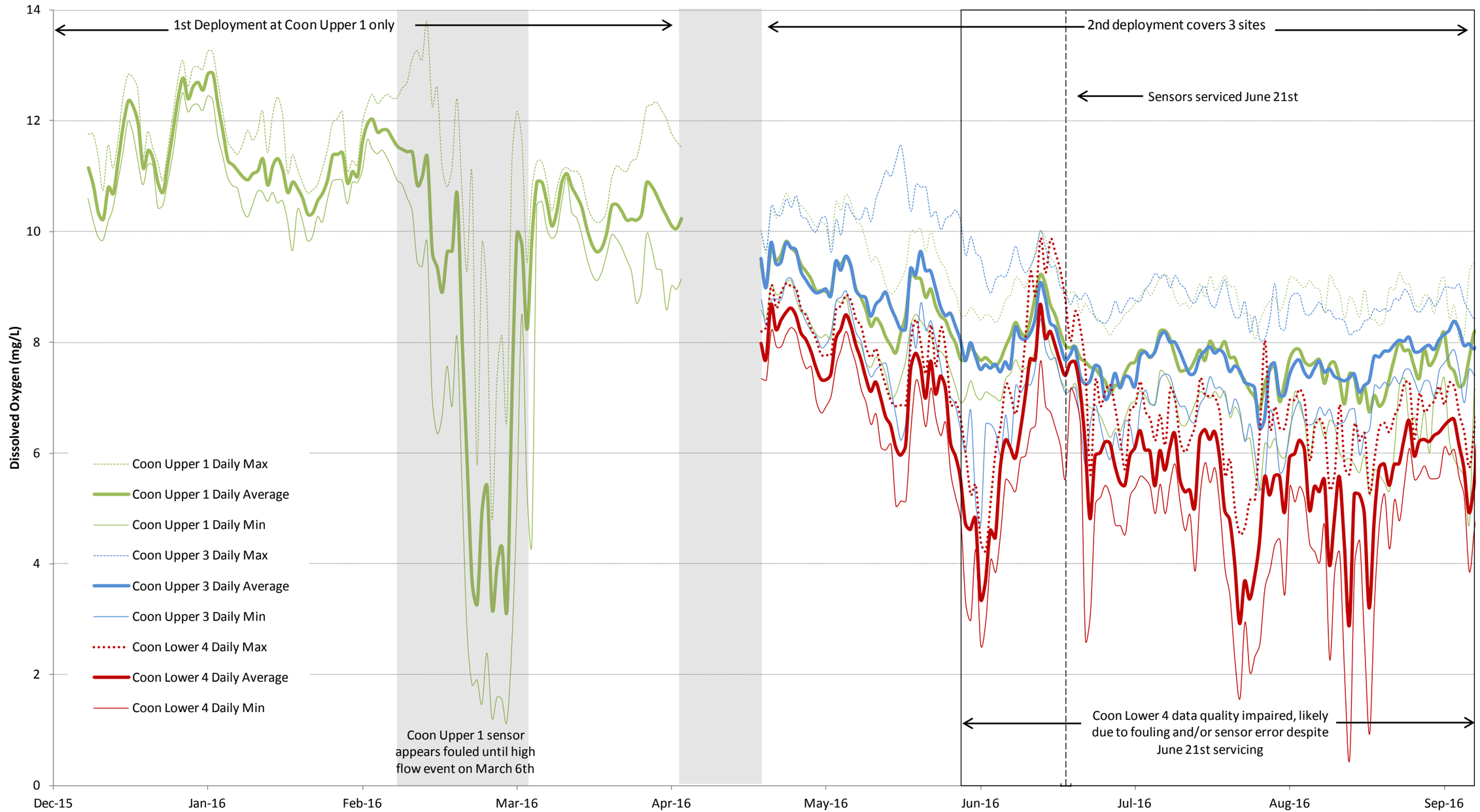


Notes: Data collected at 15-minute intervals. Coon Upper 1 sensor malfunctioned for the majority of the deployment.

Coon Creek Watershed Assessment

Dissolved Oxygen Monitoring - WY 2015

Project No. 14-1024	Created By: JDS	**Figure 58**

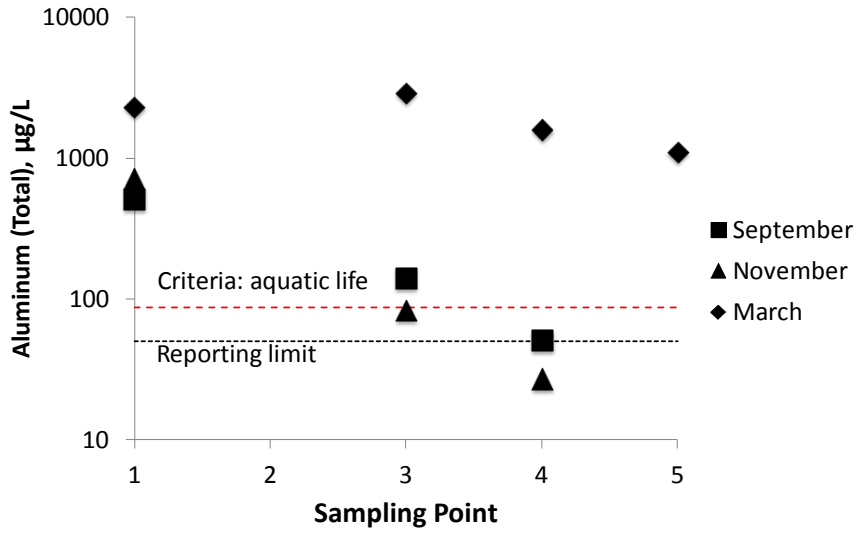


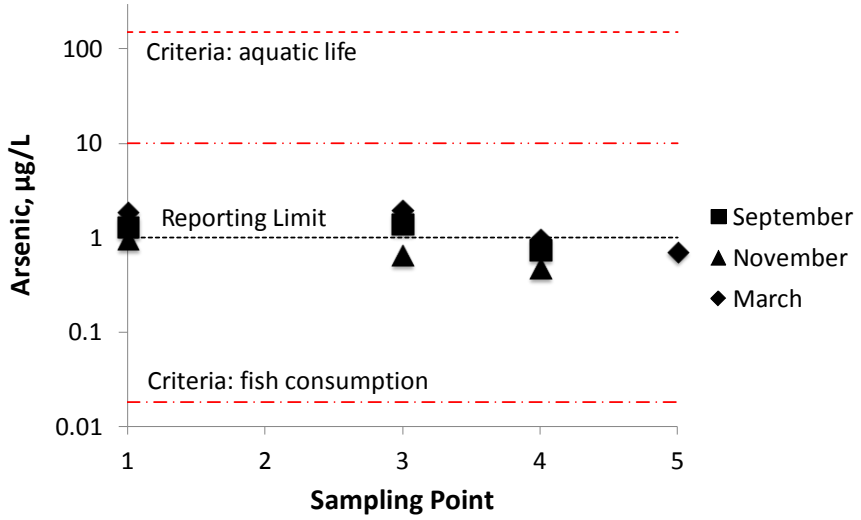
Note:

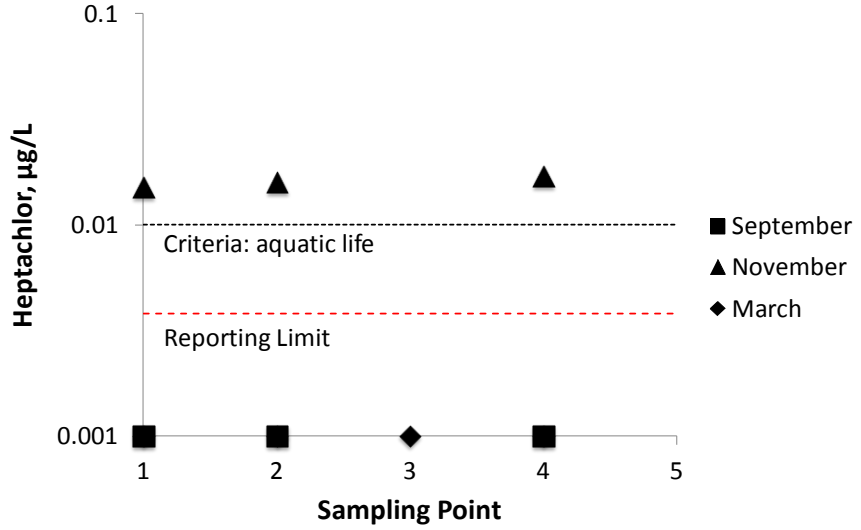
Coon Creek Watershed Assessment

Coon Creek Dissolved Oxygen Monitoring WY 2016

Project No. 14-1024	Created By: CMC	**Figure 59**





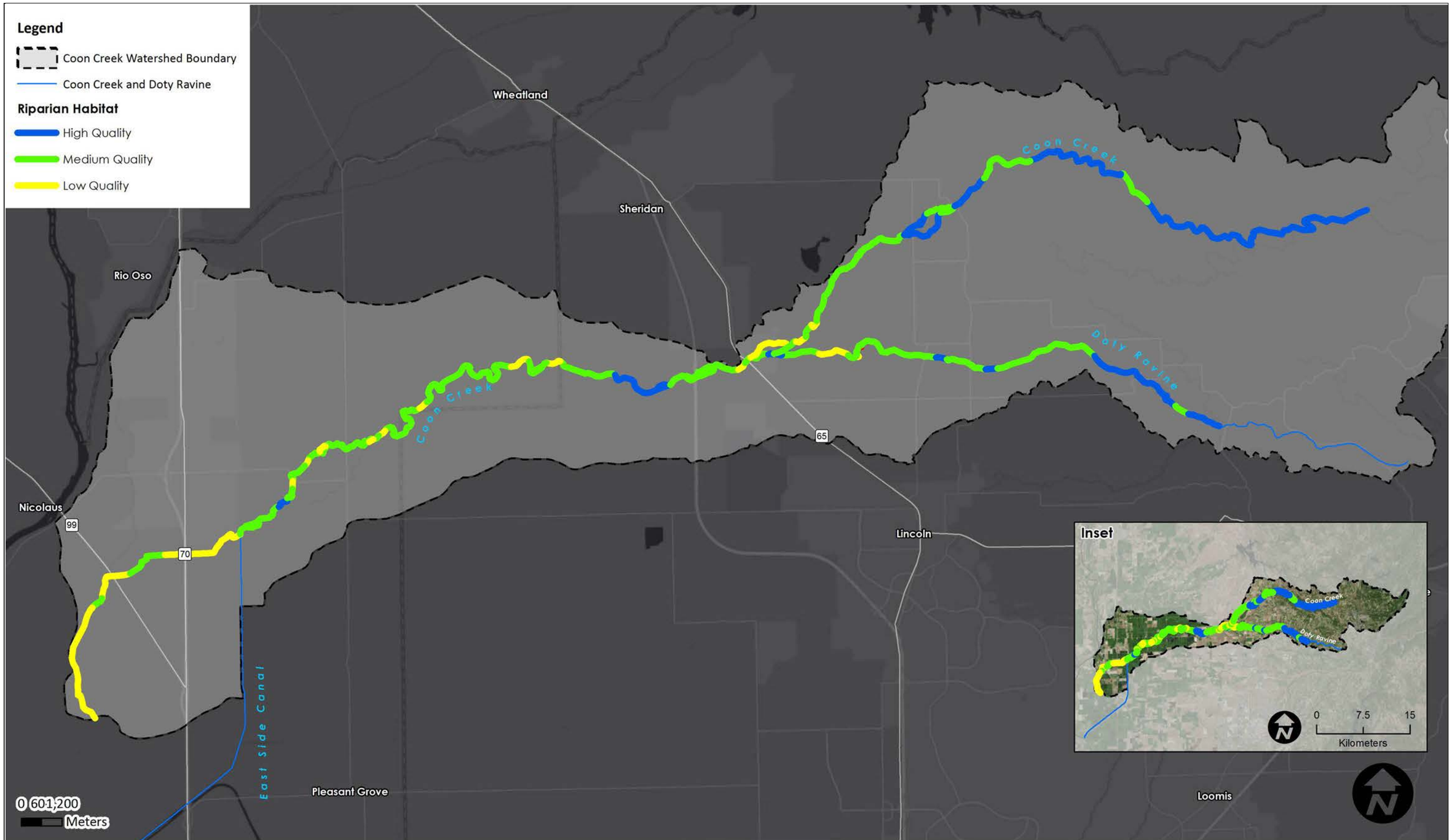


Notes:

Coon Creek Watershed Assessment

Key Lab Analyte Results

Project No. 14-1024 | Created By: TB | **Figure 60**



Notes:

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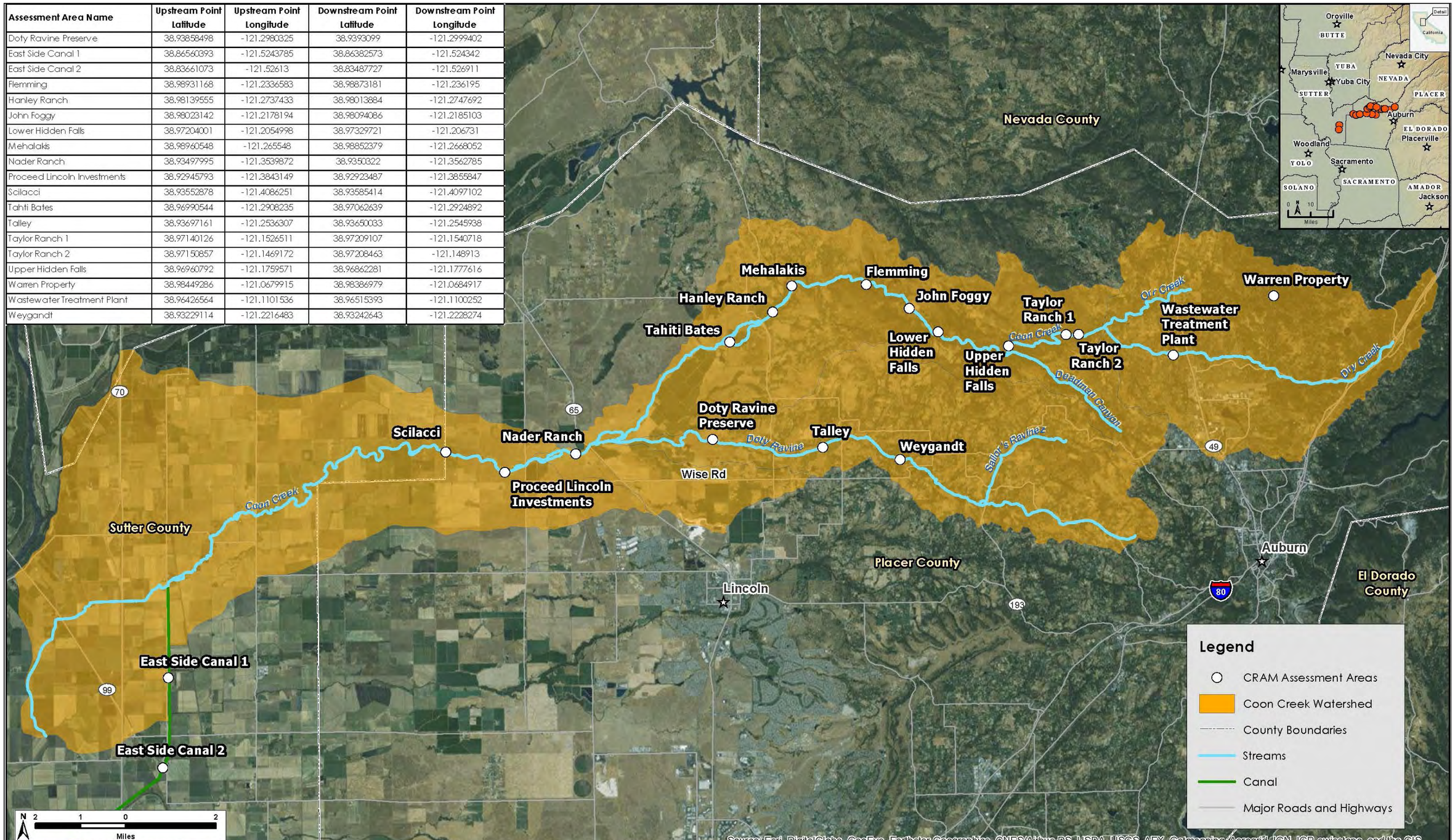
Coon Creek Watershed Assessment

Riparian Habitat Quality Mapping

Project No. 14-1024	Created By: ML	**Figure 61**

Assessment Area Name	Upstream Point Latitude	Upstream Point Longitude	Downstream Point Latitude	Downstream Point Longitude
Doty Ravine Preserve	38.93858498	-121.2980325	38.9393099	-121.2999402
East Side Canal 1	38.86560393	-121.5243785	38.86382573	-121.524342
East Side Canal 2	38.83661073	-121.52613	38.83487727	-121.526911
Flemming	38.98931168	-121.2336583	38.98873181	-121.236195
Hanley Ranch	38.98139555	-121.2737433	38.98013884	-121.2747692
John Foggy	38.98023142	-121.2178194	38.98094086	-121.2185103
Lower Hidden Falls	38.97204001	-121.2054998	38.97329721	-121.206731
Mehalakis	38.98960548	-121.265548	38.98852379	-121.2668052
Nader Ranch	38.93497995	-121.3539872	38.9350322	-121.3562785
Proceed Lincoln Investments	38.92945793	-121.3843149	38.92923487	-121.3855847
Scilacci	38.93552878	-121.4086251	38.93585414	-121.4097102
Tahti Bates	38.96990544	-121.2908235	38.97062639	-121.2924892
Talley	38.93697161	-121.2536307	38.93650033	-121.2545938
Taylor Ranch 1	38.97140126	-121.1526511	38.97209107	-121.1540718
Taylor Ranch 2	38.97150857	-121.1469172	38.97208463	-121.148913
Upper Hidden Falls	38.96960792	-121.1759571	38.96862281	-121.1777616
Warren Property	38.98449286	-121.0679915	38.98386979	-121.0684917
Wastewater Treatment Plant	38.96426564	-121.1101536	38.96515393	-121.1100252
Weygandt	38.93229114	-121.2216483	38.93242643	-121.2228274



Notes:

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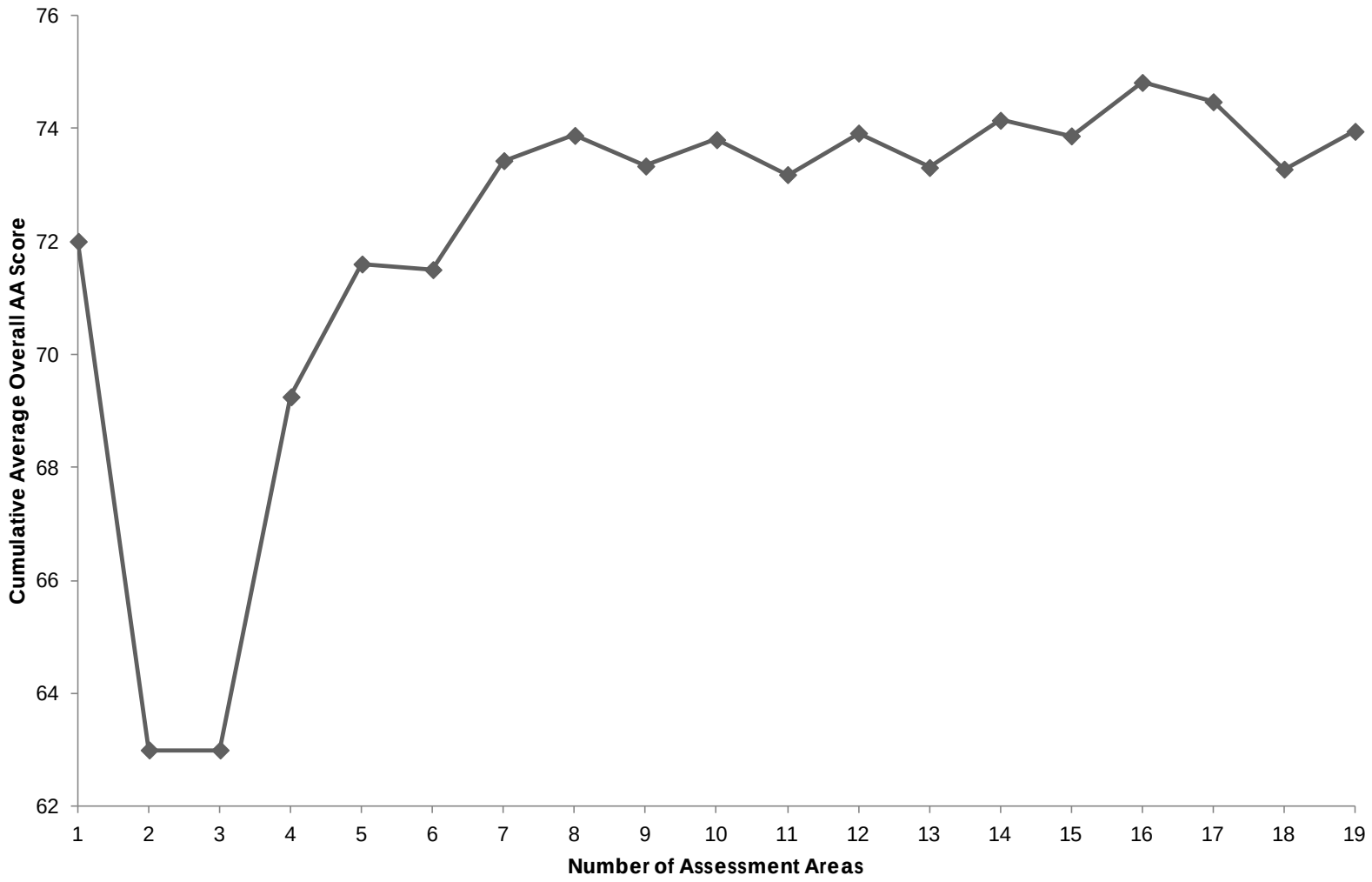
Coon Creek Watershed Assessment

CRAM Assessment Sites

Project No. 14-1024 | Created By: ML | **Figure 62**



Notes: The cumulative average overall CRAM scores presented here is taken as an incremental function of the number of the assessment areas surveyed.

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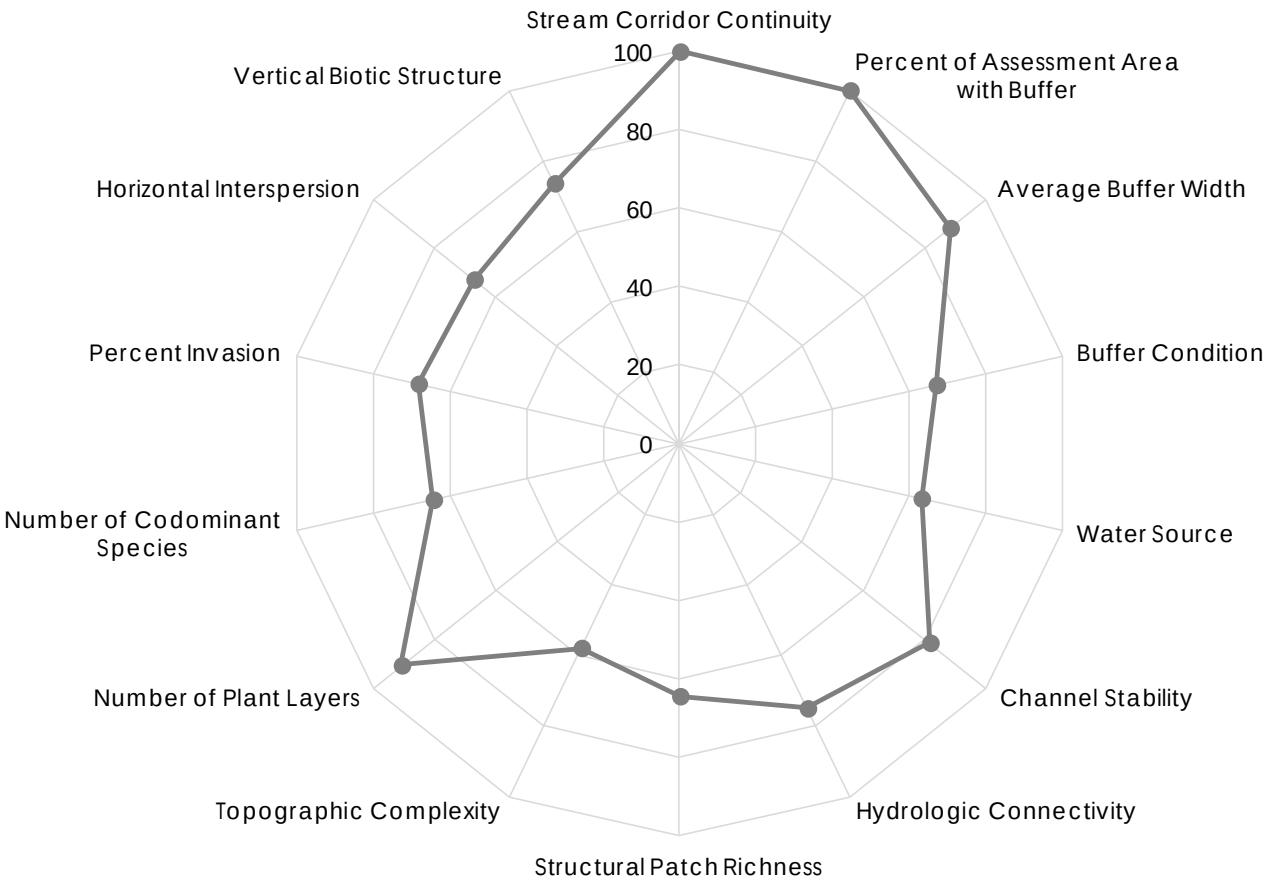
Coon Creek Watershed Assessment

Cumulative Average Overall CRAM Scores

Project No. 14-1024	Created By: CM	**Figure 63**



Notes:

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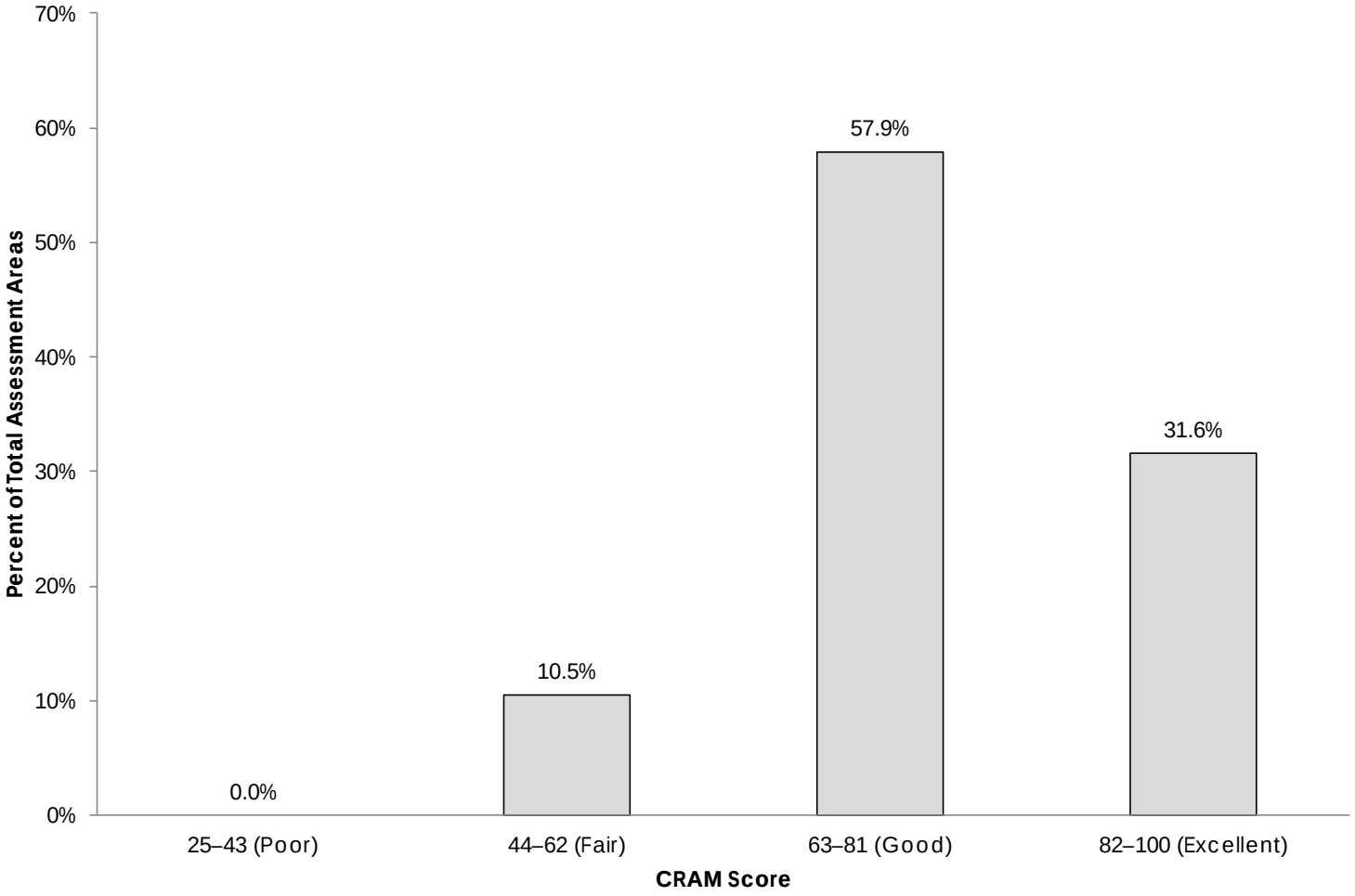
Coon Creek Watershed Assessment

Average CRAM Metric Scores

Project No. 14-1024 | Created By: CM | **Figure 64**



Notes:

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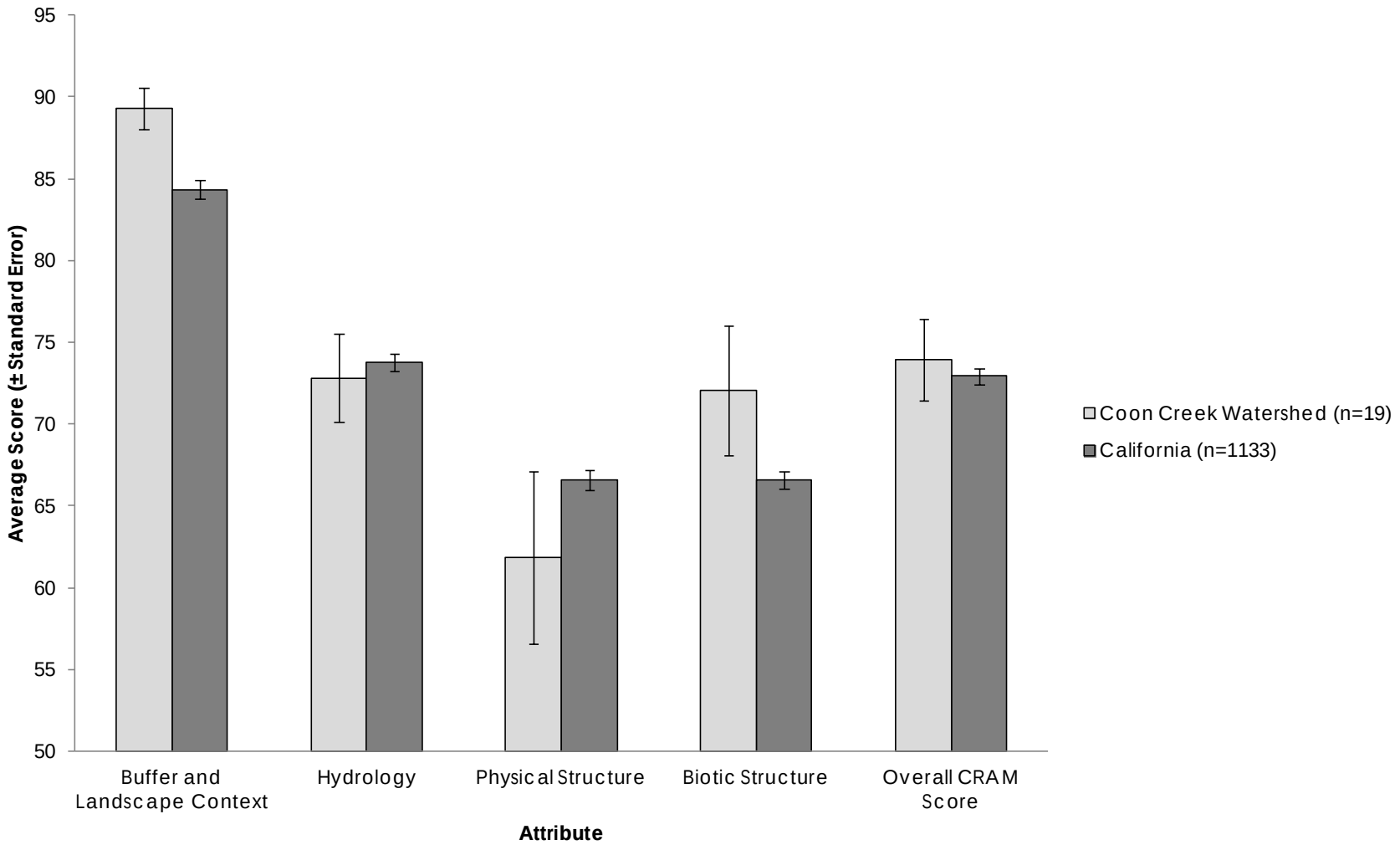
Coon Creek Watershed Assessment

Distribution of CRAM Scores among Qualitative Categories

Project No. 14-1024	Created By: CM	**Figure 65**



Notes:

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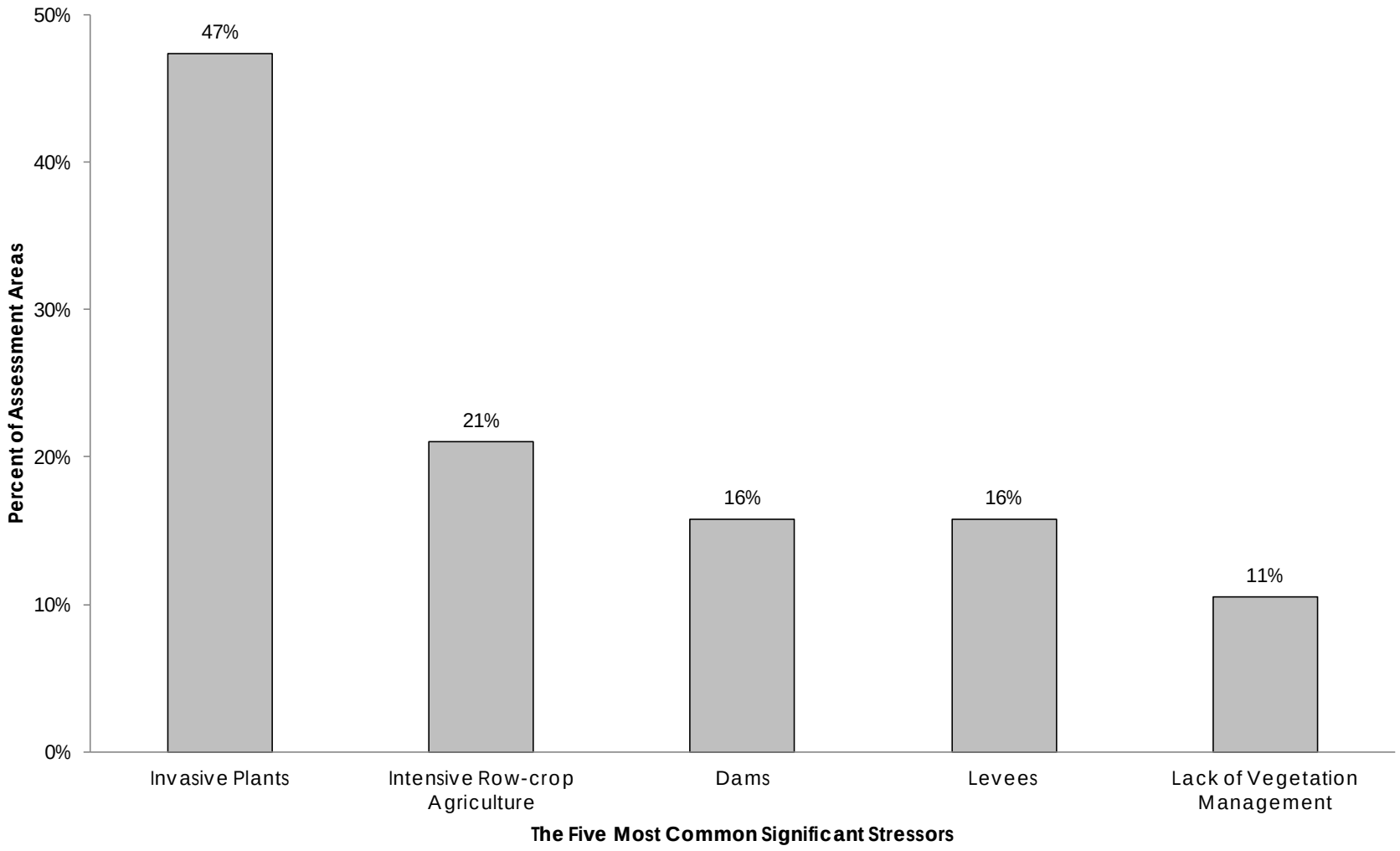
Coon Creek Watershed Assessment

Comparison of Coon Creek and California-Wide CRAM Scores

Project No. 14-1024	Created By: CM	**Figure 66**



Notes:

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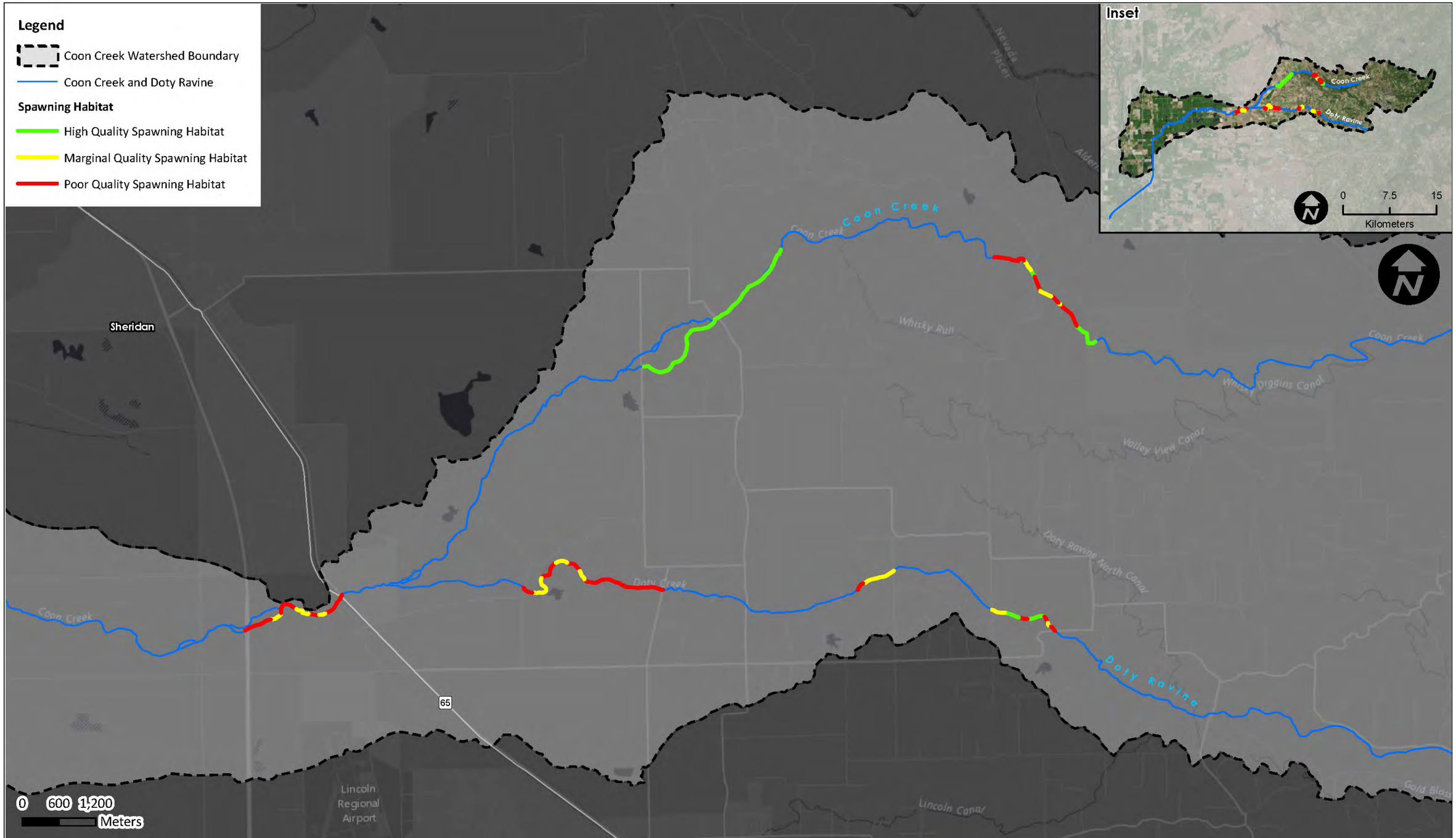
Coon Creek Watershed Assessment

Percentage of Coon Creek Sites Affected by 5 Key Stressors

Project No. 14-1024	Created By: CM	**Figure 67**



Notes:

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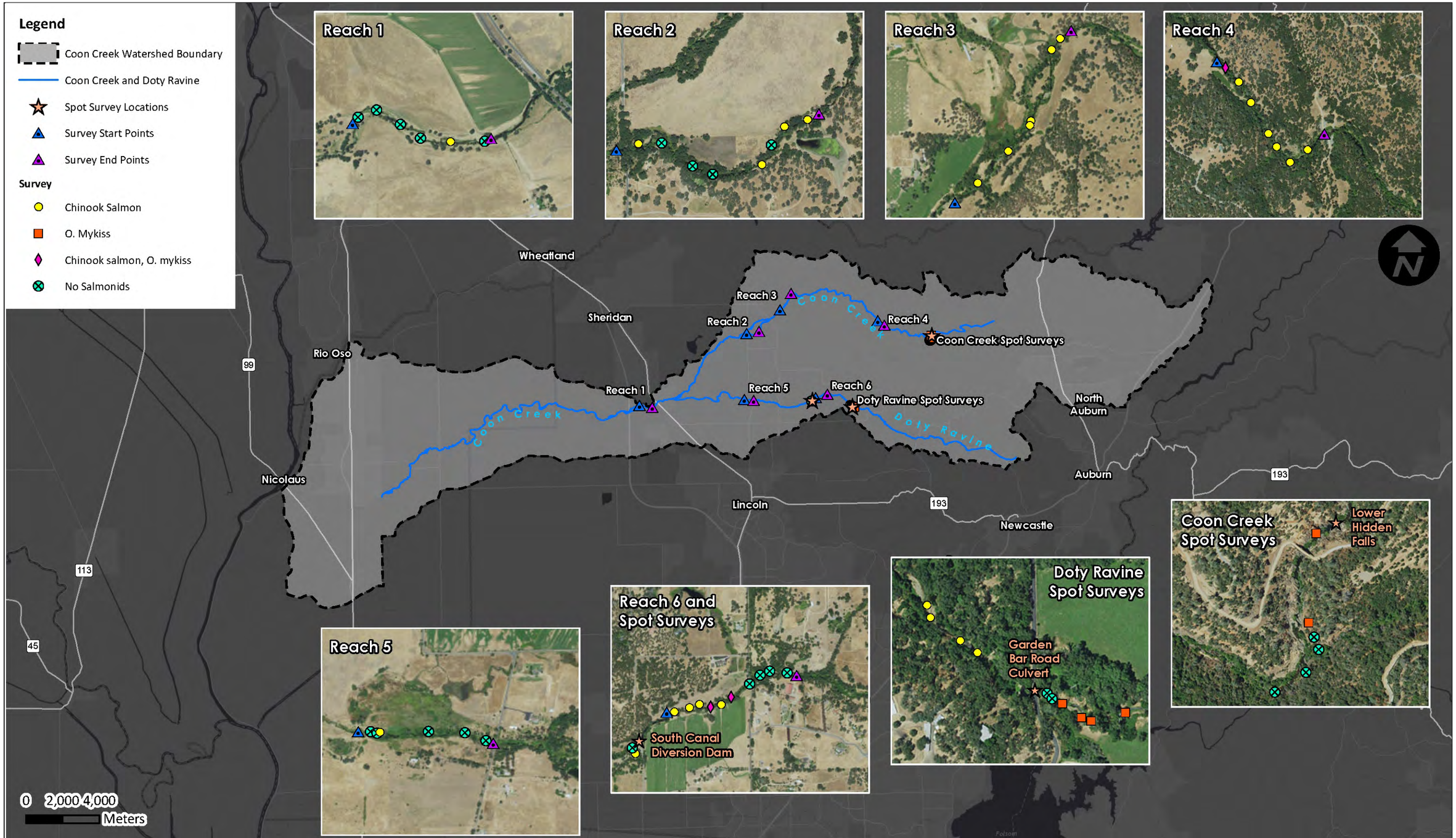
Coon Creek Watershed Assessment

Coon Creek Habitat Assessment - Winter 2015

Project No. 14-1024	Created By: ML	**Figure 68**



Notes:

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Coon Creek Watershed Assessment

Coon Creek Fish Survey Reaches - Spring 2015

Project No. 14-1024	Created By: ML	**Figure 69**

Notes:

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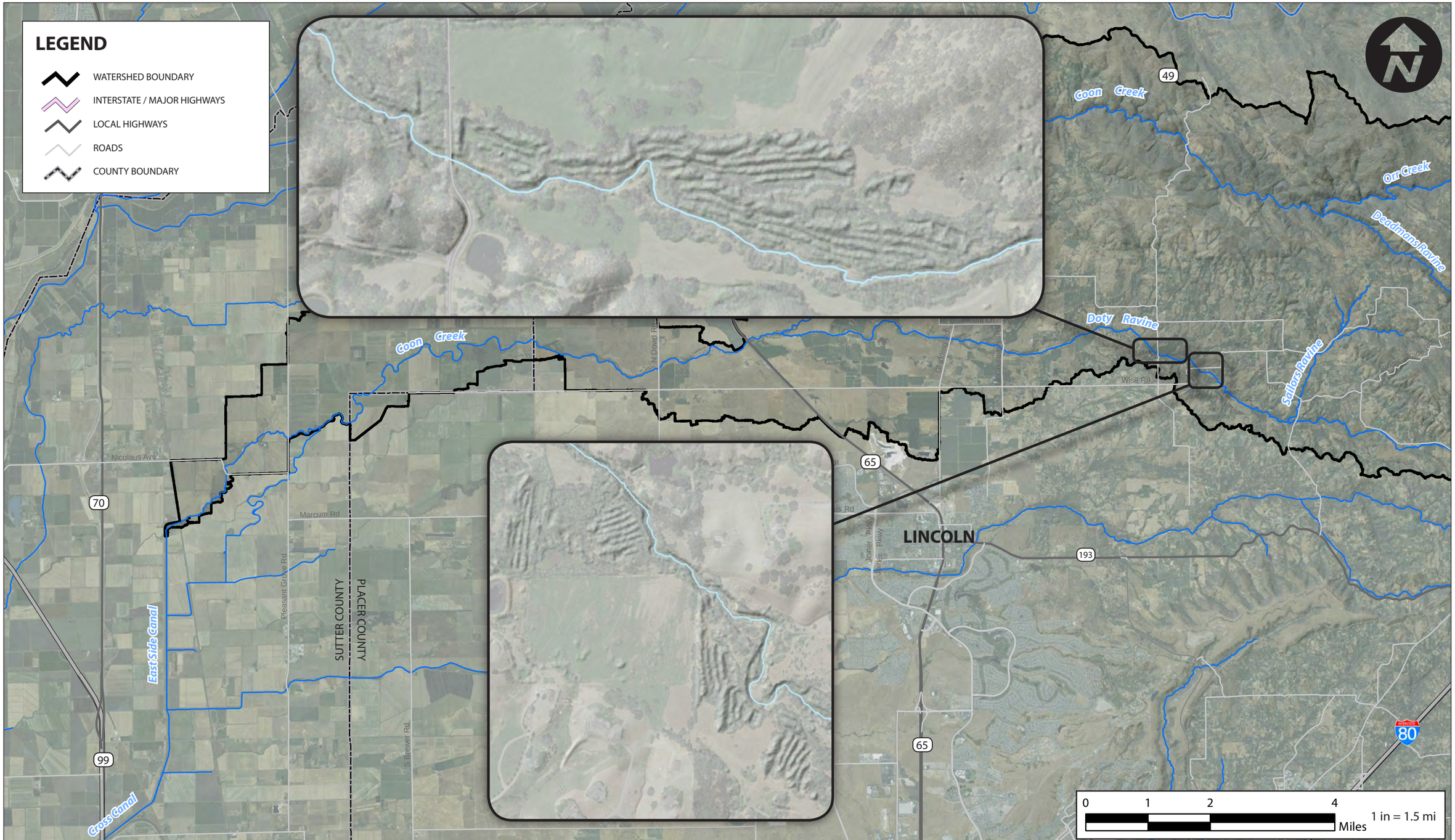
Coon Creek Watershed Assessment

Coon Creek Fish Surveys - Spring 2016

Project No. 14-1024	Created By: ML	**Figure 70**



Notes:

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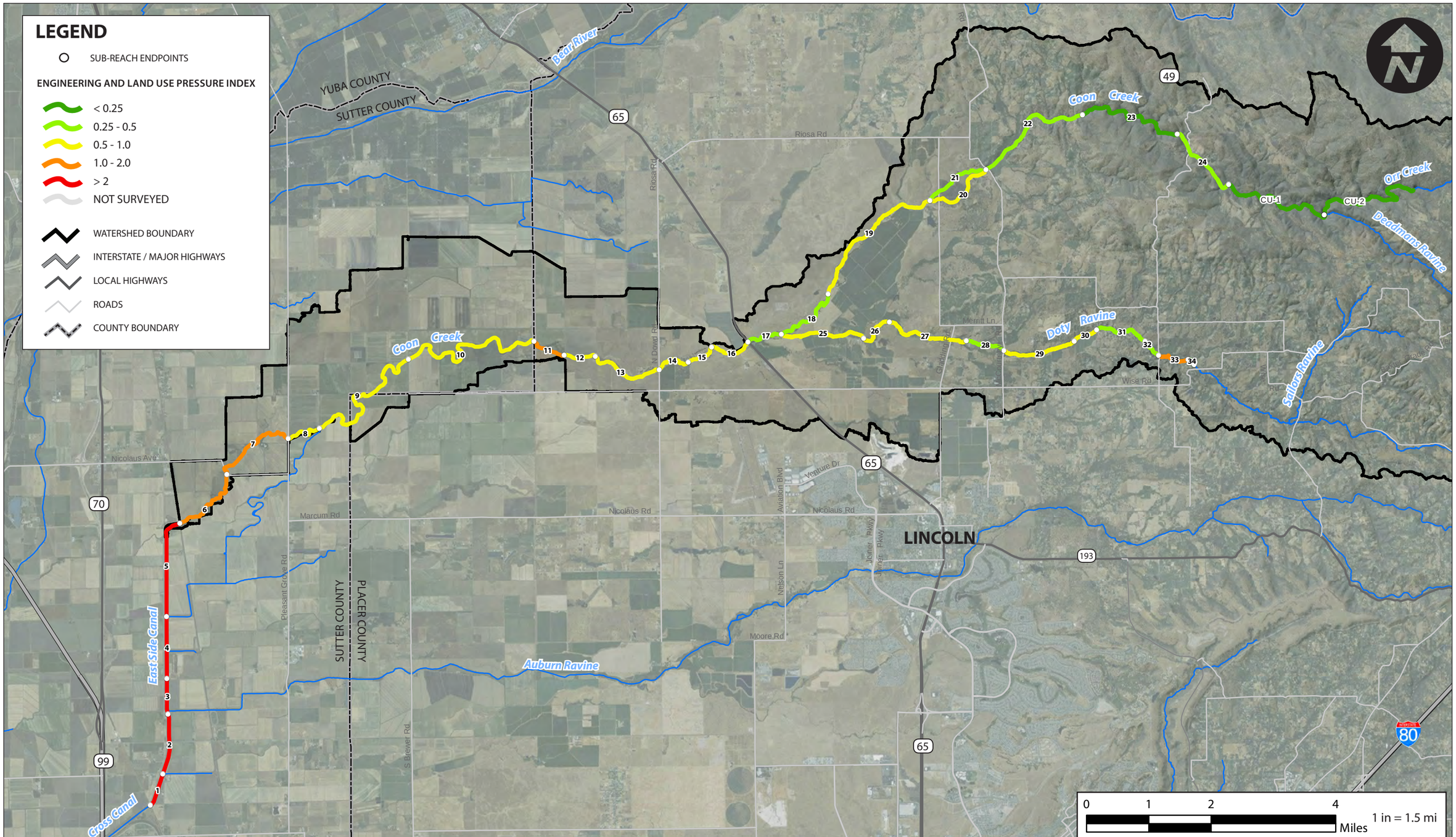
Coon Creek Watershed Assessment

Mining Tail Locations and LiDAR Details on Doty Ravine

Project No. 14-1024	Created By: SPW	**Figure 71**



Notes: Reaches calculated with remote sensing data only (bordered with white) do not include bank protection measures or cattle poaching and do not incorporate hydraulic control structures not visible from aerial imagery. As such, they likely underestimate the degree of land use and engineering pressure.

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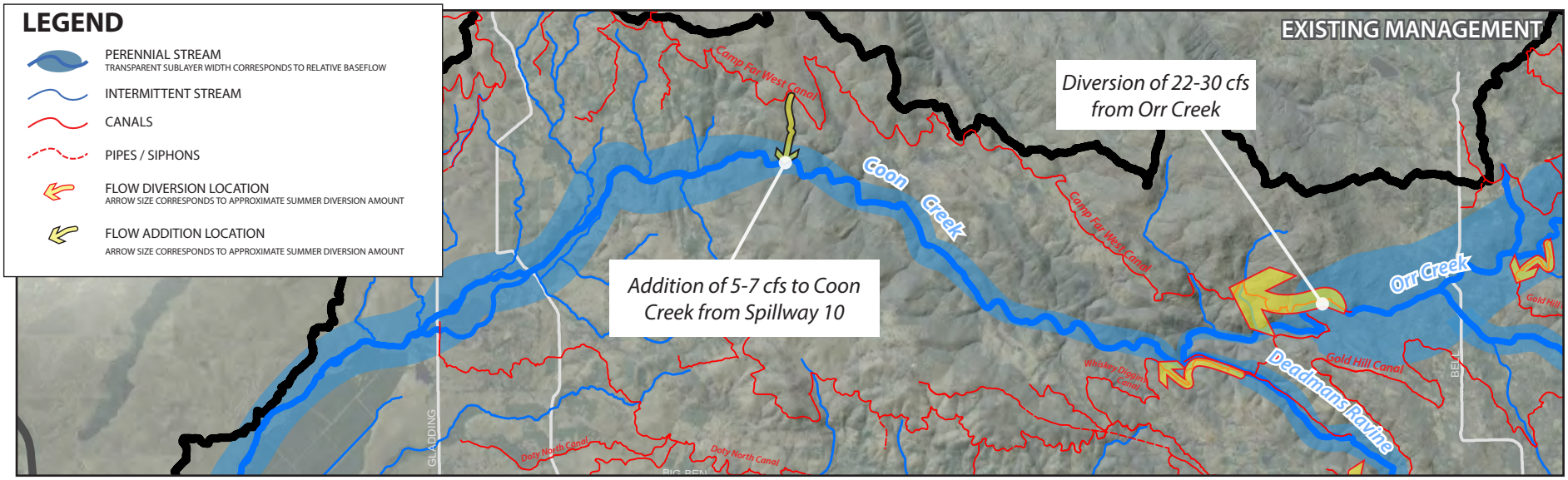
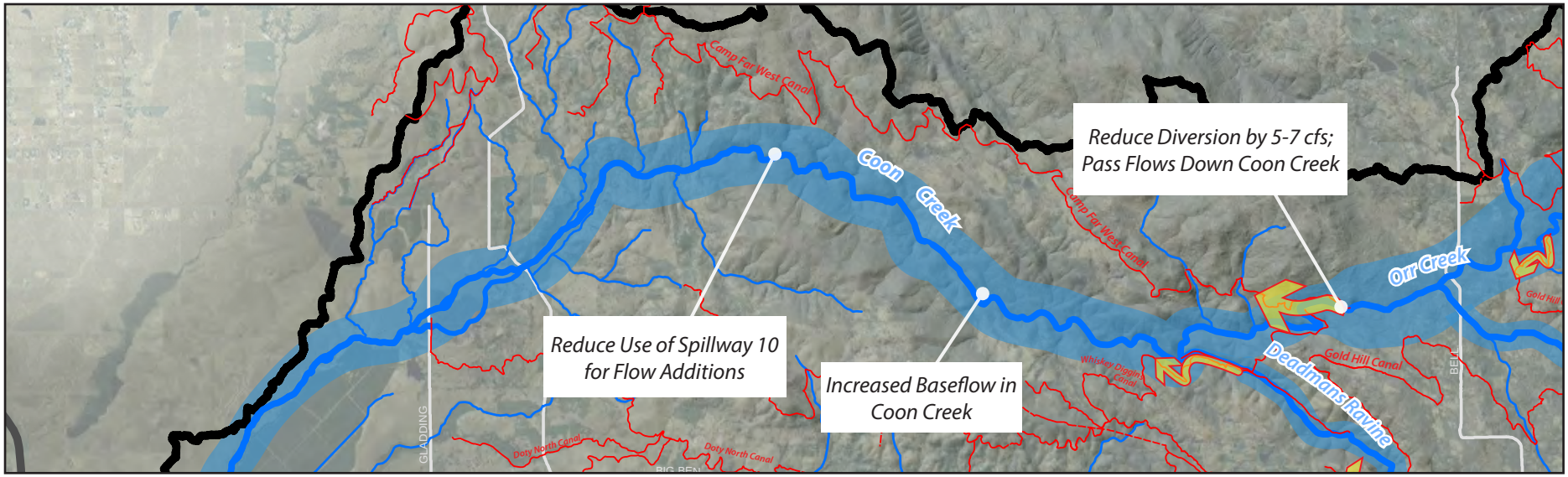
Coon Creek Watershed Assessment

Engineering and Land Use Pressure Index

Project No. 14-1024	Created By: SPW	**Figure 72**





Notes:

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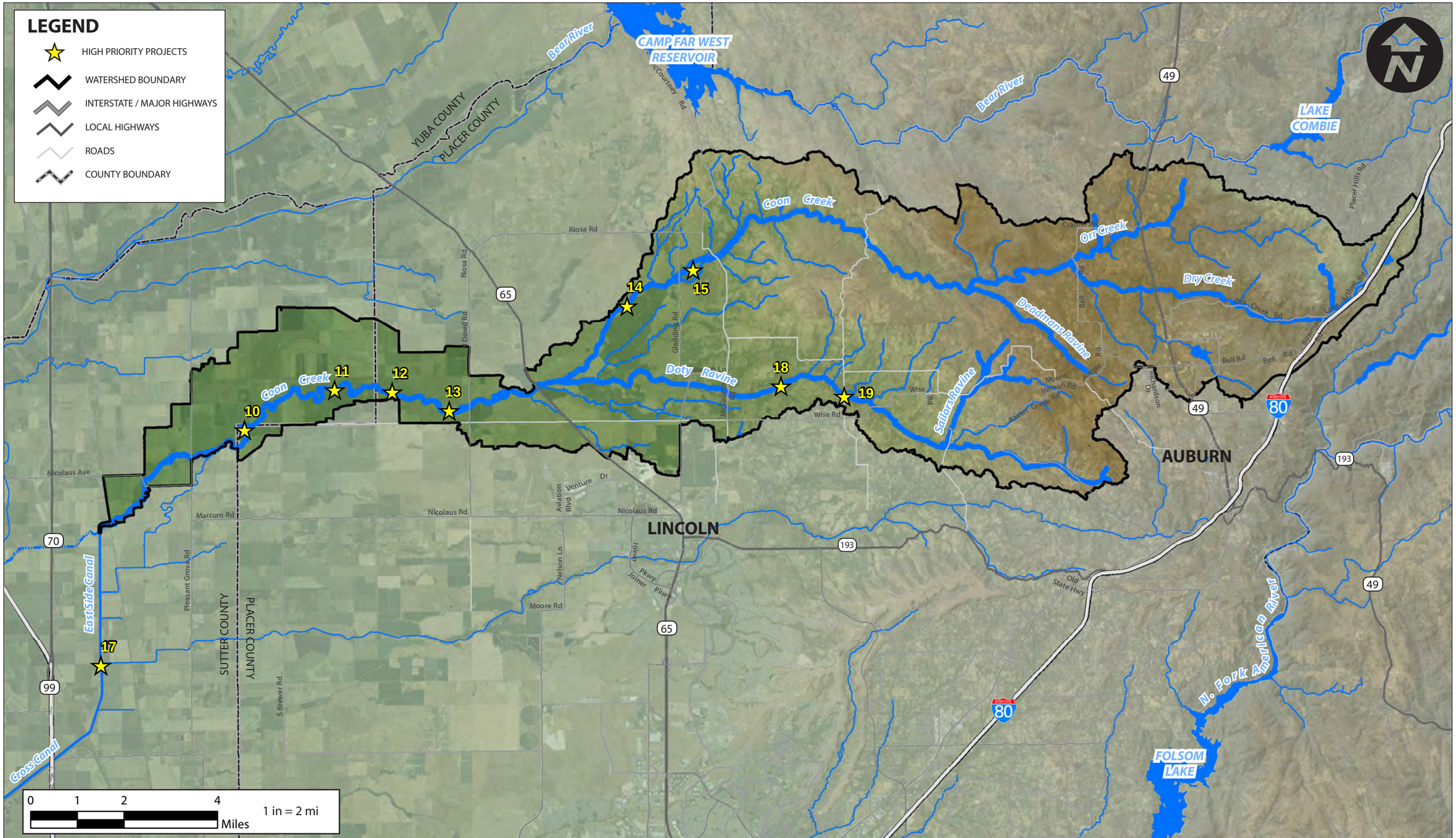
Coon Creek Watershed Assessment

Potential Flow Management Option for Upper Coon Creek / Camp Far West Canal Diversion

Project No. 14-1024	Created By: SPW	**Figure 73**



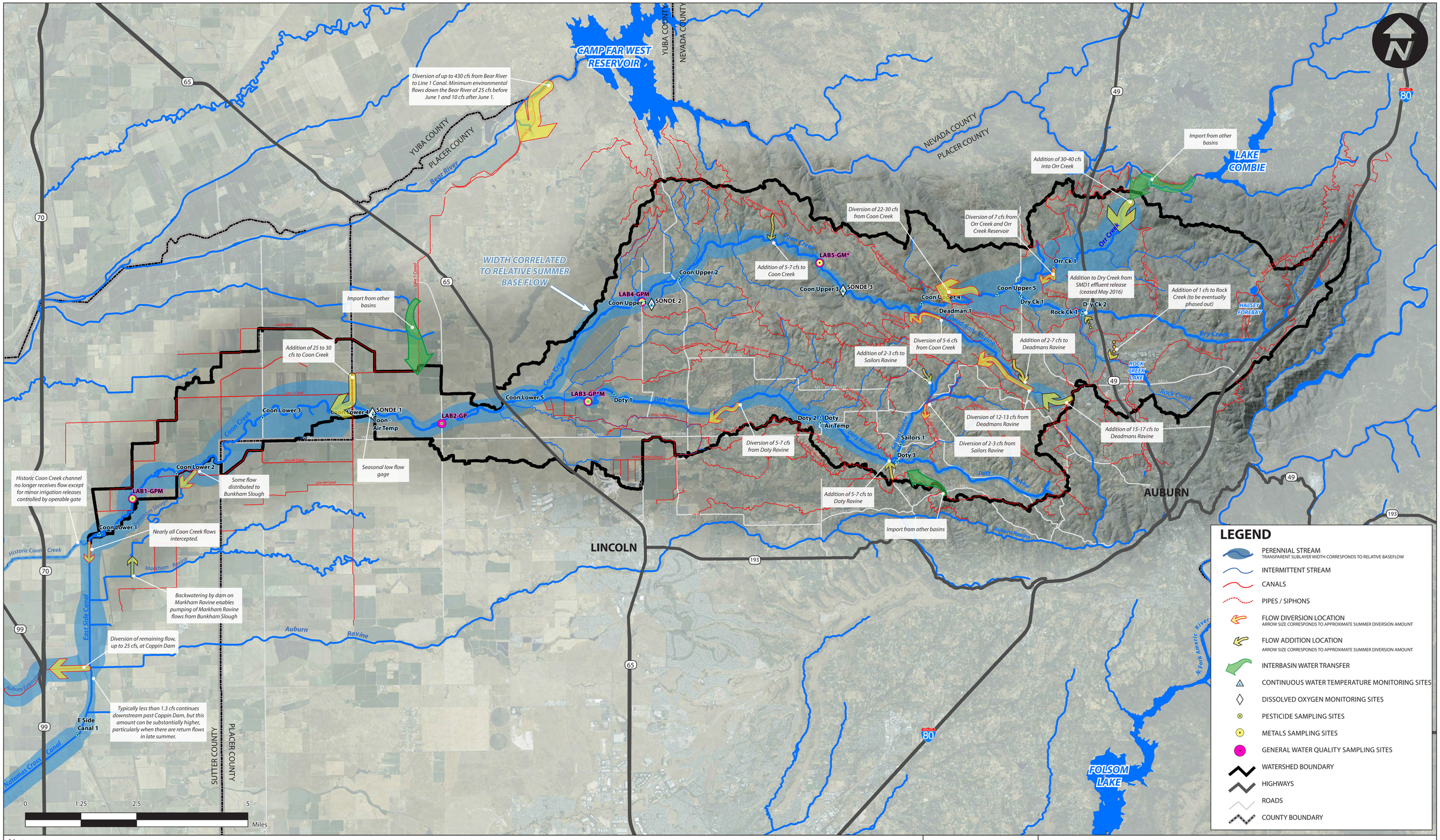
Notes: This map presents only the locations of high-priority projects for individual sites. It does not include basin-scale strategies listed in the opportunities and constraints matrix, which often involve numerous implementation sites. Additional projects and their locations are provided in the Appendix.

Coon Creek Watershed Assessment

High Priority Individual Project Site Locations

Project No. 14-1024	Created By: SPW	**Figure 74**

APPENDIX A - HYDROLOGY



Notes:

- This maps characterizes typical management of in-stream flows for conveyance purposes during the irrigation season (typically April 15th to October 15th) with an emphasis on early to mid-season flows (May and June).
- The flow additions and diversions presented are based on conversations with staff from the Nevada Irrigation District (NID) and South Sutter Water District (SSWD). NID and SSWD convey flows using both canals and stream channels to deliver water to their customers.
- The graphic focuses on the major movements of water in the system and does not seek to characterize all deliveries and withdrawals. In-stream gaging data is only available seasonally at the South Sutter Water District's low-flow gage on Coon Creek immediately upstream of the Placer-Sutter County boundary. As such, the flow overlay is intended as a relative depiction of average in-stream flows based on flow conveyance information (including canal gaging at release points and diversions) and field observations.
- Actual in-stream flows vary widely year-to-year and day-to-day based on regional water supply levels, late spring and early summer precipitation events, customer demand for water and a large array of other factors.
- Also, it should be noted that this map does not account for groundwater and surface-water interactions.

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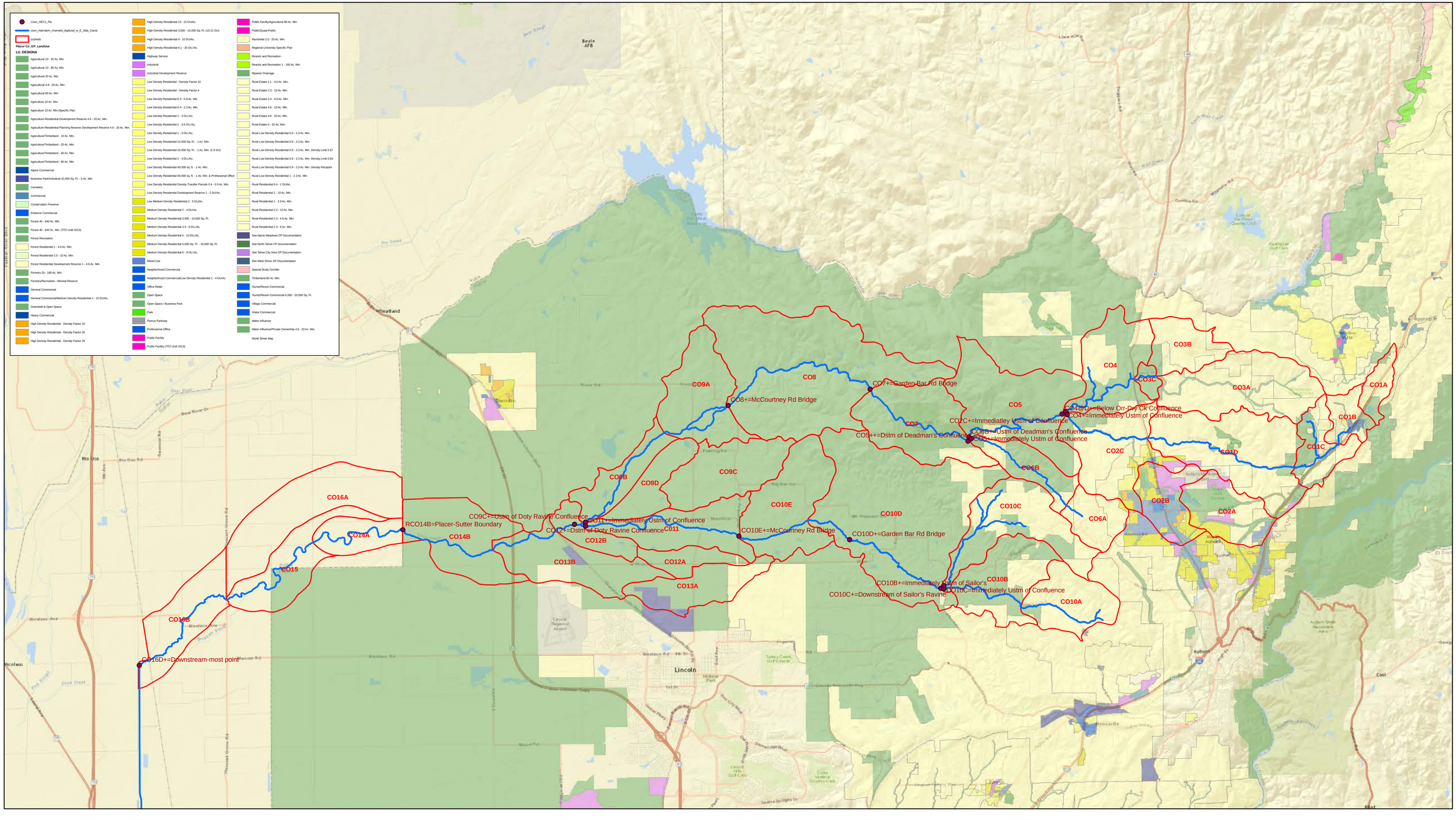
Coon Creek Watershed Assessment

COON CREEK WATERSHED IRRIGATION SEASON FLOW MANAGEMENT MAP *DRAFT*

Project No. 14-1024	Created By: SPW	**Figure A-1**

Document
Date

COON CREEK WATERSHED



CIVIL ENGINEERING SOLUTIONS, INC.

WATERSHED MAP
FLOODPLAINS AND FUTURE
GENERAL PLAN LAND USE

0 6,000 12,000 24,000 Feet

PLACER COUNTY

OCTOBER 2016

A-2

Table A-1. Peak Flows For Existing Conditions

Point Number	Model Node	Stream	Description	Percent Increase in Peak Flow					
				2-Year	10-Year	50-Year	100-Year	200-Year	500-Year
1	CO16D+	Coon Creek	Downstream-most point	4,080	9,355	17,294	21,265	25,388	34,122
2	RCO14B	Coon Creek	Placer-Sutter Boundary	4,568	11,479	21,339	26,609	32,137	44,826
3	CO12+	Coon Creek	Dstm of Doty Ravine Confluence	5,499	13,753	25,139	31,217	37,407	51,137
4	CO9+	Coon Creek	Ustm of Doty Ravine Confluence	4,109	10,492	19,877	24,608	29,311	38,662
5	CO11+	Doty Ravine	Immediately Ustm of Confluence	1,806	4,829	7,512	8,745	10,015	11,961
6	CO8+	Coon Creek	McCourtney Rd Bridge	4,108	10,487	20,121	24,888	29,547	38,698
7	CO7+	Coon Creek	Garden Bar Rd Bridge	3,576	9,347	18,071	22,297	26,420	33,909
8	CO5++	Coon Creek	Dstm of Deadman's Confluence	3,409	8,877	17,020	20,927	24,808	31,741
9	CO6B+	Deadman's	Immediately Ustm of Confluence	352	1,010	1,834	2,254	2,668	3,235
10	CO5+	Coon Creek	Ustm of Deadman's Confluence	3,177	8,420	15,361	18,925	22,448	28,803
11	CO4@D+	Coon Creek	Below Orr-Dry Ck Confluence	2,729	7,577	13,460	16,430	19,341	24,346
12	CO4+	Orr Creek	Immediately Ustm of Confluence	1,457	3,726	6,446	7,652	8,754	10,422
13	CO2C+	Dry Creek	Immediatley Ustm of Confluence	1,726	4,825	8,413	10,130	11,749	14,127
14	CO10E+	Doty Ravine	McCourtney Rd Bridge	1,710	4,824	7,450	8,712	9,985	11,956
15	CO10D+	Doty Ravine	Garden Bar Rd Bridge	1,531	4,086	6,489	7,724	8,941	10,774
16	CO10C+	Doty Ravine	Downstream of Sailor's Ravine	896	2,503	4,178	4,971	5,768	6,917
17	CO10B+	Doty Ravine	Immediately Ustm of Sailor's	573	1,486	2,418	2,847	3,262	3,903
18	CO10C	Sailor's Ravine	Immediately Ustm of Confluence	528	1,226	1,959	2,305	2,638	3,183

Table A-2. Peak Flows For Future Fully Developed Conditions

Point Number	Model Node	Stream	Description	Peak Flow (cfs)					
				2-Year	10-Year	50-Year	100-Year	200-Year	500-Year
1	CO16D+	Coon Creek	Downstream-most point	4,169	9,463	17,409	21,397	25,534	34,299
2	RCO14B	Coon Creek	Placer-Sutter Boundary	4,690	11,602	21,469	26,764	32,303	45,114
3	CO12+	Coon Creek	Dstm of Doty Ravine Confluence	5,631	13,885	25,350	31,507	37,717	51,663
4	CO9+	Coon Creek	Ustm of Doty Ravine Confluence	4,254	10,649	20,174	24,948	29,762	39,465
5	CO11+	Doty Ravine	Immediately Ustm of Confluence	1,806	4,829	7,512	8,745	10,015	11,961
6	CO8+	Coon Creek	McCourtney Rd Bridge	4,259	10,661	20,468	25,313	30,107	39,410
7	CO7+	Coon Creek	Garden Bar Rd Bridge	3,719	9,505	18,419	22,759	26,879	34,535
8	CO5++	Coon Creek	Dstm of Deadman's Confluence	3,550	9,095	17,295	21,306	25,198	32,209
9	CO6B+	Deadman's	Immediately Ustm of Confluence	352	1,010	1,834	2,254	2,668	3,235
10	CO5+	Coon Creek	Ustm of Deadman's Confluence	3,323	8,638	15,608	19,259	22,770	29,271
11	CO4@D+	Coon Creek	Below Orr-Dry Ck Confluence	2,874	7,798	13,795	16,739	19,660	24,843
12	CO4+	Orr Creek	Immediately Ustm of Confluence	1,457	3,726	6,446	7,652	8,754	10,422
13	CO2C+	Dry Creek	Immediatley Ustm of Confluence	1,900	5,049	8,670	10,412	12,027	14,421
14	CO10E+	Doty Ravine	McCourtney Rd Bridge	1,710	4,824	7,450	8,712	9,985	11,956
15	CO10D+	Doty Ravine	Garden Bar Rd Bridge	1,531	4,086	6,489	7,724	8,941	10,774
16	CO10C+	Doty Ravine	Downstream of Sailor's Ravine	896	2,503	4,178	4,971	5,768	6,917
17	CO10B+	Doty Ravine	Immediately Ustm of Sailor's	573	1,486	2,418	2,847	3,262	3,903
18	CO10C	Sailor's Ravine	Immediately Ustm of Confluence	528	1,226	1,959	2,305	2,638	3,183

APPENDIX B - WATER QUALITY

Notes:

Coon Creek Watershed Assessment

Daily Average Water Temperatures - Lower Coon Creek

Project No. 14-1024	Created By: CMC	**Figure B-1**

Notes:

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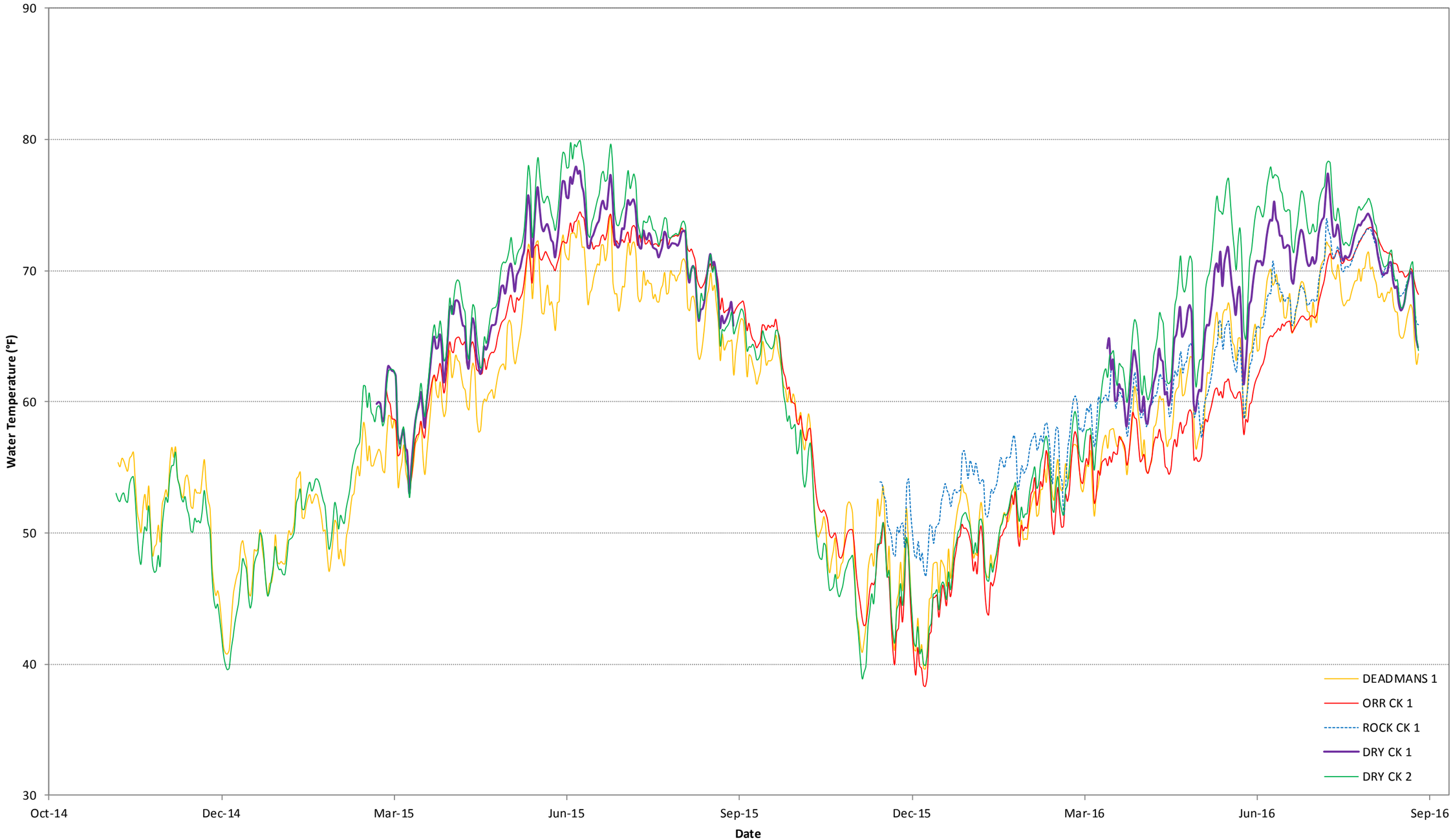
Coon Creek Watershed Assessment

Daily Average Water Temperature - Upper Coon Creek

Project No. 14-1024	Created By: CMC	**Figure B-2**

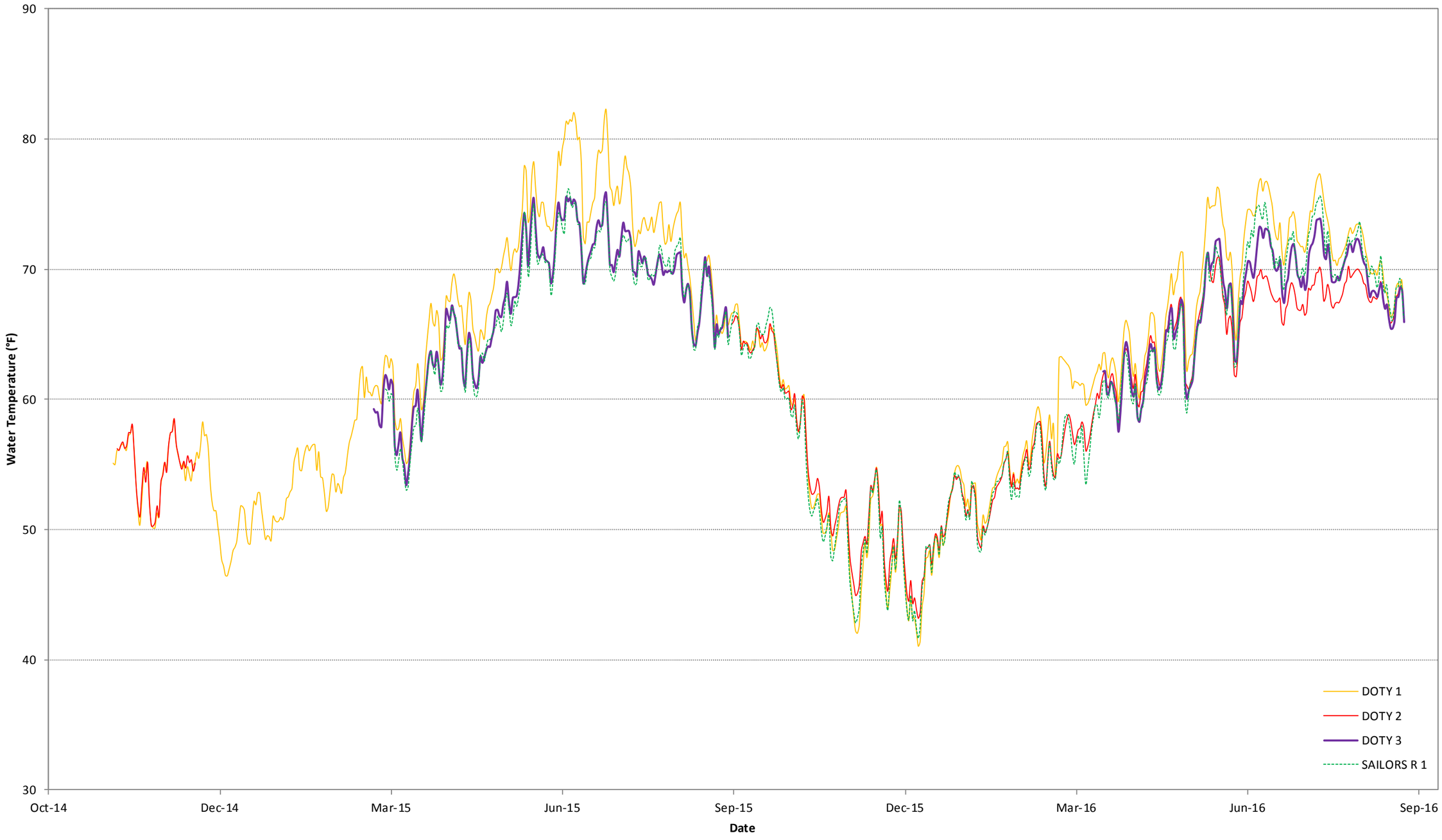


Notes:

Coon Creek Watershed Assessment

Daily Average Water Temperatures - Coon Headwaters

Project No. 14-1024	Created By: CMC	**Figure B-3**



Notes:

Coon Creek Watershed Assessment

Daily Average Water Temperature - Doty Ravine

Project No. 14-1024	Created By: CMC	**Figure B-4**

APPENDIX C - CRAM

Photograph 1. Doty Ravine Preserve, 11 June 2015.

Photograph 2. East Side Canal 1, 10 June 2015.

Photograph 3. East Side Canal 2, 10 June 2015.

Photograph 4. Flemming, 22 June 2015.

Photograph 5. Hanley Ranch, 16 June 2015.

Photograph 6. John Foggy, 23 June 2015.

Photograph 7. Lower Hidden Falls, 17 June 2015.

Photograph 8. Mehalakis, 22 June 2015.

Photograph 9. Nader Ranch, 11 June 2015.

Photograph 10. Proceed Lincoln Investments, 9 June 2015.

Photograph 11. Scilacci, 9 June 2015.

Photograph 12. Tahti Bates, 16 June 2015.

Photograph 13. Talley, 8 June 2015.

Photograph 14. Taylor Ranch 1, 23 June 2015.

Photograph 15. Taylor Ranch 2, 24 June 2015.

Photograph 16. Upper Hidden Falls, 17 June 2015.

Photograph 17. Warren Property, 24 June 2015.

Photograph 18. Wastewater Treatment Plant, 10 June 2015.

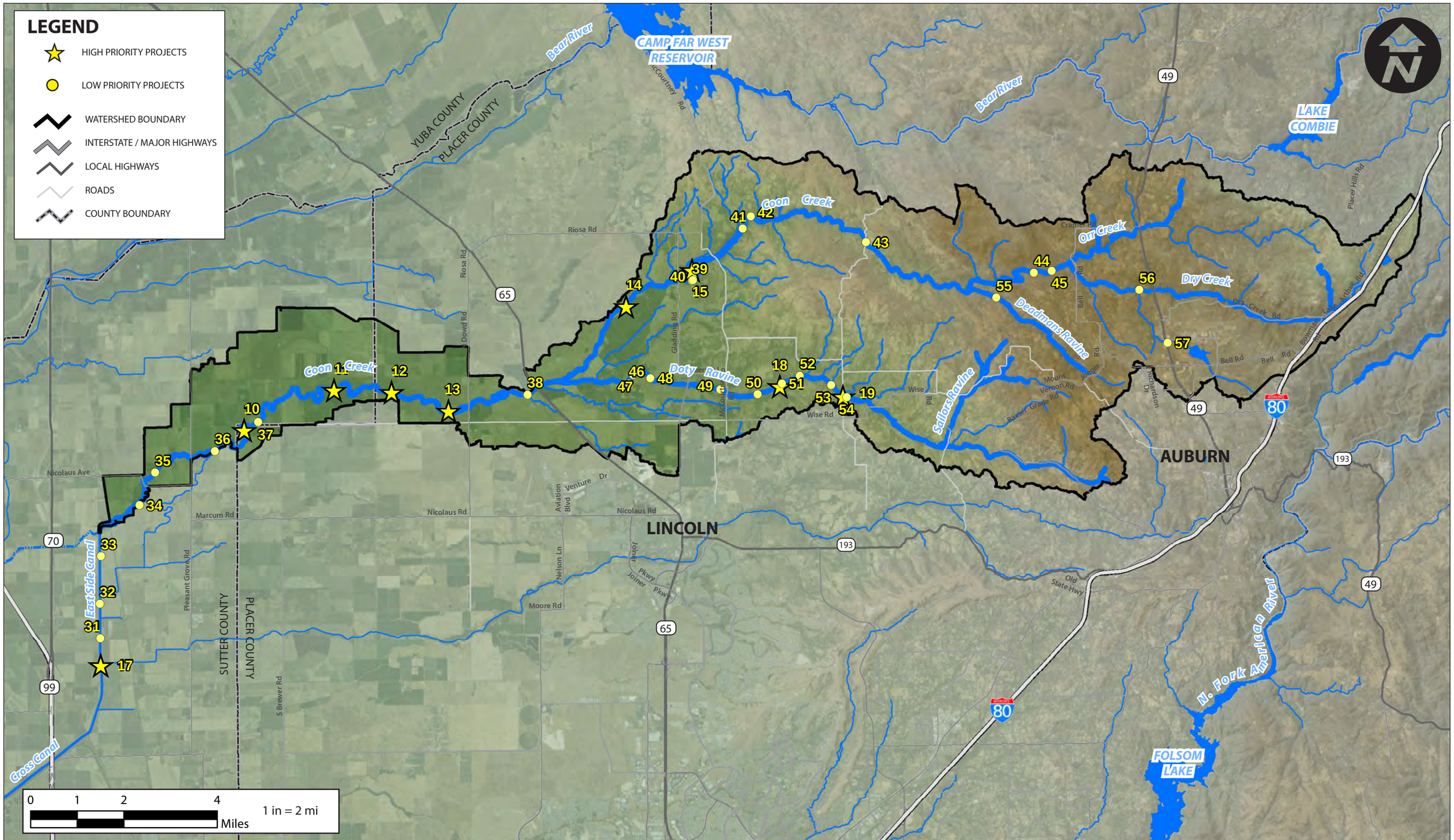
Photograph 19. Weygandt, 8 June 2015.

APPENDIX D - DISTURBANCES

Table D-1. Engineering and Land Use Index Score Calculations by Pressure Type and Sub-Reach

Sub-Reach ID #	Stream	Length (ft)	Grade Control Cumulative Score	Grade Control Impact Index	BP Cum. Impact Score	BP Impact Index	Levee Cumulative Score	Levee Impact Index	Historic Channel Realignment Score	Historic Channel Realignment Score	Loss of Historic Channel Length Score	Loss of Historic Channel Length Impact Index	Cattle Poaching Score	Cattle Poaching Impact Index	Incision Score	Incision Impact Index	Total Impact Score	Index (impact/ reach length)
1	East Side Canal	2,878	1000	0.35	0	-	5,757	2.00	5,757	2.00	720	0.25	0.0	0.00	0	-	13,233	4.60
2	East Side Canal	5,183	1775	0.34	0	-	10,366	2.00	10,366	2.00	1296	0.25	0.0	0.00	0	-	23,803	4.59
3	East Side Canal	3,014	540	0.18	0	-	6,027	2.00	6,027	2.00	753	0.25	0.0	0.00	0	-	13,348	4.43
4	East Side Canal	5,218	335	0.06	0	-	10,435	2.00	10,435	2.00	1304	0.25	0.0	0.00	0	-	22,510	4.31
5	East Side Canal	8,709	1465	0.17	0	-	17,418	2.00	17,418	2.00	2177	0.25	0.0	0.00	0	-	38,478	4.42
6	Coon Creek	7,005	817	0.12	0	-	3,503	0.50	2,425	0.35	1213	0.17	35.0	0.01	876	0.13	8,867	1.27
7	Coon Creek	8,093	1600	0.20	18	0.00	4,047	0.50	3,035	0.38	1517	0.19	20.2	0.00	1012	0.13	11,249	1.39
8	Coon Creek	3,469	583	0.17	0	-	1,388	0.40	694	0.20	347	0.10	0.0	0.00	434	0.13	3,445	0.99
9	Coon Creek	15,144	1442	0.10	244	0.02	7,193	0.48	2,272	0.15	1136	0.08	0.0	0.00	1893	0.13	14,179	0.94
10	Coon Creek	15,974	2619	0.16	0	-	5,990	0.38	1,997	0.13	998	0.06	0.0	0.00	1997	0.13	13,601	0.85
11	Coon Creek	3,068	700	0.23	0	-	1,074	0.35	1,227	0.40	614	0.20	0.0	0.00	384	0.13	3,999	1.30
12	Coon Creek	2,843	0	-	66	0.02	1,421	0.50	355	0.13	0	0.00	0.0	0.00	711	0.25	2,554	0.90
13	Coon Creek	6,786	198	0.03	0	-	2,205	0.33	848	0.13	0	0.00	0.0	0.00	1697	0.25	4,948	0.73
14	Coon Creek	3,201	1016	0.32	0	-	480	0.15	400	0.13	0	0.00	8.0	0.00	800	0.25	2,704	0.84
15	Coon Creek	2,634	636	0.24	68	0.03	329	0.13	329	0.13	0	0.00	263.4	0.10	329	0.13	1,955	0.74
16	Coon Creek	3,787	815	0.22	428	0.11	473	0.13	473	0.13	0	0.00	757.4	0.20	473	0.13	3,421	0.90
17	Coon Creek	3,287	335	0.10	0	-	329	0.10	411	0.13	0	0.00	0.0	0.00	411	0.13	1,486	0.45
18	Coon Creek	6,474	0	-	0	-	809	0.13	809	0.13	0	0.00	0.0	0.00	1619	0.25	3,237	0.50
19	Coon Creek	13,336	600	0.04	0	-	2,667	0.20	6,000	0.45	0	0.00	0.0	0.00	3334	0.25	12,601	0.94
20	Coon Creek	6,719	1250	0.19	0	-	672	0.10	-	-	0	0.00	403.1	0.06	1680	0.25	4,005	0.60
21	Coon Creek	5,978	600	0.10	40	0.01	598	0.10	-	-	0	0.00	59.8	0.01	1494	0.25	2,792	0.47
22	Coon Creek	11,271	1500	0.13	120	0.01	564	0.05	-	-	0	0.00	56.4	0.01	1409	0.13	3,649	0.32
23	Coon Creek	10,869	0	-	0	-	-	-	-	-	0	0.00	0.0	0.00	0	-	-	-
24	Coon Creek	7,025	832	0.12	859	0.12	88	0.01	-	-	0	0.00	70.2	0.01	0	-	1,849	0.26
CU-1	Coon Creek	11,076	369	0.03	0	-	-	-	-	-	0	0.00	0.0	0.00	0	-	369	0.03
CU-2	Coon Creek	12,560	647	0.05	0	-	-	-	-	-	0	0.00	0.0	0.00	0	-	647	0.05
25	Doty Ravine	7,996	298	0.04	0	-	2,998	0.38	2,599	0.33	0	0.00	0.0	0.00	0	-	5,895	0.74
26	Doty Ravine	3,432	1052	0.31	0	-	1,459	0.43	-	-	0	0.00	343.2	0.10	429	0.13	3,283	0.96
27	Doty Ravine	7,766	1150	0.15	0	-	2,718	0.35	1,165	0.15	0	0.00	233.0	0.03	0	-	5,266	0.68
28	Doty Ravine	3,637	182	0.05	53	0.01	546	0.15	273	0.08	0	0.00	218.2	0.06	455	0.13	1,726	0.47
29	Doty Ravine	6,674	1831	0.27	53	0.01	1,001	0.15	-	-	0	0.00	133.5	0.02	834	0.13	3,852	0.58
30	Doty Ravine	2,378	1120	0.47	0	-	357	0.15	-	-	0	0.00	0.0	0.00	297	0.13	1,773	0.75
31	Doty Ravine	5,019	519	0.10	20	0.00	753	0.15	-	-	0	0.00	100.4	0.02	627	0.13	2,019	0.40
32	Doty Ravine	1,862	281	0.15	0	-	186	0.10	-	-	0	0.00	0.0	0.00	233	0.13	699	0.38
33	Doty Ravine	2,957	1020	0.34	19	0.01	961	0.33	739	0.25	0	0.00	443.5	0.15	370	0.13	3,552	1.20
34	Doty Ravine	850	0	-	0	-	-	-	-	-	0	0.00	0.0	0.00	106	0.13	106	0.13

APPENDIX E - OPPORTUNITIES



Notes: This map presents only the locations of projects for individual sites. It does not include basin-scale strategies listed in the opportunities and constraints matrix, which often involve numerous implementation sites.

cbec

Coon Creek Watershed Assessment

Project Site Locations

Project No. 14-1024	Created By: SPW	**Figure E-1**

Table E-1. Additional Coon Creek Opportunities Matrix

ID	Scale [1]	Project Name	Location	Project Description and Benefits	Benefits [2]					Priority
					Physical Processes	Hydrology	Water Quality	Salmonid Habitat	Riparian Habitat	
31	IP	Replace Low Flow Crossing with An Open-Span Bridge	East Side Canal	An existing low flow vehicle crossing and box culvert can be replaced with an open-span bridge that would reduce impacts on reach-scale hydraulics as well as reduce predation of salmonid's by non-native fish at the box culvert.	M	N	N	M	N	L-M
32	MP	Habitat Complexity Improvements and Riparian Vegetation Enhancement Along East Side Canal	East Side Canal	Habitat complexity could be improved within the East Side Canal by enhancing the existing floodplain bench, creating side-channel or off-channel habitat features, and enhancing riparian vegetation cover.	M	L	L	M	M	M
33	MP	Levee Setback along East Side Canal	East Side Canal	A setback of the eastern levee of the East Side Canal could be pursued to increase the width of the stream corridor, provide greater room for channel sinuosity and increase the habitat complexity of the system. Land would likely need to be acquired from willing landowners.	H	L	L	M-H	H	M-H
34	IP	Reconnection of Historic Meander Bends along Lower Coon Creek	Lower Coon Creek between the East Side Canal and Nicolaus Ave	Historic meander bends, which are still visible in the LiDAR, could be reconnected as the primary channel alignment to restore sinuosity and improve habitat conditions.	M	L	N	M	M	M
35	IP	Restore Sinuosity of Lower Coon Creek upstream of Nicolaus Ave	Lower Coon Creek upstream of Nicolaus Ave	The highly straightened reach immediately upstream of Nicolaus Ave can be realigned to exhibit a more natural sinuosity, improved morphological complexity and enhanced habitat conditions.	M	L	N	L-M	M	M

[1] MP = Multiple Projects; IP = Individual Project [2] H = High; M = Moderate; L = Low; N = None

Table E-1. Additional Coon Creek Opportunities Matrix

ID	Scale [1]	Project Name	Location	Project Description and Benefits	Benefits [2]					Priority
					Physical Processes	Hydrology	Water Quality	Salmonid Habitat	Riparian Habitat	
36	IP	Replace Low-Flow Private Vehicle Crossing with an Open-Span Bridge	Lower Coon Creek two thirds of a mile upstream of Pleasant Grove Road	An existing private vehicle crossing can be replaced with an open-span bridge that would reduce impacts on reach-scale hydraulics and physical processes as well as reduce potential for predation of salmonid's by non-native fish at the culverts.	M	N	N	L-M	N	L-M
37	IP	Restore sinuosity of Lower Coon Creek downstream of Brewer Road	Lower Coon Creek 1 mile downstream of Brewer Road	The highly straightened reach 1 mile downstream of Brewer Road can be realigned to exhibit a more natural sinuosity, improved morphological complexity and enhanced habitat conditions.	M	L	N	L-M	M	M
38	IP	Channel Rehabilitation and Livestock Exclusion along Coon Creek	Coon Creek between Old Hwy 65 and the new Hwy 65 bypass	Where unrestricted livestock access have degraded the stream channel, channel rehabilitation measures (e.g., biotechnical bank stabilization, bank regrading, etc.), riparian vegetation enhancement and cattle exclusion measures can be implemented to improve habitat and water quality conditions.	L-M	N	M-H	M-H	M-H	M-H
39	IP	Removal of Unused Flashboard Dam Wing Walls and Sill	Coon Creek between Gladding Road and McCourtney Road	Assuming this flashboard dam is no longer is use, the wing walls and dam sill can be removed to eliminate the artificial influence on reach hydraulics and physical processes.	L-M	N	N	L	N	L
40	IP	Stabilize Eroding Pond Drainage Ditch	Coon Creek between Gladding Road and McCourtney Road	A badly eroding drainage ditch for a stock pond likely contributes excessive fine sediment to the stream channel and could be stabilized with several large wood structures or other grade controls.	L	N	L	L	N	L

[1] MP = Multiple Projects; IP = Individual Project [2] H = High; M = Moderate; L = Low; N = None

Table E-1. Additional Coon Creek Opportunities Matrix

ID	Scale [1]	Project Name	Location	Project Description and Benefits	Benefits [2]					Priority
					Physical Processes	Hydrology	Water Quality	Salmonid Habitat	Riparian Habitat	
41	IP	Channel Re-Profiling to Address Incision on Coon Creek	Coon Creek upstream of McCourtney Road	Several sections of Coon Creek upstream of McCourtney Road are significantly incised and could be improved their channel re-profiling efforts. These actions could include the placement of large wood, beaver dam analogs, strategic bed elevation augmentation (e.g., Newbury Weirs, roughened rock ramps) or other strategies to reduce incision and enhance floodplain connectivity.	M-H	L-M	L	M	M	M
42	IP	Removal of Informal Boulder Weirs	Coon Creek appropximately 1.2 miles upstream of McCourtney Road	Two informal boulder weirs located along the stream bed could be removed to eliminate artificial influence on reach hydraulics and physical processes.	L	N	N	N	N	L
43	IP	Removal of Bank Armoring along Right Bank of Coon Creek Upstream of Garden Bar Road	Coon Creek immediately upstream of Garden Bar Rd	A 600 foot long section of cobble and boulder bank armoring could be retrofitted with more natural biotechnical bank stabilization methods to enhance a more natural physical process regime.	L-M	N	N	N	L	L
44	IP	Retrofit or removal of Camp Far West Diversion Dam	Coon Creek approximately 1 mile west of Bell Rd	The Camp Far West Diversion Dam could be retrofitted or removed to improve fish passage and reduce the disruption of physical processes along Coon Creek. Any project pursued would need to be compatible with NID operations along Coon Creek, particularly diversion of flows into the Camp Far West Canal.	M	M	N	L-M	L	L-M

[1] MP = Multiple Projects; IP = Individual Project [2] H = High; M = Moderate; L = Low; N = None

Table E-1. Additional Coon Creek Opportunities Matrix

ID	Scale [1]	Project Name	Location	Project Description and Benefits	Benefits [2]					Priority
					Physical Processes	Hydrology	Water Quality	Salmonid Habitat	Riparian Habitat	
45	IP	Cattle Exclusion and Riparian Enhancement along Upper Coon Creek	Coon Creek approximately a half mile west of Bell Road	Cattle exclusion measures and off-channel watering areas could be implemented to reduce or eliminate livestock impacts on the stream. Riparian habitat enhancement efforts could simultaneously be pursued to improve riparian corridor conditions.	M	N	L-M	L	M-H	M
46	IP	Channel rehabilitation and cattle exclusion on Doty Ravine upstream of Manzanita Cemetery Road	Doty Ravine immediately upstream of Manzanita Cemetery Road	The degraded stream channel can be enhanced through berm removal, cattle exclusion, channel enhancement measures (e.g., bank grading, large wood placement, inset floodplain bench creation, etc.) and riparian vegetation enhancement.	M	N	M	M	M	M
47	IP	Replace low flow private vehicle crossing with an open-span crossing	Doty Ravine immediately upstream of Manzanita Cemetery Road	The existing low-flow private vehicle crossing can be replaced with an open-span bridge that would reduce impacts on reach-scale hydraulics and physical processes as well as reduce potential for predation of salmonid's by non-native fish at the culverts.	M	N	N	L-M	N	L-M
48	IP	Channel rehabilitation at bank erosion sites along historic levee features	Doty Ravine within Placer Land Trust preserve downstream of Gladding Road	Several existing, high-severity bank erosion sites appear to be driven by channel interactions with historic levee material. Removal of this material could eliminate constraints on more natural physical processes (e.g., lateral channel migration) as well as reduce excessive fine sediment contributions.	M-H	N	M	L	L	M

[1] MP = Multiple Projects; IP = Individual Project [2] H = High; M = Moderate; L = Low; N = None

Table E-1. Additional Coon Creek Opportunities Matrix

ID	Scale [1]	Project Name	Location	Project Description and Benefits	Benefits [2]					Priority
					Physical Processes	Hydrology	Water Quality	Salmonid Habitat	Riparian Habitat	
49	IP	Channel Rehabilitation along Degraded Reach of Doty Ravine Downstream of McCourtney Rd	Doty Ravine downstream of McCourtney Road	The degraded stream channel, which was likely realigned due to historic mining practices, and now features limited riparian vegetation in some areas, can be enhanced through a variety of measures including channel realignment, bank grading and stabilization, riparian vegetation enhancement and livestock exclusion.	M-H	N	L	L-M	M	M
50	IP	Removal of Improvised Cobble Weir	Doty Ravine immediately downstream of Madera Island Lane	An improvised cobble weir can be removed to eliminate any effects on physical processes	L	N	N	N	N	L
51	IP	Stabilization of Drainage Outfall	Doty Ravine immediately upstream of NID Doty South at Head Diversion Dam (and downstream of Crosby Herold Road)	A badly eroding drainage channel entering the southern side of Doty Ravine can be stabilized to prevent excessive sediment loading.	L	N	M	L	N	L
52	IP	Removal of Improvised Weir	Doty Ravine immediately upstream of Crosby Herold Road	An improvised weir, constructed of stacked sand bags or concrete bags, can be removed to eliminate any effects on physical processes	L	N	N	N	N	L
53	IP	Channel Re-Profiling to Address Incision on Doty Ravine	Doty Ravine approximately one third of a mile downstream of Garden Bar Road	Channel re-profiling can be conducted along this incised reach through the placement of large wood, beaver dam analogs, strategic bed elevation augmentation (e.g., Newbury Weirs, roughened rock ramps) or other strategies to reduce incision and enhance floodplain connectivity.	M-H	L	N	L-M	L-M	M

[1] MP = Multiple Projects; IP = Individual Project [2] H = High; M = Moderate; L = Low; N = None

Table E-1. Additional Coon Creek Opportunities Matrix

ID	Scale [1]	Project Name	Location	Project Description and Benefits	Benefits [2]					Priority
					Physical Processes	Hydrology	Water Quality	Salmonid Habitat	Riparian Habitat	
54	IP	Selective Removal of Mining Tailing Mounds along Doty Ravine	Doty Ravine upstream of Garden Bar Road	Historic mining tailing mounds along the Doty Ravine's northern floodplain can be selectively removed to eliminate constraints on more natural physical processes (e.g., lateral channel migration) as well as reduce excessive fine sediment contributions at several high-severity bank erosion sites.	M-H	N	L-M	L	M	M
55	IP	Fish Screen Installation on Whisky Diggins Canal Inlet along Deadman's Ravine	Whisky Diggins canal inlet near North Legacy Way crossing over Deadman's Ravine	A fish screen could be installed at the inlet of Whisky Diggins canal along Deadman's Ravine to prevent mortality of resident trout.	N	N	N	M	N	L
56	IP	Repurposing of stream-side property along SMD-1 for stormwater detention and treatment	SMD-1 WWTP at Dry Creek / Rock Creek Confluence	Depending on future land use plans of the former SMD-1 waste water treatment plant, stream-side portions of the property could be re-purposed for stormwater detention and treatment features. Peak flows from Rock Creek and/or Dry Creek could be captured on-site in stormwater treatment wetlands to reduce impacts of urban development and hydromodification on downstream storm flows.	M	H	M	N	L	M-H

[1] MP = Multiple Projects; IP = Individual Project [2] H = High; M = Moderate; L = Low; N = None

Table E-1. Additional Coon Creek Opportunities Matrix

ID	Scale [1]	Project Name	Location	Project Description and Benefits	Benefits [2]					Priority
					Physical Processes	Hydrology	Water Quality	Salmonid Habitat	Riparian Habitat	
57	MP	Channel Rehabilitation within Upper Urbanized Tributaries	Coon Creek headwater tributaries in vicinity of Auburn (mainly Rock Creek and Dry Creek)	A combination of channel rehabilitation measures (e.g., realignment, channel geometry improvements, creation of inset floodplain benches, etc.), riparian corridor enhancement and stormwater detention and treatment can help improve the condition of headwater streams in the Coon Creek watershed. Example details are provided in the Rock Creek Restoration Master Plan (Foothill Associates, 2007).	M-H	L	L	M	M	M

[1] MP = Multiple Projects; IP = Individual Project [2] H = High; M = Moderate; L = Low; N = None

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