The Merced River Alliance Project



Interim Biological Monitoring and Assessment Report

Prepared for
East Merced Resource Conservation District
Merced, California
State Water Resources Control Board
Sacramento, California

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The Merced River Alliance Project Interim Biological Monitoring and Assessment Report

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Table of Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Appendices A – F are available in the Biological Monitoring & Assessment Plan (Stillwater Sciences 2006a) and will be included in the final report, due August 2008.

LIST OF ACRONYMS AND ABBREVIATIONS

af – acre-feet
AMFSTP – Adaptive Management Forum Scientific and Technical Panel
BLM – Bureau of Land Management
BMAP – Biological Monitoring and Assessment Plan
BMI – aquatic benthic macroinvertebrate
CAMP – Comprehensive Assessment and Monitoring Plan
CAS – cascade
CBDA – California Bay-Delta Authority
CDFG – California Department of Fish and Game
CDWR – California Department of Water Resources
cfs – cubic feet per second
CMARP – Comprehensive Monitoring, Assessment, and Research Program
CMIN – Calaveras Materials Inc.
CNDDB – California Natural Diversity Database
CON – Confluence Reach
CPUE – catch per unit effort
CSPB – California State Bioassessment Procedure
CTV – California tolerance value
DO – Dissolved oxygen
DQO – data quality objective
DTR – Dredger Tailings Reach
DWR – Department of Water Resources
EMRCD – East Merced Resource Conservation District
ENC – Encroached Reach
EPA – Environmental Protection Agency
EPT – Ephemeroptera, Plecoptera, Tricoptera
FFG – functional feeding group
FOM – fine organic matter
fps – feet per second
ft - feet
GB – Glaciated Batholith Reach
GIS – geographic information system
GJHA – George J. Hatfield State Park
GLD – glide
GM1 – Gravel Mining 1 Reach
GM2 – Gravel Mining 2 Reach
GPP – generator-powered pulsator
GPS – global positioning system
HEPA – Henderson Park
HGR – high gradient riffle
ID – irrigation district
in - inches

km – kilometer
LB – Lower Batholith Reach
LGR- low gradient riffle
LSP – lateral scour pool
LWD – large woody debris
m – meters
MCP – mid channel pool
MCRCD – Mariposa County Resource Conservation District
MEFA – Merced Falls Avenue
MeID – Merced Irrigation District
MF – Merced Falls Reach
mi - miles
mm - millimeters
MRR – Merced River Ranch
MRS – Merced River stakeholders
MSRA – McConnell State Recreation Area
MVZ – Museum of Vertebrate Zoology
NAWQA – USGS National Water-Quality Assessment Program
NOAA – National Oceanic and Atmospheric Administration
NPS – National Parks Service
NRS – Natural Resource Scientists, Inc.
PAEP – Project Assessment and Evaluation Plan
PFMC – Pacific Fisheries Management Council
PLP – plunge pool
POW – pocket water
PRBO – Point Reyes Bird Observatory
QA/QC – quality assurance, quality control
QAPP – Quality Assurance Project Plan
RM – river mile
RST – rotary screw trap
s - seconds
SJR – San Joaquin River
SWRCB – State Water Resources Control Board
SWAMP – Surface Water Ambient Monitoring Program
TID – Turlock Irrigation District
UF1 – Upper Foothills 1 Reach
UF2 – Upper Foothills 2 Reach
UF3 – Upper Foothills 3 Reach
UMRWC – Upper Merced River Watershed Council
USBR – United States Bureau of Reclamation
USFWS – United States Fish and Wildlife Service
USGS – United States Geological Survey
VAMP – Vernalis Adaptive Management Plan

VCP – variable circular plot
WQ – water quality
WY – water year
YNP – Yosemite National Park
YV – Yosemite Valley Reach

1 DISTRIBUTION LIST

The following individuals received copies of the final version of the Interim Biological Monitoring and Assessment Report.

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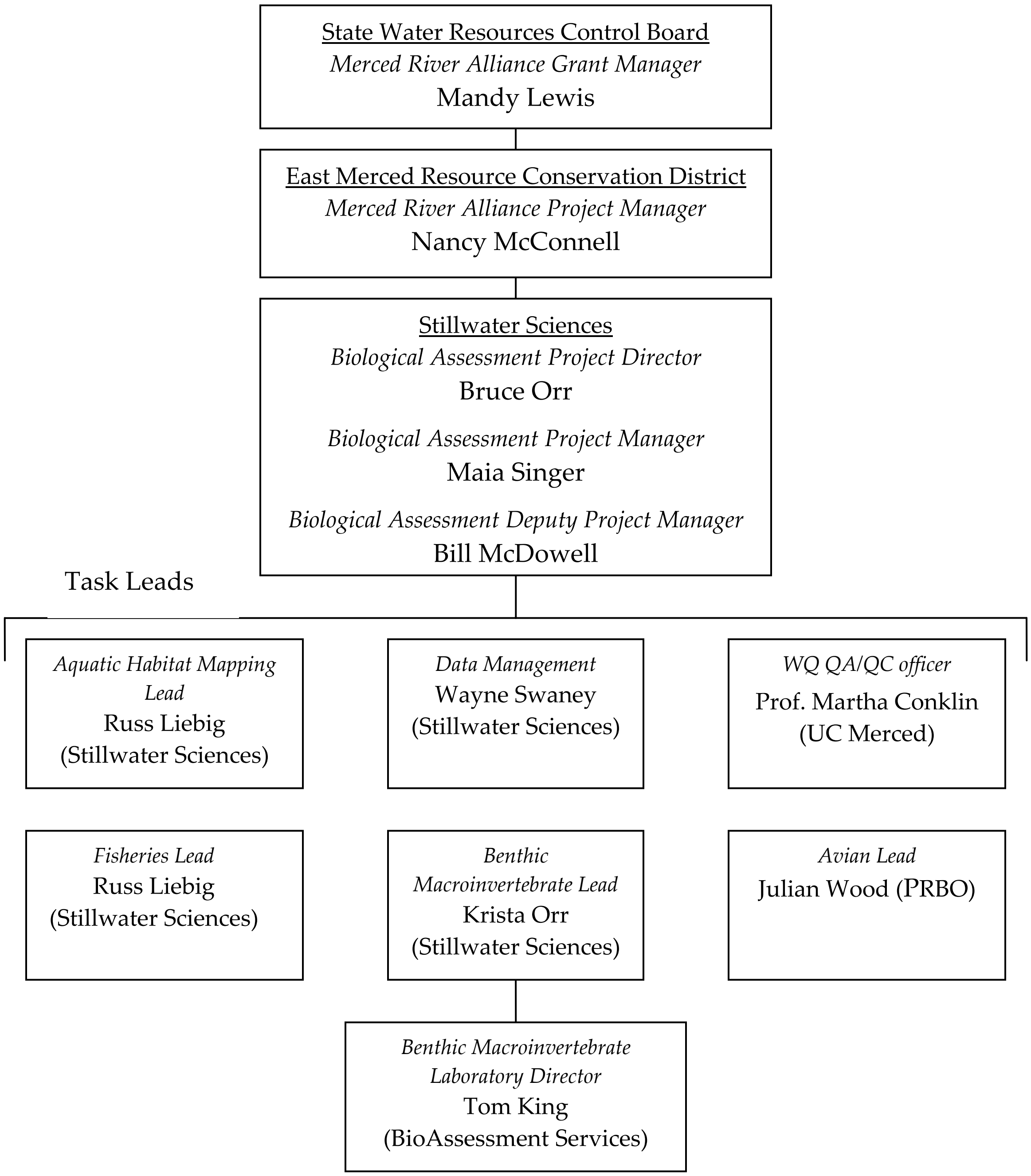
2 PROJECT ORGANIZATION



3 PROBLEM STATEMENT AND BACKGROUND

3.1 Problem Statement

The Merced River, a major tributary to the San Joaquin River, is located in the southern portion of California's Central Valley (Figure 3-1a). The upper and lower segments of the Merced River, and the greater watershed have been affected by a range of human interventions including dams and flow regulation, flow diversion, gold and aggregate (sand and gravel) mining, levee construction, land use conversion in the floodplain, clearing of riparian vegetation, introduction of exotic plant and animal species, and point and non-point source pollution from abandoned mines. Beyond these, effluent from wastewater treatment plants, bank protection, and recreational use are also potential factors affecting the range of biological and physical processes occurring in the Merced River watershed. Although a number of restoration projects have been undertaken during the past two decades (Figure 3-2) (see also Table A-1, Appendix A of the Biological Monitoring and Assessment Plan [BMAP] [Stillwater Sciences 2006a]), there is currently a lack of contemporary watershed-scale data to evaluate the effects of various reach or sub-reach scale projects in both the upper and lower segments of the Merced River.

This interim report encompasses methods and results from the first year of a 2-year biological monitoring and assessment effort for the Merced River. Partial analysis and interpretation of first year data is included in the interim report, but the majority of intended analyses described in the BMAP (Stillwater Sciences 2006a) will be included in the final report, scheduled for completion in August 2008.

3.2 Study Rationale

The BMAP (Stillwater Sciences 2006a) was developed as a component of the Merced River Alliance Project and represents the first planned comprehensive assessment of fish, bird, and BMI (benthic macro invertebrate) species composition and distribution in the Merced River. The larger Merced River Alliance Project concatenates two independent management efforts in the same watershed, creating an umbrella under which the watershed conservation districts and stakeholder groups for the upper and lower Merced River can work collaboratively to address watershed-wide issues. The East Merced Resource Conservation District (EMRCD) and Merced River Stakeholders (MRS) represent the lower segment of the watershed, and the Mariposa County

Resource Conservation District (MCRCD) and the Upper Merced River Watershed Council (UMRWC) represent the upper segment.

A river-wide biological assessment is included in the Merced River Alliance Project for several reasons. First, a contemporary baseline data set of this scope is necessary to improve our understanding of the general patterns of distribution and relative abundance of fish, BMI, and birds throughout the river-riparian corridor. Although a baseline "snapshot" of the Merced River will not represent either pristine or static conditions, analysis and synthesis of bioassessment results is expected to increase understanding of the interactions between the aquatic-riparian biota and watershed processes on the Merced River and to help identify factors that may limit ecosystem health. The contemporary baseline data provided in this study will establish an initial condition against which to compare future restoration and management actions, and supply information necessary for prioritizing those actions. Finally, a contemporary biological assessment of the Merced River will increase the scientific evidence available upon which to develop, refine, and strengthen CALFED Ecosystem Restoration Program goals and objectives (CALFED 2004).

Fish, BMI, and birds have been chosen as the focal species of the baseline biological monitoring task because: 1) they are generally sensitive and readily measurable indicators of environmental conditions (Temple and Wiens 1989, Klemm et al. 1990, Barbour et al. 1999, Uliczka and Angelstam 2000, Bryce et al. 2002, Brown et al. 2003); 2) there has been no river-wide comprehensive attempt to establish an understanding of baseline ecological conditions for these organisms; and 3) very little is known regarding their composition, distribution, and relative abundance in the Merced River outside of Yosemite National Park (AMFSTP 2002, Stillwater Sciences 2002). Although a number of studies have been conducted within the Park, many of the results are not readily available to the scientific community and the public.

3.3 Physical and Biological Setting

The Merced River is the southernmost major tributary to the San Joaquin River in California's Central Valley (Figure 3-1a). The river drains an approximately 3,305-km^2 (1,276-mi^2) watershed that originates in Yosemite National Park and flows southwest through the Sierra Nevada range before joining the San Joaquin River 140 km (87 mi) south of the City of Sacramento. Elevations in the watershed range from 3,960 m (13,000 ft) at the crest to 15 m (49 ft) at the confluence with the San Joaquin River. The Merced River watershed is bisected into upper and lower segments by New Exchequer Dam (River Mile [RM] 62.5[1]), which controls runoff from 81 percent of the basin and creates Lake McClure.

[1] River Mile (RM), rather than River Kilometer (RK), designations are reported following USGS convention. All RM's are derived from the USGS 1:100,000 Digital Land Graph (DLG).

The upper Merced River contains the mainstem, the North Fork (RM 83.3), and the South Fork Merced River (RM 99.7). The mainstem and South Fork originate within the boundaries of Yosemite National Park, beginning in the southern peaks of the park and draining an area of approximately 1,323-km^2 (511-mi^2) (NPS 2000). From the headwaters to Lake McClure, the mainstem and South Fork rivers are designated by Congress as Wild and Scenic River (Figure 3-1b) (NPS 2005). The North Fork originates in the Stanislaus National Forest and joins the mainstem within lands administered by the Bureau of Land Management (BLM). The potential for Wild and Scenic river designation for the North Fork Merced River is currently being studied by BLM (Cranston pers. comm. 2005). Overall, the National Park Service, U.S. Forest Service, and Bureau of Land Management administer 242,811 hectares (600,000 acres), or 86%, of the watershed in the upper segment of the Merced River , while approximately 40,469 hectares (100,000 acres), or 14%, are privately owned and dedicated to ranching and other agriculture, much of it on the North Fork of the river.

The only major tributary to the lower Merced River is Dry Creek, which drains a 285-km^2 (110-mi^2) watershed and joins the Merced River at RM 32.7. The lower portion of the Merced River watershed is almost entirely privately owned and land use is predominantly agricultural (grazing, dairy, poultry, and orchard). Aggregate mining of dredger tailings occurs within the Dredger Tailings Reach (DTR), an 11-km (7-mi) stretch of river between Crocker-Huffman Dam (RM 52) and a point just downstream of the Snelling Road Bridge (RM 45.2) (Stillwater Sciences 2002). Within the DTR, CDFG owns the Merced River Ranch (MRR [RM 50 to 51]). The MRR was purchased by CDFG in 1998 as a source of sand, gravel, and cobble for future restoration projects and as a floodplain restoration site. Merced ID owns the Cuneo Fishing Access property at the north boundary of the MRR and the Main Canal which runs through the southern portion of the Ranch. Merced ID also owns land under which the CDFG operates a Chinook salmon hatchery, and leases property to the Calaveras Trout Farm at the north-east boundary of the MRR. Small parcels of publicly owned land occur throughout the lower Merced River, including Henderson County Park, Hagaman County Park, McConnell State Park, and George J. Hatfield State Park (Figure 3-1b).

3.3.1 Geomorphology and Hydrology

The Merced River originates in the Sierra Nevada Mountains. It flows westward through about 595-km^2 (230-mi^2) of granitic terrain in Yosemite National Park, where it is confined by bedrock valleys or steep bedrock gorges. Prior to the mid-19th century, wet meadows were prevalent in Yosemite Valley, particularly in the western portion of the Valley proximal to a large moraine at the foot of El Capitan. In 1879, a 1.2 to 2.7-m (4 to 9-ft) portion of the moraine was blasted out of the Merced River channel in order to lower the water table behind the moraine. The intent was to reduce the amount of wet meadows, thereby reducing mosquito populations in the Valley. Since the blasting, the Merced River upstream of El Capitan has become more channelized, with fewer wet meadows in the riparian zone, and an increased erosion rate of the river base level in adjacent areas between El Capitan Meadow and Yosemite Lodge (NPS 2000).

After leaving Yosemite National Park, the Merced River flows through roughly 155 km^2 (60 mi^2) of metamorphic terrain in the western Sierran foothills between El Portal and the Merced Falls Dam (Stillwater Sciences 2001). Construction and operation of the Merced Falls Dam (1901), along with that of the original Exchequer Dam (1926), the New Exchequer Dam (1967) and Mc Swain Dam (1966), has caused major geomorphic and hydrologic perturbations to the mainstem Merced River downstream of confluence with the North Fork Merced River (RM 83.3). Details about these and other, smaller dams on the Merced River are discussed in Section 3.3.1.1, and the effects of flow regulation and diversion on hydrology and sediment supply to the lower portion of the Merced River watershed is discussed in Section 3.3.1.2 .

The river leaves the upland landscape near Merced Falls Dam (RM 55) and enters the broad, unconfined eastern California Central Valley. The river valley broadens near Crocker-Huffman Dam (RM 52) and the river enters into what was historically a highly dynamic, multiple channel (anastomosing) river system. Review of maps and aerial photographs circa 1915 and 1937 indicates that these channels, which included the current mainstem channel as well as Ingalsbe, Dana and Hopeton sloughs, once occupied the entire width of the valley floor (up to 7.2-km [4.5-mi] wide) in the Snelling vicinity (Figure 3-3a). The combined effects of valley-scale gold dredging, flow regulation, elimination of coarse sediment supply, reduction of fine sediment supply, and land-use development have converted the lower Merced River in this reach from a complex, multiple-channel system to a single-thread system with a narrow floodplain adjacent to the confined channel (Figure 3-3b). Downstream of the Dry Creek confluence (RM 32.7), the valley width narrows again. Historically, the conversion from the braided to the meandering system may have been a response to deposition of fine sediments.

Similar to other rivers originating from the west side of the Sierra Nevada Mountains, flow in the Merced River is typified by late spring and early summer snowmelt, fall and winter rainstorm peaks and low summer baseflows. Annual water yield from the Merced River averages 996,500 acre-feet[2] (for the period 1903–1999). With the exception of that portion of the river that is now Lake McClure, the upper Merced River experiences a natural hydrograph (Figure 3-4). In contrast, the lower river is regulated by four mainstem dams, developed for hydroelectric power, flood control, and agricultural water supply.

[2] Hydrologic and related data is commonly presented in English units and is a convention followed in the BMAP.

3.3.1.1 Dams and Flow Diversions on the Merced River

Although flow is unregulated on the upper Merced River, there are four jurisdictional dams located along this reach (Table 3-1). The New Exchequer Dam is located on the mainstem, while McMahon, Green Valley, and Metzger dams are located on tributaries upstream of Lake McClure. The latter dams are relatively small, non-regulating dams which have combined reservoir capacity of 835 acre-feet[3]. The Cascades Diversion Dam, a timber crib dam constructed in 1917, was removed in 2004 from the mainstem Merced River east of Yosemite Valley. The Wawona Impoundment, located on the South Fork Merced River approximately 1.6 km (1 mi) east of Wawona, is a small water supply dam. This dam is below the California jurisdictional threshold (50 acre-ft or 20 ft dam height) and is therefore not a regulated facility (NPS 2000). In addition, eleven bridges cross the Merced River in Yosemite Valley, influencing the width, location, and velocity of the upper river at these locations (NPS 2000).

Flow in the lower Merced River is regulated by New Exchequer Dam (RM 62.5) and McSwain Dam (RM 56). These dams, which are known collectively as the Merced River Development Project, are owned by Merced Irrigation District (Merced ID) and are licensed by the Federal Energy Regulatory Commission (FERC) through 2014. McSwain dam is operated as a re-regulation reservoir and hydroelectric facility. Merced Falls Dam and Crocker-Huffman Dam are low-head irrigation diversion dams which divert flow into the Merced ID Northside Canal (capacity = 2.5 m^3s^{-1}, 90 cfs) and Main Canal, respectively. Merced Falls Dam is owned by Pacific Gas and Electric; Crocker-Huffman Dam is owned by Merced ID.

In addition to the Merced ID diversions, the Merced River Riparian Water Users maintain seven riparian diversions between Crocker-Huffman Dam and Shaffer Bridge (Oakdale Road) (RM 32.5). At these diversions, flow is directed into diversion channels by small gravel wing dams that are constructed each year. Downstream of Shaffer Bridge, the CDFG has identified 238 diversions, typically small pumps, used to supply water for agricultural use (G. Hatler, pers. comm., 1999).

Table 3-1. Dams regulated by the California Division of the Safety of Dams in the Merced River watershed.

Dam	Stream	Year Closed	Capacity (acre-feet)
Upper Merced River			
New Exchequer[1]	Merced River	1967	1,024,600
McMahon[2]	Maxwell Creek	1957	519
Green Valley[3]	Smith Creek	1957	243
Metzger[3]	Dutch Creek	1956	73

[3] An acre-foot is the volume of water that would inundate one acre of land to a depth of one foot and is equivalent to approximately 326,000 gallons.

Dam	Stream	Year Closed	Capacity (acre-feet)
Lower Merced River			
McSwain	Merced River	1966	9,730
Merced Falls	Merced River	1901	900
Crocker-Huffman	Merced River	1910[4]	200
Kelsey	Dry Creek	1929	972
		Total:	**1,037,237**

(sources: CDWR 1984, Kondolf and Matthews 1993)

[1] New Exchequer Dam bisects the Merced River into two segments, the upper segment and the lower segment.
[2] Located upstream of the New Exchequer Dam.
[3] Located on the North Fork.
[4] A diversion dam has been operated at this location since the 1870s.

3.3.1.2 Effects of Flow Regulation and Diversion on Hydrology in the Lower Merced River

Since the completion of New Exchequer Dam in 1967, mean annual flood discharge in the lower river has been reduced by 80% (based on records from WY 1968 to 2000 at the Snelling gage, CDWR [http://cdec.water.ca.gov/]) (Stillwater Sciences 2002). Operating rules for the Merced ID imposed by the U.S. Army Corps of Engineers currently limit releases from New Exchequer Dam to 170 m^3s^{-1} (6,000 cfs), which reduce the incidence of flow events believed to be geomorphically effective for maintaining properly functioning stream channels and associated riparian and floodplain habitats in the lower reach of the Merced River. Since 2000, the highest flows occurring on the lower Merced River during drier years (e.g., WY2001 to WY2004) have related to spring flows released annually by Merced ID as part of the Vernalis Adaptive Management Program (VAMP) to enhance conditions for outmigrating Chinook salmon smolts. The flow magnitude is determined in conjunction with flow releases from the Tuolumne and Stanislaus rivers. As an example, in 2004, VAMP outmigration flows commenced in mid-April, reached a maximum of 53 m^3s^{-1} (1,870 cfs) in the first week of May, and were returned to base flow levels by mid-May. It has been estimated that incipient motion of the channel bed occurs at approximately 136 m^3s^{-1} (4,800 cfs) under current conditions. This flow relates to the post-dam Q_5 event and illustrates how infrequently geomorphically-effective events occur under present conditions.

3.3.2 Habitat and Biota

A compilation and synthesis of existing fish, bird, and BMI data for the upper and lower Merced River is being undertaken as a component of the Merced River biological assessment monitoring, and is discussed in more detail in Section 6. The following section represents a basic overview of general habitat and biota conditions.

Habitat along the Merced River corridor varies with topography and elevation as the river flows through mountains, foothills, and the valley floor to its confluence with the San Joaquin River. Three ecoregions are represented: the Central California Valley, the Southern and Central California chaparral and woodlands, and the Sierra Nevada

Mountains (Omernik and Bailey, 1997, Miles and Goudey 1997). The upper portion of the Merced River, located in the Sierra Nevada Mountains and upper foothills, contains large blocks of high-quality mature forest, relatively diverse and abundant wildlife communities, and high water quality. While habitat fragmentation affects wildlife species in the upper portion of the Merced River watershed (NPS 2000), the majority of land in Yosemite National Park is designated Wilderness under the California Wilderness Act of 1984 (Public Law 98-425), not including the developed Valley areas where the majority of park infrastructure and facilities are located (NPS 2005). Five major vegetation zones are supported in Yosemite National Park: chaparral/oak woodland, lower montane, upper montane, subalpine, and alpine (NPS 2000). El Portal, just outside the Park, is in the chaparral/oak woodland zone. Distributions of vegetation cover types in Yosemite National Park and El Portal are currently being mapped by the National Park Service (NPS *in progress*). Other areas outside of Yosemite Valley are in the lower montane, upper montane, and subalpine zones (NPS 2000). Non-native plant species occur to some extent throughout the upper portion of the Merced River watershed. A number of state-listed rare vegetation types are sustained in the El Portal area (NPS 2000). Fire suppression and changing land-use practices have altered natural fire regimes of the Sierra Nevada dramatically, affecting ecological structures and functions in associated plant communities (UC Davis 1996).

The lower Merced River segment is located in the valley-floor and lower foothills. Along this segment of the river, land use activities including gold dredging, gravel mining, and agricultural development have significantly reduced the extent of riparian vegetation. While there are no pre-colonial estimates of riparian forest extent specific to the Merced River, the remaining riparian landscape in the lower portion of the watershed (approximately 1,619 hectares [4,000 acres]), represents roughly 20% of the pre-dam floodplain area (Stillwater Sciences 2001). A wide range of vegetation conditions currently occurs in the Merced River corridor, from a thin band of trees one tree canopy wide in developed reaches to large patches of relatively intact floodplain forest near the confluence with the San Joaquin River. In general however, widespread encroachment of riparian vegetation into the former active river channel has prevented establishment of pioneer riparian species and has arrested natural vegetation successional patterns (Stillwater Sciences 2001). Non-native invasive grasses and forbs dominate the herbaceous communities on the lower Merced River, and some non-native tree and shrub species have become established and threaten to invade more of the corridor.

Although biota in the upper portion of the watershed have experienced relatively less land use disturbance than that of the lower portion, habitat quality and species composition has been altered in the upper river. For example, most fish in Yosemite National Park are introduced species (NPS 2000). Although fish stocking in Yosemite no longer occurs, past stocking activities, along with other anthropogenic influences (e.g., fallen tree removal from streams, elimination of riparian vegetation by human trampling and bank stabilization, alteration of meadow hydrology by roads, ditches and utility structures), have altered fish populations in Yosemite Valley. While rainbow trout (*O. mykiss*) is the only fish species native to the upper portion of the watershed, including Yosemite National Park, it is now outnumbered by non-native brown trout (*Salmo trutta*) in many stretches of the upper Merced River (NPS 2000)[4]. Additionally, introductions of the non-native rainbow trout have altered the genetics of Yosemite Valley's native strain (NPS 2000) (see Section 6.1.1.1 for further detail of fish species distribution and stocking in Yosemite National Park). Noticeable population declines have been detected in a variety of bird species in the Sierra Nevada, including two species that have been observed in the Merced River watershed; great gray owls (*Strix nebulosa*) and willow flycatchers (*Empidonax traillii*). Possible causes for these declines include grazing, logging, fire suppression, development, recreational use, pesticides, habitat destruction on wintering grounds, large-scale climate changes, and nest parasitism by Brown-headed cowbirds (*Molothrus ater*) (NPS 2000).

In the lower river, biotic responses to the severe degradation of in-channel and floodplain habitats have not been well documented. For example, although the riparian zone area has significantly decreased since pre-colonial times, and the natural successional patterns of the vegetation are now impaired, the impact on avian species has not been formally studied. Additionally, it is known that dam construction eliminated access to upstream holding pools and spawning areas and resulted in the extirpation of spring-run Chinook salmon from the basin by the late 1940s (Skinner 1962). Because fall-run Chinook salmon do not require cold pools in which to over-summer as adults, they were not as vulnerable to habitat loss and alteration as the spring run.

Fall-run Chinook salmon are an important management species in the Merced River, and numerous state and federal resource programs include increasing the abundance of Chinook salmon in their goals. Although anadromous salmonids historically migrated into the upper reaches of the Merced River, spawning is now concentrated in the Dredger Tailings Reach (RM 44.7 to RM 51.3) directly downstream of the Crocker-Huffman Dam, which is a barrier to upstream fish movement. The Merced River Hatchery is located just below Crocker-Huffman Dam and is the only hatchery in the San Joaquin River basin. The hatchery utilizes San Joaquin Chinook salmon broodstock (CDFG 1998a, as cited by Vogel 2003), producing 9% of the fall-run Chinook in 2000 (USFWS 2002). Merced ID currently increases flows during the critical fall-run Chinook salmon outmigration period (VAMP flows) to increase juvenile Chinook salmon survival during outmigration in the lower Merced River and, in conjunction with VAMP flow releases on other tributaries, downstream in the San Joaquin River and Delta.

[4] Results by Brown and Short (1999) indicate relatively more rainbow trout than brown trout at several Yosemite National Park sites monitored in 1993-1995.

Steelhead (the anadromous life history form of *O. mykiss*; rainbow trout are the resident life history form) are also an important management species, although their historical occurrence and distribution in the Merced River is not well documented. The Central Valley steelhead ESU is listed as threatened under the federal Endangered Species Act (USFWS 1998).

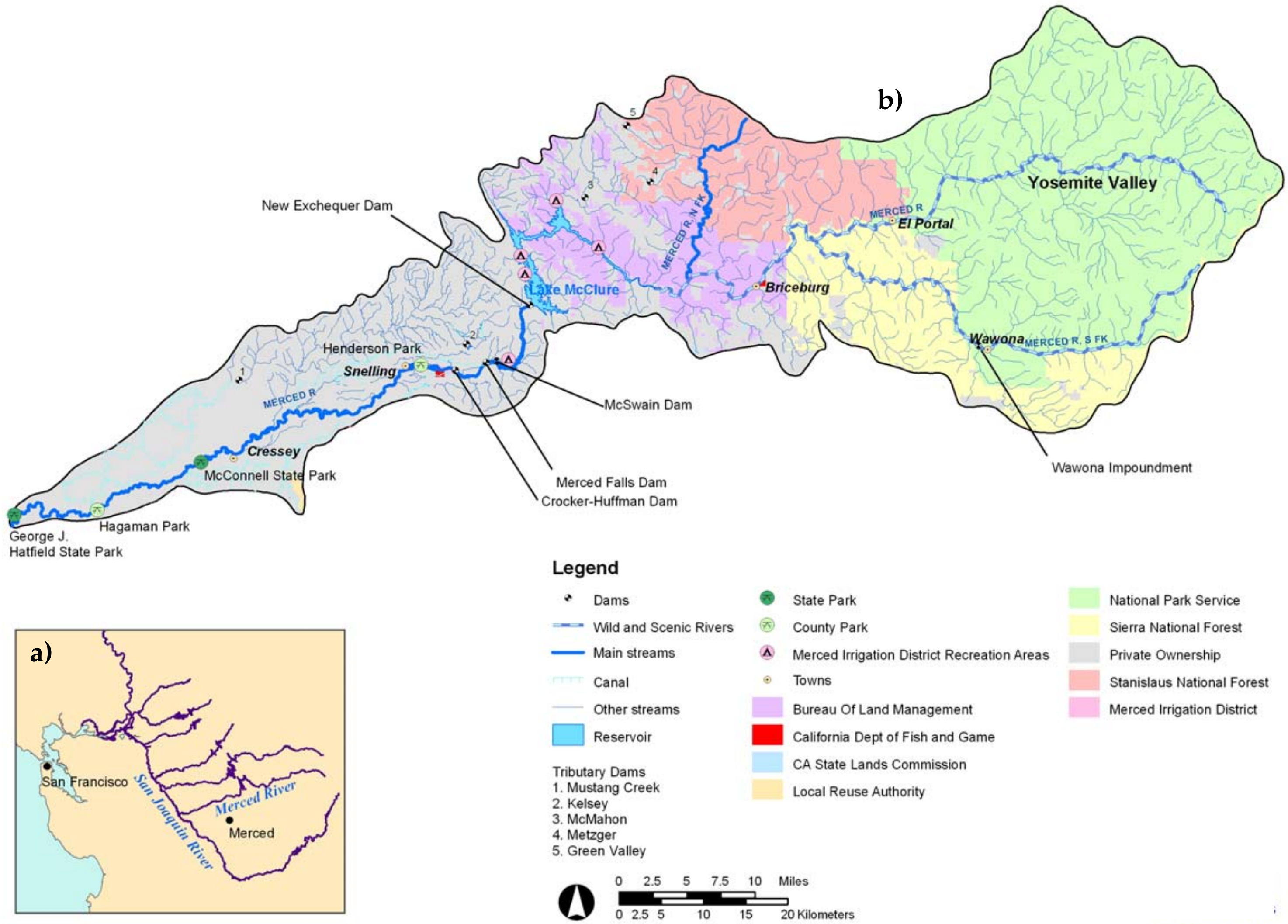


Figure 3-1. Merced River watershed, project location, and land use. a) Location of the Merced River as a tributary to the San Joaquin River, flowing north and eventually into the San Francisco Bay-Delta. b) The Merced River is shown with Lake McClure bisecting the upper and lower segments at New Exchequer Dam. Land use along the upper river is primarily federal, while in the lower river it is primarily private and agricultural.

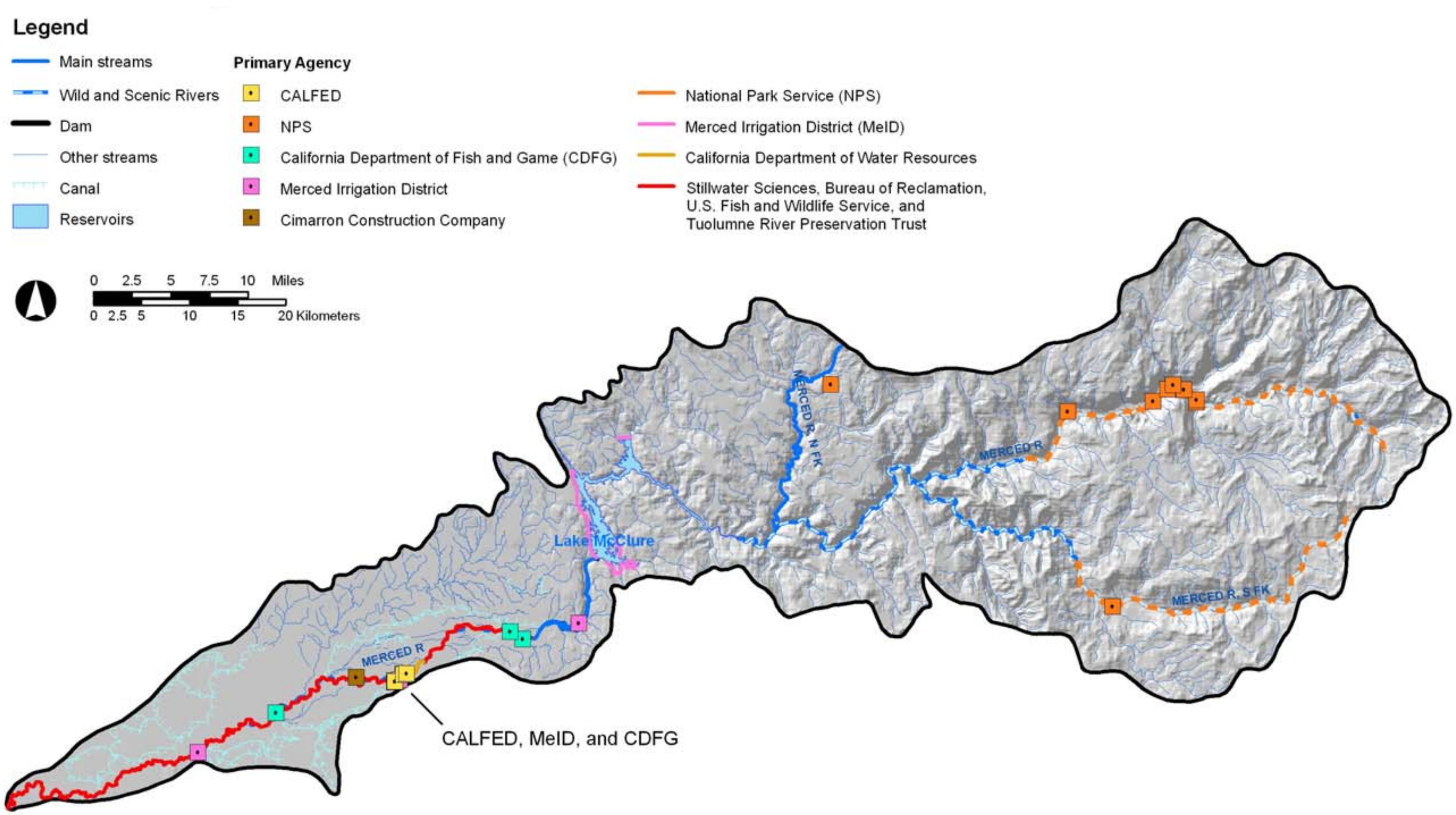


Figure 3-2. Restoration projects on the upper and lower Merced River. See Appendix A, Table A-1 (Stillwater Sciences 2006a) for a brief description of these restoration projects.

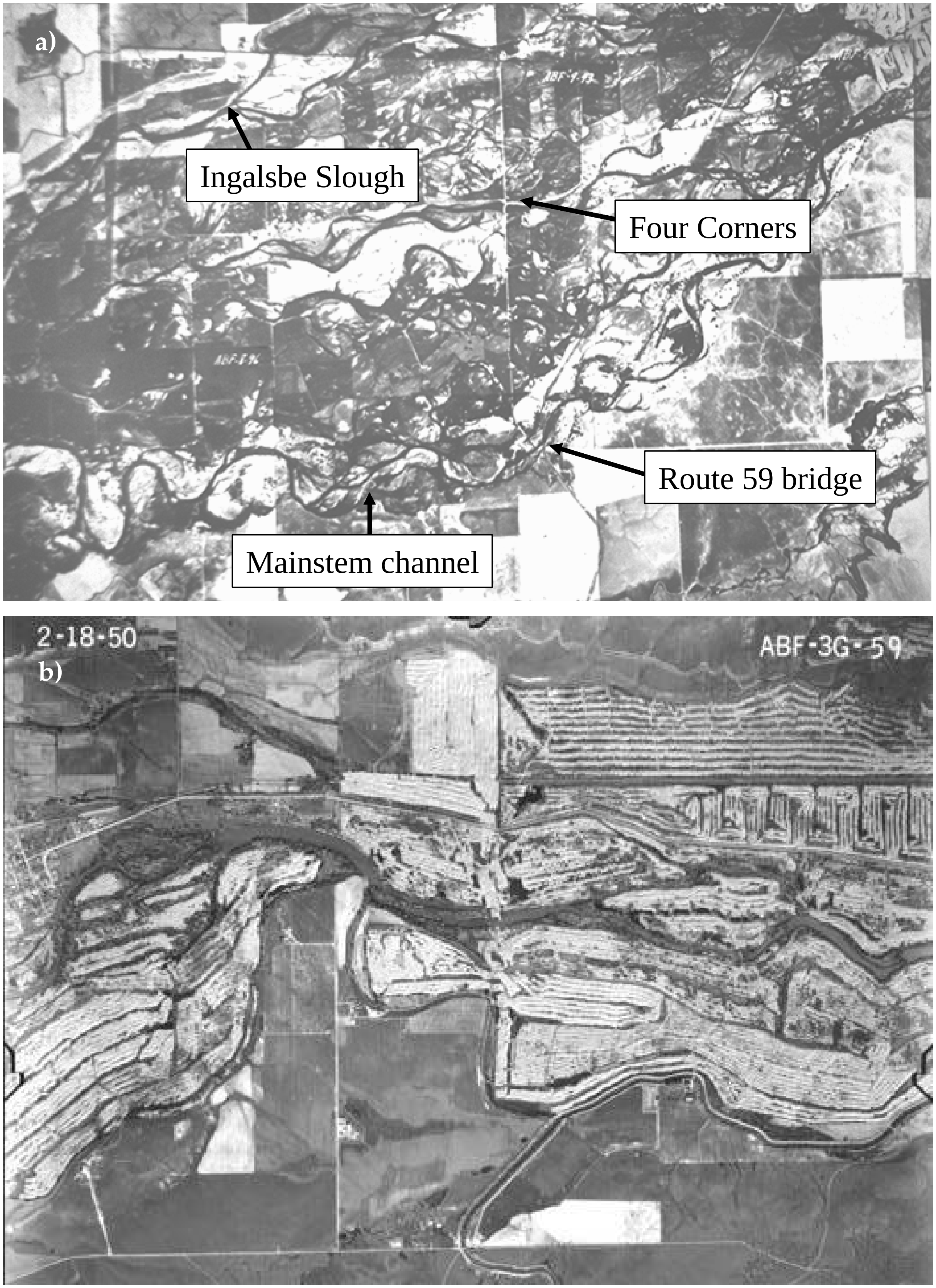


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Figure 3-3. 1937 and 1950 aerial photographs of the lower Merced River. a) 1937 photograph of the Merced River depicts a multiple-channel anastomosing reach; and b) 1950 photograph of the Merced River Dredger Tailings Reach (Source: Agricultural Stabilization and Conservation Service).

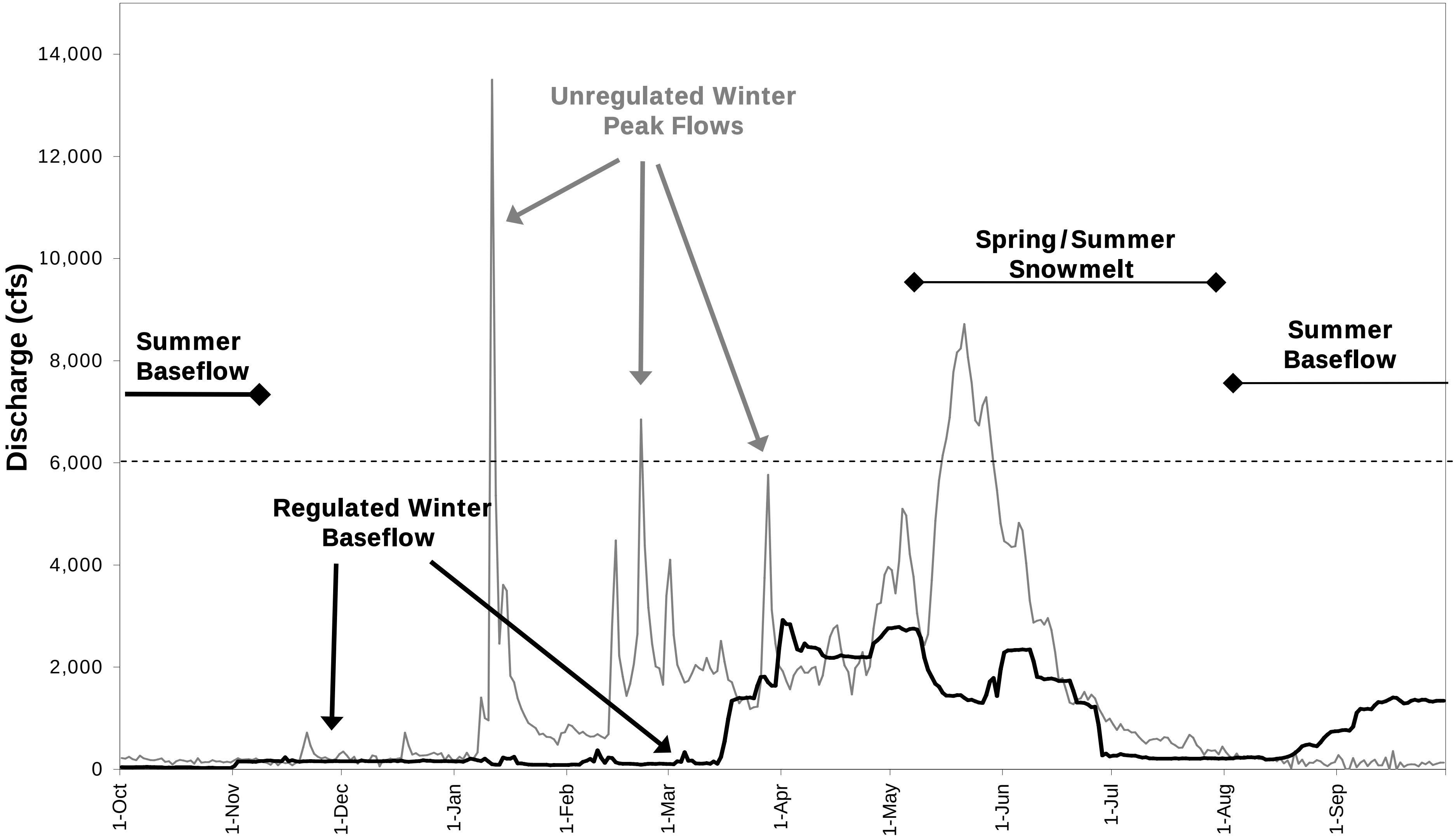

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Figure 3-4. Annual hydrograph components for the Merced River. Unregulated upper Merced River flow conditions (estimated inflow to Lake McClure) (grey) are shown in comparison with lower river flow at Crocker-Huffman Dam (black) for a San Joaquin Valley 'above normal' water year type (WY 1979) (Source: MeID). Dashed line indicates U.S. Army Corps of Engineers release limit from New Exchequer Dam (6,000 cfs).

4 BIOLOGICAL MONITORING & ASSESSMENT GOALS & OBJECTIVES

The primary goal of the biological monitoring and assessment is to provide contemporary baseline data regarding native and non-native fish, riparian bird, and BMI species on the upper and lower reaches of the Merced River[5]. This goal supports several AFRP/CALFED Adaptive Management Forum recommendations for including adaptive management techniques in current and future restoration projects on the Merced River (AMFSTP 2002). While the complete adaptive management process itself is not addressed in the Merced River Alliance Project, monitoring necessary to support the application of an adaptive management approach is addressed. For example, the study is designed to expand existing information beyond the current focus on adult Chinook salmon abundance, distribution and smolt output for the lower Merced River, by including other life history stages of salmon and by collecting ecological data on other species of interest (AFRP/CALFED Monitoring Recommendation 4.3.1). Additionally, because the scope of the project is river-wide, it will provide baseline information at multiple scales for areas outside those currently under restoration. The baseline biological monitoring and assessment will offer a potentially large set of comparative data on habitat use in restored and un-restored environments (AFRP/CALFED Monitoring Recommendation 4.3.1, cont.). The multi-year, river-wide scope also supports the application of an ecosystem-scale perspective to management and recovery of listed species on the Merced River (AFRP/CALFED Ecosystem Perspective Recommendation 4.1).

In an effort to guide current and projected restoration activities on the Merced River, the BMAP (Stillwater Sciences 2006a) was designed with a secondary goal of testing hypotheses for each monitoring component (e.g., fish, BMI, riparian birds) when feasible. Although the hypotheses are being tested as part of the monitoring program, the baseline surveys, combined with other ongoing monitoring of environmental conditions, are expected to provide information from which additional, more specific hypotheses can be developed in future studies.

The following list summarizes the overall biological objectives for the Merced River Alliance Project:

1. Compile and synthesize existing biological data for the Merced River corridor;

[5] Riparian vegetation monitoring, while not a separate component of the monitoring plan, is addressed as part of avian habitat characterization (Section 0).

2. Compile and map aquatic habitat data for the Merced River corridor in GIS;
3. Undertake 2 years of biological monitoring for fish, BMI, and riparian bird communities in the Merced River watershed;
    a. Expand and enhance past and existing monitoring efforts;
    b. Standardize monitoring protocols to ensure compatibility with regional datasets (including SWAMP Quality Assurance Project Plan [QAPP] elements) and allow for comparisons with other Central Valley river corridors;
    c. Apply river-long monitoring and assessment protocols that support CALFED Science Board recommendations (AMFSTP 2002); and,
    d. Address specific biological assessment hypotheses developed to guide current and future river restoration efforts.
4. Organize baseline biological and relevant physical habitat data and make available to local watershed-related entities and agencies;
    a. Present at community meetings;
    b. Transfer data to the Merced River Alliance web-site (www.mercedalliance.org); and,
    c. Submit annual reports to the SWRCB.

Detailed methods for each of the monitoring components are described in Section 5, including subject-specific monitoring objectives, methods and hypotheses. Following the SWRCB recommended report structure, a review of existing data for the Merced River is detailed in Section 6, which corresponds to that given in the BMAP (Stillwater Sciences 2006a). As existing data collection is ongoing throughout the project, Section 6 will be updated for the final report. Interim results are presented in Section 7. While Section 8 includes a brief data evaluation for each monitoring component in the interim report, comparison of new data to existing data will not be undertaken until the final report. The discussion points in Section 0 serve as a preliminary evaluation step and do not indicate study conclusions. All field measurements, including dissolved oxygen, temperature, conductivity, pH, and depth as well as data from BMI sampling are measured in accordance with SWAMP protocols and the SWAMP QAPP, as detailed in the BMAP (Stillwater Sciences 2006a). These data will be submitted for inclusion in the SWAMP database.

5 BIOLOGICAL MONITORING & ASSESSMENT DESCRIPTION

5.1 Monitoring Budget and Project Schedule

Monitoring costs for the 3-year Project duration are presented in Table 5-1, broken into two items as given in SWRCB Grant Agreement No. 04-306-555-0. The biological monitoring costs include overall task management, management of subtasks (e.g., aquatic habitat mapping, fish monitoring, etc.), field efforts, travel, expenses, data management, existing data collection and synthesis, education and outreach to local landowners and agencies, development of draft and final project reports, grant accounting, permitting, and development of the Project Assessment and Evaluation Plan (PAEP; a requirement of the SWRCB grant process). Table 5-2 presents the project schedule.

Table 5-1. Monitoring costs for the biological assessment portion of the Merced River Alliance project.

Description	Total by Item
Develop the Biological Monitoring and Assessment Plan (BMAP)	$ 135,558
Develop fish section	
Develop avian section	
Develop BMI section	
Communication	
External peer review	
Conduct Biological Assessment Monitoring	$ 1,629,845
Land owner outreach	
Compile and synthesize existing data	
Aquatic habitat mapping	
Fish reconnaissance, monitoring, and data analysis	
Avian reconnaissance, monitoring, and data analysis	
BMI reconnaissance, monitoring, and data analysis	
Reports	
Draft and final reports	
Permitting	
Project Assessment & Evaluation Plan	
Invoicing / progress reports	
TOTAL	**$ 1,765,403**

Table 5-2. The Merced River Alliance project schedule.

	2005										2006												2007												2008		
Task Component	March	April	May	June	July	August	September	October	November	December	January	February	March	April	May	June	July	August	September	October	November	December	January	February	March	April	May	June	July	August	September	October	November	December	January	February	March
Biological Monitoring and Assessment Plan (BMAP) Development																																					
List of existing data sources						X																															
Develop draft BMAP																																					
Submit draft to SWRCB and external review panel[1]								X																													
Review period for draft BMAP																																					
Address review comments																																					
Submit revised draft to SWRCB[2]											X				X																						
Submit final BMAP[1]																X																					
Aquatic Habitat Mapping																																					
Low altitude videography of lower river (RM 0-65)																																					
Low altitude videography of upper river (RM 65-105.5)																																					
On-the-ground habitat mapping in Yosemite National Park (discrete reaches)																																					
Data synthesis and map production											X																										
Monitoring site selection																																					
Fish Monitoring																																					
Field reconnaissance[3]																																					
Surveys of fish species composition and habitat use[3]																																					
Data analysis																																					
Avian Monitoring																																					
Field reconnaissance																																					
Point count surveys																																					
Mist netting (potentially)																																					
Area searches																																					
Data analysis																																					
Macroinvertebrate Monitoring																																					
Field reconnaissance																																					
Aquatic bioassessment																																					
Aquatic invertebrate inventory																																					
Exotics survey																																					
Data analysis																																					
Annual Reports																																					
Monthly Invoicing / Quarterly Progress Reports																																					
Project Assessment and Evaluation Plan[4]										X																											
Report writing																																					
Report review																									X									X			X
CLOSE OF PROJECT																																					

Key

▨ Intermittent work due to SWRCB grant delays

X Draft deliverable due

X Final deliverable due

[1] The original grant agreement scheduled the draft and final BMAP for September 2005 and November 2005 respectively; however the project schedule reflects adjusted due dates.

[2] Revised draft BMAP was submitted in two parts. First submittal included all reviewer comments except BMI study plan. Second submittal included BMI study plan.

[3] Originally scheduled fish field reconnaissance and sampling during Spring 2006 was postponed due to extremely high flows.

[4] The original grant agreement scheduled the PAEP for August 2005, however the project schedule reflects the adjusted due date.

5.2 Monitoring Methodology

As discussed in Section 4, the Merced Alliance biological monitoring and assessment is designed to provide a river-long contemporary snapshot for three major communities of organisms; fish, BMI, and riparian birds. As a reflection of the river-long monitoring and assessment approach, and in an effort to significantly expand and enhance past and existing monitoring efforts on the Merced River, a total of 95 monitoring sites have been located throughout the lower and upper river segments (Figure 5-1). During 2006 and the first quarter of 2007, the majority of fish and bird monitoring sites were sampled during two or more seasons. BMI sites were sampled mainly in the fall, with the exception of Chinese mitten crab sites which were also sampled during summer months. Timing of individual sampling efforts is based on species biology and life history and is considered separately for each community in sections 5.2.2.3, 5.2.3.3, and 5.2.4.3.

5.2.1 Coarse-scale Aquatic Habitat Mapping

This task was designed to provide information regarding stream habitat along the mainstem Merced River (approximately 123 river miles) in order to support the final selection of representative fish and BMI monitoring sites for the Merced River Alliance biological studies. Aquatic habitat mapping was intended to provide a continuous view of the Merced riverscape through systematic sampling of coarse-scale aquatic habitats at low-flow conditions. The coarse-scale habitats were determined remotely by use of aerial videography and air photos. The habitat "types" were defined using a simplified version of standard habitat classifications (i.e., riffles, runs, pools, backwaters) commonly described in the literature (e.g., McCain et al. 1990). Figure 5-2 indicates the relative scale of habitat classifications applied to the Merced River basin, following the basin, segment, and reach scale conventions of Fausch et al. (2002).

Mapping was used to document the longitudinal distribution and relative proportions of habitat types throughout the river, and to identify physical features such as channel confinement, dominant bed substrate size, and barriers to fish migration. However, the spatial scale of this effort does not provide sufficient resolution for comparative assessment of the effects of future restoration activities on aquatic habitat. Rather, the data is intended to be used at the segment scale to reveal larger patterns in habitat distribution to aid in understanding of factors that contribute to fish population characteristics (Fausch et al. 2002, Ward 1998).

Finer-scale habitat delineation, including sub-classifications of habitat type and measurement of microhabitat parameters, is carried out as part of the continuing individual fish and BMI surveys (Sections 5.2.2 and 5.2.3). During the biological surveys, habitat delineation is carried out at each monitoring site using on-the-ground observations. Since the assessments are seasonal, these site-specific habitat delineations take place at multiple flows. Microhabitat parameters (focal velocity, focal depth, distance to cover, etc.) are measured only when physical characteristics at the scale of the individual fish or group of fish are considered to be an important criterion determining habitat use (e.g., for juvenile salmonids).

5.2.1.1 Objectives

The objectives of the aquatic habitat mapping task are to: 1) describe the distribution, frequency, and/or length of coarse-scale habitat types (e.g., pool, riffle, run) of the Merced River; 2) characterize various coarse-scale habitat parameters (e.g., unit dimensions, dominant substrate type, etc.); 3) supplement existing reach-scale temperature information, and; 4) record coarse-scale stream habitat features such as potential migration barriers to fish, large woody debris (LWD), and locations of tributaries or other important features. These stated objectives supported the selection of representative habitats for fish and BMI surveys (Sections 5.2.2 and 5.2.3) and provide information useful for species distribution analyses.

5.2.1.2 Methods

Aquatic habitat mapping of the Merced River was conducted primarily using low-altitude aerial (helicopter) video taken in 2005. Other resources used to develop final aquatic habitat maps included available orthorectified aerial photographs, and existing habitat data and stream descriptions completed during past surveys and ongoing restoration projects along the river (Section 6). The existing orthorectified photographs, which did not provide sufficient resolution for habitat mapping (Stillwater Sciences 2006b), were used as a GIS template for map attributes collected by other methods. Coarse-scale habitat types used for remote assessment of aquatic habitat are listed in Table 5-3.

Table 5-3. Coarse-scale habitat types used for remote aquatic habitat assessment.

Habitat Type[1]	Abbreviation	Description
Low Gradient Riffle	LGR	Shallow with swift flowing, turbulent water. Partially exposed substrate dominated usually by cobble . Gradient moderate (less than 4%).
High Gradient Riffle	HGR	Shallow with swift flowing, turbulent water. Partially exposed substrate dominated usually by boulder. Steep gradient (greater than 4%).
Cascade	CAS	Steep "riffle" consisting of small waterfalls and shallow pools or pockets, substrate usually composed of bedrock and boulders. Gradient high (more than 4%).
Run	RUN	Fairly smooth water surface, low gradient, and few flow obstructions. Mean column velocity generally greater than one foot per second (fts^{-1}).
Glide	GLD	Fairly smooth water surface, low gradient, and few flow obstructions. Mean column velocity generally less than 1 fts^{-1}.
Pocket Water	POW	Swift flowing water with large boulder or bedrock obstructions creating eddies or scour holes. Gradient low to moderate.
Mid-channel Pool	MCP	Large pools formed by mid-channel scour where the scour hole encompasses more than 60% of the wetted channel. Slow flowing, tranquil water with mean column water velocity less than 1 fts^{-1}.
Lateral Scour Pool	LSP	Formed by flow impinging against one stream bank or against a partial channel obstruction where the associated scour is confined to <60% of wetted channel width.
Plunge Pool	PLP	Found where stream passes over a channel obstruction and drops steeply into the streambed below, scouring out a depression, often large and deep. Substrate size highly variable.

[1] Adapted from McCain et al. 1990, Payne 1992, Armantrout 1998.

In the lower portion of the river, reach classifications follow those defined by the Merced River Corridor Restoration Plan (MRCRP), using physical characteristics of the river and anthropogenic alterations to the river system (Stillwater Sciences 2002). One additional reach was added between Crocker-Huffman Dam (RM 52.0) and New Exchequer Dam (RM 62.5), as the MRCRP reach designations did not extend beyond RM 52.0. With the exception of Yosemite Valley, the majority of the upper river segment has not experienced major anthropogenic alterations to the river channel. Therefore, reach designations for the upper portion of the river follow sections of river between readily identifiable endpoints such as a structures and confluences.

Table 5-4. Merced River reach designations.

Reach Name	Reach Abbreviation	River Mile Range
Lower River		
Confluence Reach	CON	RM 0.0–8.1
Encroached Reach	ENC	RM 8.1–26.6
Gravel Mining 2 Reach	GM2	RM 26.6–32.3
Gravel Mining 1 Reach	GM1	RM 32.3–44.7
Dredger Tailings Reach	DTR	RM 44.7–51.3
Merced Falls Reach	MF	RM 51.3–54.3
Foothill Reservoirs Reach	MCL	RM 54.3–79.9
Upper River		
Upper Foothills Reach 3	UF3	RM 79.9–91.3
Upper Foothills Reach 2	UF2	RM 91.3–100.6
Upper Foothills Reach 1	UF1	RM 100.6–105.6
Lower Batholith Reach	LB	RM 105.6–118.7
Yosemite Valley Reach	YV	RM 118.7–126
Glaciated Batholith Reach	GB	RM 126 to headwaters

Within each reach, individual habitat units were digitized as two-dimensional features of varying shapes, or polygons, where each unit is a discrete functional habitat, as defined above. This approach is consistent with the general techniques of McCain (1992), Thomas and Bovee (1993), and Cannon and Kennedy (2003) and allows a flexible approach to evaluating habitat and habitat use patterns at a scale that can be easily delineated given available data (i.e., aerial photos, video), readily depicted, and is ecologically meaningful for aquatic species. Digitized habitat units were coded within the project GIS and drawn onto maps derived from the orthorectified aerial photos.

Helicopter videography of the lower river segment was acquired during October 3–5, 2005. Upper river videography occurred on November 15, 2005 and on-the-ground habitat mapping in Yosemite National Park took place during November 15–22, 2005. Remote and on-the-ground aquatic habitat mapping was conducted under minimum flow conditions, in order to: 1) facilitate evaluation of low-flow fish migration barriers, 2) maximize access and safety during fieldwork, and 3) evaluate habitat composition during the seasonal period of greatest habitat heterogeneity.

In coordination with Merced Irrigation District (MeID) flows in the lower Merced River were reduced to approximate normal summer baseflow conditions (2.8–5.6 m^3s^{-1} [100–200 cfs]) during October 3–5, 2005 (T. Selb, pers. comm.). The flow reduction was carried out to support Merced Phase IV geomorphic investigations (Stillwater Sciences 2006b) and Merced River Alliance aquatic habitat mapping efforts. Without the flow reduction, flows in the lower Merced River were projected to exceed 14 m^3s^{-1} (500 cfs) through October 2005 (T. Selb pers comm.). As the upper reach is unregulated, low-altitude videography was conducted in mid-November 2005, when flows had decreased as much as possible.

The continuous study area included the Merced River from the San Joaquin River Confluence (RM 0) to New Exchequer Dam (RM 62.5) (lower Merced River), and the Merced River upstream of New Exchequer Dam to El Portal (RM 105.5) near the entrance to Yosemite National Park (upper Merced River). Three additional discrete reaches of the upper Merced River within Yosemite were also included in the study area, where safety and permit constraints allowed for on-the-ground mapping activities (see Section 5.2.1.2).

As shown in Table 5-5, multiple parameters and features were recorded during the remote aquatic habitat mapping of the upper and lower Merced River. The flow conditions at which habitat mapping occurred were determined from stream gage data on the date the video was taken.

Table 5-5. Parameters measured during coarse-scale aquatic habitat mapping.

Parameter	Method	Metric/Descriptor	Method Reporting Limit
Habitat Parameters			
Date/Start time/End time	Video time stamp	Day/month/year	Minute
Latitude/Longitude	Video stamp or GPS	UTM	N/A
Natural sequence order	Visual estimation	A-1, A-2, A-3 …	N/A
Habitat unit length	Calculated by helicopter velocity and unit flight time	Feet	10 ft
Habitat unit width	Estimated from apparent length to width ratio	Feet (as a ratio of unit length)	10 ft
Channel confinement	Visual estimation	Confined, moderately confined, unconfined	N/A
Dominant/subdominant substrate	Visual estimation	Boulder, cobble, gravel/ sand/ silt	N/A
Habitat Features			
LWD in active channel	Visual identification	Tally	N/A
Depth categories	Visual estimation from aerial video	0–4 ft, 4–10 ft, >10 ft	4 ft
Potential for stranding	Visual estimation	Comments	N/A
Diversions	Visual identification	Comments	N/A
Fish migration barriers	Visual identification	Presence / absence	N/A
Access points	Visual identification	Roads, boat ramps, land ownership	N/A

Field Methods. Since existing orthorectified aerial photographs did not provide sufficient resolution for mapping throughout the Merced River (Stillwater Sciences 2006b), helicopter videography was used for habitat mapping, except within Yosemite National Park boundaries. Aerial videography provides higher-resolution, lower-altitude information about the stream channel as compared with aerial photography, particularly in the upper river segment where there is a prevalence of steep canyons and frequent meandering of the channel. Aerial video was flown at fall low-flow conditions throughout the upper and lower river. The helicopter crew consisted of a pilot, an experienced videographer, and a narrator. The narrator was generally familiar with the Merced River corridor and included landmark descriptions (e.g., roads, bridges, in-channel features), during the video. The video also included a time-stamp and GPS coordinates to allow habitat locations to be accurately referenced during mapping activities.

Aerial videography was not possible in Yosemite National Park because park regulations require that helicopter or airplane flights be at least 2,000 ft[6] (~610 m) above the ground at all times (Steve Thompson, pers. comm.) Typical videography flight elevations occur at 150–300 ft above the ground. Therefore, on-the-ground mapping was used for habitat delineation in discrete reaches of the Merced River within Park boundaries. Mapped reaches were located upstream, within, and downstream of Yosemite Valley. The most upstream reach was located in Little Yosemite Valley, above 6000 ft (1,829 m) or the elevation at which fish were naturally precluded from the river following glaciation (Joe Meyer, pers. comm.). Approximately one river mile was mapped in Little Yosemite Valley, with the final mapped stream length dependent on mapping time plus travel time to and from the study reach. Within the Yosemite Valley, approximately six river miles were mapped in order to re-occupy locations that were mapped in 1991 by USFS (Kisanuki and Shaw 1992). Approximately 1.6 km (1 river mile) was mapped between Yosemite Valley and the Park boundary in El Portal, with the final location based on accessibility within the canyon alongside Highway 140.

On-the-ground mapping was conducted by a team of two biologists. Starting points, ending points, and landmarks were referenced using a handheld GPS receiver, which enabled the habitat mapping data to be georeferenced and added to the project GIS. Notable features not necessarily identified using aerial photography or videography, such as spawning activity (e.g., redds) were noted and their locations recorded on a topographic map or using GPS and transferred to the digital base maps. Field verification of mapped habitat units occurred during individual fish surveys.

Analytical Methods. Preliminary data analysis occurred within two months following remote and field investigations, so that the results could be made available to other Project tasks. Existing aquatic habitat in the Merced River was delineated using

[6] The regulation is given in feet by Yosemite National Park.

ArcView GIS software and digitized onto topographic quads (1:24,000). Frequency distributions of habitat types were summarized by reach. Analysis at the basin and segment scale is intended to reveal larger patterns in habitat distribution that suggest mechanisms of fish population regulation (Fausch et al. 2002, Ward 1998), thus the hierarchical classification of habitat types will be included in the final report following completion of the 2007/2008 fish surveys. Habitat heterogeneity at the basin and segment scales (Figure 5-2) will be mapped using a hierarchical classification of habitat types following Hawkins et al. (1993).

5.2.2 Fish Study

The baseline fish population monitoring surveys were designed to complement information available from current and ongoing studies (Section 6) and to ensure compatibility with ongoing data collection efforts to the maximum extent possible. Observations of species composition, relative to habitat types and use patterns, made during the Merced River Alliance fish surveys, in combination with available pre-existing data, will provide information that will support future restoration activities by associating fish habitat use and timing within the Merced River.

5.2.2.1 Objectives

The objectives of the river-wide baseline fish monitoring task are to: 1) document baseline fish community species composition (native and introduced in the Merced River; 2) identify spatial patterns at multiple scales (e.g., segment, reach, habitat unit, microhabitat) and seasonal shifts (e.g., late winter/early spring, late spring/early summer, late summer/early fall) in fish species composition and distribution; 3) document fish use of specific habitat types in order to better link documented habitat characteristics to species-specific life history requirements, and; 4) address specific fish hypotheses, as detailed in the next section.

5.2.2.2 Hypotheses

The fish hypotheses focus on juvenile Chinook salmon and resident fish species in the lower Merced River, and trout species in the upper Merced River. As such, they are declarative statements of important assumptions about these species which will be systematically evaluated during the study and either verified or modified. Hypotheses developed for resident fish in the lower river incorporate several ideas detailed in CALFED's Comprehensive Monitoring, Assessment, and Research Program (CMARP) regarding the distribution and relative abundance of resident fish and introduced species (Brown *et al.* 2003) in the Merced River. As such they are based on the conceptual model described in CMARP and discussed in Section 6.1.1.1 (Figure 9). The upper river hypotheses incorporate recommendations made by Kisanuki and Shaw (1992) following their habitat mapping studies in Yosemite National Park. As discussed in Section 4, addressing the following hypotheses is a secondary goal of the Merced River Alliance biological assessment monitoring, with collection of contemporary baseline data for fish, avian, and macroinvertebrate species as the primary goal. Fish hypotheses will be addressed in the final report, following the second year of Merced Alliance biological data collection.

Fall-run Chinook salmon (*Oncorhynchus tshawytsch*) hypotheses:

1. In the lower river, Chinook fry (<50 mm [<2 in] FL) are found primarily in channel margin and backwater habitat, with relative density determined by microhabitat variables (e.g., water velocity, water depth, cover).
2. The relative density of Chinook fry is different between reaches where spawning habitat restoration (Appendix A, Table A-1) has occurred and reaches where no restoration has occurred.
3. In areas with suitable physical habitat (e.g., water velocity, water depth, cover), temperature, and water quality (e.g., dissolved oxygen), the relative density of juvenile Chinook fry (> 50 mm [>2 in] FL) will be lower where predators (e.g., bass) are present compared to areas where predators are absent. Density of Chinook fry will be inversely related to predatory density in co-occupied or adjacent habitats.
4. Variable seasonal flow magnitude and duration will determine the longitudinal distribution pattern of Chinook fry in the lower river. At low spring flows (<28.1 m^3s^{-1} [<1,000 cfs]), Chinook fry will be clustered in the upper reaches of the lower river, with very few fry rearing near the SJR confluence. At higher spring flows (>28.1 m^3s^{-1} [>1,000 cfs]), fry will be distributed throughout the lower river, with little or no clustering in upstream areas (i.e., near spawning locations).

Steelhead (*Oncorhynchus mykiss*) hypothesis:

5. In the lower river, the distribution of steelhead will be determined largely by water temperature, with deleterious effects on each life stage due to both short-term near-lethal temperatures and chronic elevated sub-lethal temperatures that impose significant bioenergetic stress on the fish.

Lower river fish community hypotheses (except salmonids):

6. The effect of 2005 high flows on the Merced River will be to extend the downstream limit of the native Foothill Community (as defined in Brown *et al.* [2003]: Sacramento pikeminnow, tule perch, Sacramento sucker, hardhead, riffle sculpin), and to limit the upstream limit of the Large Tributary Community (as defined in Brown *et al.* [2003]: largemouth bass, bluegill, redear sunfish, white catfish, channel catfish), as compared with earlier surveys by Brown in 1993–1995 (Brown 2000), which were collected following an extended 6-year drought.
7. Prickly sculpin and smallmouth bass distribution in the lower Merced River during 2006–2007 will be similar to that of earlier surveys by Brown *et al.* in

1993–1995 (Brown 2000), as flow differences between these years are not expected to affect the longitudinal distribution of these species.

Upper river fish community hypotheses:

8. In the upper Merced River, thermal stratification in large, deep pools provides temperature refugia for trout species, therefore the longitudinal distribution of these species in reaches where water temperature might otherwise be too warm will be correlated with pool distribution.
9. Rainbow trout abundance will be greatest in upper Merced River mainstem reaches that have been restored for spawning habitat (Appendix A, Table A-1) and will exceed pre-restoration observations made by Kisanuki and Shaw (1992).

5.2.2.3 Methods

The fish sampling design is summarized in Table 5-9 and described in more detail in the remainder of this section. In general, the study elements focus on fish community composition and distribution in the upper and lower segments of the Merced River, as well as habitat associations at multiple scales.

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Table 5-6. Summary of fish sampling design and monitoring site selection.

Fish Monitoring Site ID	Approx. RM	UTM[1]		Sampling Period[2]						Land Ownership/Administration
		Northing	Easting	Summer 2006	Fall 2006	Spring 2007	Summer 2007	Fall 2007	Spring 2008	
Lower River										
CON-F1	1	4135519	680403	**X**	**X**	X	X	X	X	Private
CON-F2	3.5	4136995	682042	**X**	**X**	X	X	X	X	Private
CON-F3 [3]	8.3	4136625	686101	**X**	**X**	X	X	X	X	Private
ENC-F1	13	4138063	691623	**X**	**X**	X	X	X	X	Private
ENC-F2	15	4139773	693777	**X**	**X**	X	X	X	X	Private
ENC-F3	20	4141111	699080	**X**	**X**	X	X	X	X	Private
ENC-F4	23	4143020	702653	**X**	**X**	X	X	X	X	McConnell State Park
GM2-F1	26.5	4144738	705565	**X**	**X**	X	X	X	X	Private
GM2-F2	27.5	4144587	706844	**X**	**X**					Private
GM2-F3	29.5	4148170	711567	**X**	**X**	X	X	X	X	Merced County DPW
GM1-F1	32.5	4149978	714924	**X**	**X**	X	X	X	X	Private
GM1-F2	36	4150003	716444	**X**	**X**	X	X	X	X	Private
GM1-F3	37.5	4149524	716431	**X**	**X**	X	X	X	X	Private
GM1-F4	39	4149826	717224	**X**	**X**	X	X	X	X	Private
DTR-F1	45	4149702	717309	**X**	**X**	X	X	X	X	Snelling Rd. Bridge
DTR-F2	48.5	4153214	724510	**X**	**X**	X	X	X	X	Henderson Park
DTR-F3	50	4155548	728304	**X**	**X**	X	X	X	X	CDFG
MFR-F1	54	4155644	735440	**X**	**X**	X	X	X	X	MeID
Upper River										
UF3-F1	82	4164887	758111		**X**			X		BLM
UF3-F2	86	4167717	761977		**X**			X		BLM
UF3-F3	87	4166644	764084		**X**			X		BLM
UF3-F4	90	4165224	236691		**X**			X		BLM
UF2-F1	92	4166650	238555		**X**			X		BLM
UF2-F2	94.5	4169385	241080		**X**			X		BLM

Fish Monitoring Site ID	Approx. RM	UTM[1]		Sampling Period[2]						Land Ownership/Administration
		Northing	Easting	Summer 2006	Fall 2006	Spring 2007	Summer 2007	Fall 2007	Spring 2008	
UF2-F3	97.5	4172993	242204		**X**			X		SNF
UF2-F4	100	4165224	236691		**X**			X		SNF
UF1-F1	100.5	4171691	245901		**X**			X		SNF
UF1-F2	102.5	4171932	247662		**X**			X		SNF
UF1-F3	104	4173120	249912		**X**			X		SNF
LB-F1	109	4173512	255660		**X**			X		YNP
LB-F2	113.5	4177294	260292		**X**			X		YNP
LB-F3	114.5	4178575	261263		**X**			X		YNP
LB-F4	117	4177636	265098		**X**			X		YNP
YV-F1	119	4178097	267727		**X**			X		YNP
YV-F2	123	4180087	271224		**X**			X		YNP
YV-F3	126	4179569	274628		**X**			X		YNP

1 UTM, Easting/Northing, taken in NAD 83.

2 "X" indicates the number of visits per monitoring site during the specified sampling period. Bold font indicates the sampling visit has already occurred.

3 While this site was originally intended to be located within the Confluence Reach, it was actually sampled 0.3 miles upstream of the reach break and in the Encroached Reach during 2006. The site may be renamed as an Encroached Reach site for the final report.

During 2006, fish surveys were conducted at 18 monitoring sites in the lower river segment and 17 monitoring sites in the upper river segment (Table 5-6). The majority of these monitoring sites will be re-occupied for 2007-2008 sampling events. While the fish surveys were designed to be conducted three (3) times per year in the lower Merced River, flow-related safety concerns and equipment limitations posed by extremely high flows (>142 m^3/s [5,000 cfs]) and turbidity during spring 2006 resulted in only summer and fall seasons being sampled in the first year of the study. An additional spring sampling event will be undertaken during 2008 as a substitute for originally planned spring 2006 event.

Fish survey timing is based on species biology and life history timing in order to collect data at ecologically meaningful time intervals. In the lower river segment, summertime (July-August) surveys in the lower river were timed to follow salmonid outmigration and thus focus on introduced and native resident fish (e.g., bass, sunfish, catfish), while fall (October) surveys to corresponded to late-summer rearing period for most resident species and overlap with the fall-run Chinook spawning period. Concurrent Merced River Alliance fish surveys do not duplicate ongoing CDFG redd surveys or carcass counts (Section 6), nor do they interfere with spawning activities. Upcoming spring surveys in the lower river will be conducted during late spring (March-April) to coincide with emergence of fall-run Chinook salmon fry and the primary period of juvenile rearing and outmigration. They also coincide with the spring spawning period of many of the native resident fish (e.g., lamprey, Sacramento splittail, Sacramento sucker). Sampling in the upper river segment was designed to occur once annually during the late summer or fall, when flows are lowest and all ages of rainbow trout, including young-of-the-year (YOY), and brown trout are expected to be observed.

Fish monitoring sites were selected throughout the Merced River watershed using the following criteria:

1. To represent the range of coarse-scale aquatic habitat types identified during the mapping efforts described in Section 5.2.1;
2. To include likely juvenile salmonid rearing habitat (e.g., stream margins under overhanging vegetation, backwaters) in the lower Merced River;
3. To be accessible;
4. To take advantage of existing fish and water quality monitoring data, fluvial geomorphological characterization of stream channel, and riparian habitat monitoring, where possible.

The majority of land in the lower Merced River corridor is privately owned (Stillwater Sciences 2002), and property access permission is not often granted when special-status species may be involved. For this reason, publicly-owned sites were chosen for sampling in the lower Merced River corridor whenever possible. Privately owned sites were included as well, with their ultimate availability for sampling dependent on landowner access agreements.

Site selection reconnaissance occurred prior to initiation of field work to verify the presence of desired aquatic habitat types and conditions and to determine the most appropriate and efficient sampling approach. Reconnaissance included limited testing of field sampling methods and equipment to ensure compatibility with local conditions. All access routes were designated in accordance with the agreements to access private property.

Multiple parameters were measured in order to meet the objectives for the fish study (Table 5-7). Photos and GPS locations were taken of each site, and site locations identified on GIS maps corresponding to mapped aquatic habitat units. Accuracy, precision, recovery, and completeness requirements for field measurements were SWAMP compatible as discussed in Section 9.1 of the BMAP (Stillwater Sciences 2006a).

Table 5-7. Parameters measured during fish monitoring.

Parameter	Method	Metric/Descriptor	Method Reporting Limit
Community Composition and Distribution			
Species identification	Visual identification	Species name	N/A
Longitudinal fish assemblage	Location in the watershed	River kilometer (RKM) (mile; RM)	N/A
Number of Individuals	Count	Number	1
Fish length – snorkeling	Fork and total length	millimeter	50 mm
Fish length – seining & electrofishing	Fork and total length	millimeter	1 mm
Weight - seining & electrofishing	Electronic balance	gram	0.1 g
Site Scale Habitat Characterization			
Date/Start time/End time	N/A	Day/month/year	N/A
Latitude/Longitude	Handheld GPS receiver	UTM	N/A
Natural sequence order (Reach ID – Habitat unit #)	N/A	A-1, A-2, A-3, …	N/A
Habitat type	Visual estimation	See Table 5-12	N/A
Average unit width	Wetted channel width	meter (feet) (measured at multiple transects)	0.01 m (0.1 ft)
Average unit length	Longitudinal distance	meter (feet)	0.01 m (0.1 ft)
Bed substrate composition	Visual estimation	5-10% increments; Bedrock, boulder, cobble, gravel, sand, silt, organic	N/A
Fish Cover type	Visual estimation	Boulder, woody debris, bedrock ledges, overhead vegetation, flooded terrestrial vegetation, etc.	N/A
Cover quantity	Visual estimation	0%, 25%, 50%, 75%, 100%	N/A
Maximum/minimum depth	Vertical distance	meters (feet)	0.15 m (0.5 ft)

Parameter	Method	Metric/Descriptor	Method Reporting Limit
Discharge	USGS data	$m^3 s^{-1}$ (cfs)	1 m^3s^{-1} (1 cfs)
Temperature[1]	Field probe	°C	0.1 °C
Dissolved Oxygen[1]	Field probe	mg/L	0.0 mg/L
Conductivity	Field probe	micro siemens (uS) /cm	1.0 uS/cm
pH[1]	Field probe	s.u	0.1 s.u.
Turbidity	Field probe	NTU	0.1 NTU
Visibility	Secchi depth	meters (feet)	0.01 m (0.1 ft)

[1] This parameter will conform to SWAMP SOPs given in Appendix E of SWAMP document (http://www.swrcb.ca.gov/swamp/qamp.html#appendixe) and SWAMP requirements (or suggestions) for accuracy, precision, recovery and completeness, as described in Section 9.1 of the BMAP (Stillwater Sciences 2006a).

Field Methods. Fish surveys were conducted using direct observation (snorkel surveys), seining, backpack electrofishing, and boat electrofishing. The methods were consistent with the species and life stage targeted, location, seasonal conditions, and regulatory restrictions. Monitoring sites were comprised of one or more habitat units defined by mapping effort. The number of habitat units chosen at a given monitoring site varied directly with the diversity of habitat at the site. In general, sites consisted of one to three habitat units considered representative of local channel conditions, with the number of units surveyed dependent on the amount of time available. The latter was largely determined by the overall length and complexity of the habitat units present. Sampled habitat units were generally contiguous, and sampling occurred from mid-morning until late in the afternoon, when sunlight conditions maximize visibility. When possible, rare or unexpected species were photographed. As permitted under the CDFG 4(d) Research Program (Appendix F of BMAP [Stillwater Sciences 2006a]), specimens were collected for laboratory identification if they could not be identified in the field.

All methods of collection, transportation, storage of samples, analysis, and data management procedures were conducted in accordance with guidelines established or referenced in the BMAP (Stillwater Sciences 2006a) and sources given in Table 5-8. For all methods, data was recorded in the field on standard field datasheets and reviewed for completeness and accuracy (see Section 7) prior to leaving the site. In the office, the data was entered into a database developed specifically for the project, and checked for errors using standardized QA/QC protocols.

Table 5-8. Sources used for fish sampling methods.

Author	Year	Title	Publication Information
Murphy, B. R., and D. W. Willis	1996	Fisheries techniques, 2nd edition	American Fisheries Society, Bethesda, Maryland
McCain, M., D. Fuller, L. Decker, and K. Overton	1990	Stream Habitat Classification and Inventory Procedures for Northern California	FHR Currents, Volume 1. USDA Forest Service, Pacific Southwest Region. June.

Direct Observation. Direct observation (snorkel) surveys were conducted similarly to other snorkel surveys described by Edmundson *et al.* (1968), Hankin and Reeves (1988), McCain (1992), Dolloff *et al.* (1996), and Cannon and Kennedy (2003). At each snorkel location, the river was stratified into snorkel lanes, aligned perpendicular to the channel and the direction of flow. Two to three divers, trained staff biologists with experience in the identification of Pacific Northwest fish species and swiftwater safety techniques, positioned themselves at the downstream end of the habitat unit, one per snorkel lane, to avoid duplicating fish counts. During sampling, divers proceeded upstream through each habitat unit in the designated lanes at approximately the same pace. Multiple habitat units within a monitoring site were generally sampled sequentially from downstream to upstream in a zigzag pattern. This decreased 1) the potential for sediment disturbance, 2) the approach speed of the diver, and 3) startle-bias due to the upstream-orientation of fish in the current. At monitoring sites with higher flows, divers proceeded downstream through each habitat unit.

At all snorkel sites, divers recorded their observations on dive slates attached to their forearms. Care was taken to observe and count fish just once by passing individuals or groups of fish and allowing them to escape downstream of the diver. Numbers of fish were recorded by species and size, with fish lengths estimated to the nearest 50 mm (1.96 in). Graduated markings on each slate were used to calibrate the underwater observations. Start and end times were noted and all data recorded on the dive slates transcribed to a data sheet upon completion of the snorkel survey. Divers also recorded visibility and weather conditions during each snorkel survey.

Seining. Seining surveys were used primarily to document smaller fish. Seining was conducted by crews of two to three staff biologists using a beach seine net to sample fish in shallow channel margins and on inundated floodplains possessing adequate space for seine haul-out (e.g., bar). For upcoming 2007 spring sampling, seining will be used to reduce the need for electrofishing when sampling during the spring period of Chinook salmon juvenile rearing. Seining will also be especially important for sampling floodplains if springtime inundation persists long enough during spring to permit reproduction by fish that spawn in the floodplain (e.g., Sacramento splittail).

The beach seine creates a "wall" extending from the surface to the bottom of the water column. Mesh panels hang from a float line, which sits at the water surface, to a lead line, which sits at the bottom of the seine, and prevent fish from escaping from the net. The beach seine, at 1.8 m

(6 ft) high, 9.1 m (30 ft) wide, and possessing a 0.32 cm (0.125 in) mesh, was hauled through a location by a two person team and then drawn to shore to trap and capture the fish. Fish were held in buckets for transport and processing. Start and end times and the sampling duration of each seine pass were recorded. The width of the deployed seine opening was recorded, and haul distance was estimated in order to calculate an approximate sample area for use in calculating catch per unit effort (CPUE). All fish were identified to species, counted, and measured for length and weight before being returned to the river at approximately the same location where they were captured.

Boat Electrofishing. Boat electrofishing was used primarily to document presence of adult fish, and was necessary in deeper areas and in habitat units where higher water velocities made wading or snorkeling unsafe. While these conditions were common throughout the lower river segment during 2006, they were not encountered in the upper river segment. Thus, fish data collected via boat electrofishing were confined to the lower Merced River.

Boat electrofishing was conducted using one of two different types of boats. Sampling with the first type of boat, a 6.4 m (21 ft) aluminum Smith-Root electrofishing boat, was conducted by a crew of three to four staff biologists including one operator, two crew members netting and removing the captured fish from the nets, and one crew member stationed on the shore. Sampled fish were placed in a live well on-board the boat, or in supplementary on-shore live wells if capture numbers exceeded the capacity of the boat live-well. Boat electrofishing was also conducted using a 4.3 m (14 ft) Zodiac inflatable raft (Mark II Classic) outfitted with a 5 HP outboard motor and a Smith-Root 1.5 KVA electrofishing apparatus as detailed by Stangl (2001). Sampling with the Zodiac raft was conducted by a crew of two staff biologists including one operator, and one crew member netting and removing the captured fish from the nets and placing them in a live well on-board the raft.

Start and end times and the sampling duration of the pass for each habitat unit were recorded from the meter on the electrofisher. All fish captured, whether held on-board or on-shore, were processed immediately following each electrofishing pass. Data collected during boat electrofishing was recorded in the field on standard field datasheets (Appendix E). Each captured fish was identified to species, measured to the nearest millimeter (fork length and total length), weighed to the nearest tenth of a gram. After processing was completed, fish from all passes were returned to the river at approximately the same location where they were captured.

Backpack Electrofishing. Backpack electrofishing was conducted opportunistically along the wade-able stream margins at snorkel sites to: (1) help verify species identifications made during snorkeling; 2) potentially obtain species length and weight relationships for estimating fish biomass from snorkel data; and 3) to capture species that, because of either their behavior or size, were difficult to observe while snorkeling. Backpack electrofishing was also conducted along wade-able stream margins at boat electrofishing sites, in areas that were too shallow to accommodate the boat electrofisher.

Backpack electrofishing throughout the upper and lower Merced River was conducted with the use of one to two Smith-Root backpack electrofishers (Model LR-24 or Model 12 with 11-inch anode rings and standard "rat-tail" cathodes) and a crew of two to three staff biologists per backpack electrofisher, including one shocker and one to two netters. At sites where backpack electrofishing was employed, all areas within the selected habitat unit were sampled from the center of the channel towards the stream margins. When two backpack electrofishers were used, sampling consisted of simultaneous and roughly parallel passes upstream through the habitat unit. In excessively turbulent portions of the waterway, such as high-gradient riffles, netters positioned their nets directly downstream of the anode ring to maximize capture of fish that could not be easily observed or that were caught in the turbulent flow. Start and end times and the sampling duration (in seconds) were recorded from each backpack electrofisher.

In the upper segment of the Merced River, three sites were selected for trout density and biomass measurements. At these sites, a multiple-pass depletion method (Platts *et al.* 1983) was used, with block nets (4.76 mm [0.1875 inch] mesh size) placed at each site to prevent the movement of fish into or out of the sampling locations. The bottom edges of the block nets were sealed with cobble and small boulders and the top edges of the nets propped above the water surface with dowels to prevent fish from escaping during sampling. Multiple passes of equal effort were made to capture as large a percentage of the population as possible.

After completion of each pass, biologists identified each fish to species level and recorded fork length (mm) and weight (g) of each individual fish. Fish weight, to the nearest tenth of a gram, was measured using an electronic balance. Scale samples were collected from selected trout species and stored in labeled envelopes for potential use in age verification by the California Department of Fish and Game (CDFG). All captured fish were allowed to recover in buckets or live wells before being returned to the river at approximately the same location where they were captured.

Site-specific Fish Habitat Assessment. While remote coarse-scale aquatic habitat mapping was conducted under low-flow conditions to aid in monitoring site selection (Section 5.2.1), site-specific habitat information, including sub-classifications of habitat types and focal habitat descriptions (see Figure 5 for scale definitions), was collected at seasonal flows during the fish surveys themselves. This allowed for finer-scale habitat characterization than was possible for the remote monitoring effort, providing more information on fish choice of habitat and potentially helping to describe the influence of physical habitat parameters on fish behavior and bioenergetics. Focal habitat parameters were characterized for rearing Chinook salmon and other species of interest (e.g., lamprey and trout in the lower segment of the Merced River) to help define parameters that may be useful for future habitat restoration. Such parameters were also used for other fish species when physical characteristics at the scale of the individual fish or group of fish were considered to be an important criterion determining habitat use. Focal habitat descriptions included additional measurements such as focal velocity, focal depth, distance to cover, and distance to bank (Table 5-10), where velocity, depth were measured at the location of individual fish or group of fish, and minimum and maximum depth were taken from a series of measurements made throughout the habitat unit.

Table 5-9. Habitat types used for site-specific fish habitat assessment.

Habitat Type[1]	Abbreviation	Description
Low Gradient Riffle	LGR	Shallow with swift flowing, turbulent water. Partially exposed substrate dominated usually by cobble. Gradient moderate (less than 4%).
High Gradient Riffle	HGR	Shallow with swift flowing, turbulent water. Partially exposed substrate dominated usually by boulder. Steep gradient (greater than 4%).
Cascade	CAS	Steep "riffle" consisting of small waterfalls and shallow pools or pockets, substrate usually composed of bedrock and boulders. Gradient high (more than 4%).
Run	RUN	Fairly smooth water surface, low gradient, and few flow obstructions. Mean column velocity generally greater than one foot per second (fts^{-1}).
Glide	GLD	Fairly smooth water surface, low gradient, and few flow obstructions. Mean column velocity generally less than 1 fts^{-1}.
Pocket Water	POW	Swift flowing water with large boulder or bedrock obstructions creating eddies or scour holes. Gradient low to moderate.
Mid-channel Pool	MCP	Large pools formed by mid-channel scour where the scour hole encompasses more than 60% of the wetted channel. Slow flowing, tranquil water with mean column water velocity less than 1 fts^{-1}.
Lateral Scour Pool	LSP	Formed by flow impinging against one stream bank or against a partial channel obstruction where the associated scour is confined to <60% of wetted channel width.
Plunge Pool	PLP	Found where stream passes over a channel obstruction and drops steeply into the streambed below, scouring out a depression, often large and deep. Substrate size highly variable.
Backwater	--	Off-channel, slow flowing, tranquil water with mean water column velocity generally less than 1 fts^{-1}. Usually shallow and dominated by finegrain substrates.
Floodplain	--	Off-channel, seasonally flooded areas. Usually shallow and slow flowing, tranquil water with mean water column velocity less than 1 fts^{-1}.
Margin	--	Quiet, shallow area found along the edges of the stream which is qualitatively different than habitat found in the mid-channel. Water velocity is generally less than 1 fts^{-1} and sometimes lacking. Substrate varies.

1 Adapted from McCain et al. 1990, Payne 1992, Armantrout 1998.

Table 5-10. Microhabitat parameters for species-specific fish surveys.

Microhabitat Parameter	Unit
Focal velocity	m s^{-1}
Focal depth	m
Distance to bank	m
Distance to cover	m

Water quality measurements. SWAMP-compatible methods (Stillwater Sciences 2006a) were used for *in situ* water quality parameters measured during fish surveys. A Yellow Springs Instruments (YSI) multi-parameter probe was used to measure water temperature, pH, conductivity, and dissolved oxygen (DO). Field calibration of the YSI multi-parameter probe occurred daily, and if applicable after every 20 measurements in a given day, following the calibration/maintenance log (Appendix E of the BMAP [Stillwater Sciences 2006a]). For DO measurements, the probe was allowed to equilibrate in-stream for at least 90 seconds before recording results to the nearest 0.1 mg/L. Temperature was measured to the nearest tenth of a degree Centigrade. Once placed in the stream, the pH probe was allowed to equilibrate for 60 seconds before recording to the nearest 0.1 of a pH unit. Turbidity was measured using grab samples taken at each location using a clean, rinsed sample bottle and a HF Scientific Micro TPI or Hach 2100 P turbidimeter. Turbidity was typically measured at the monitoring site following survey completion for each sample unit. When sampling conditions did not allow for immediate processing of grab samples, they were stored in a cool, dark container, and processed prior to leaving the site. Four to six turbidity sample readings were taken for an average turbidity at each location. Field calibration of the turbidimeter occurred daily or after every 50 measurements.

Vertical water clarity was measured using a Secchi disk during electrofishing and seining surveys. The disk was suspended from a vinyl tape and lowered into the water column until it disappeared, then slowly raised until it reappeared. The average of the disappearing and reappearing depths was recorded as the Secchi disk transparency. If the water was too clear or shallow for a disappearing depth to be recorded, the deepest point in the sampled habitat unit was measured and Secchi depth was recorded as ">X", where X is the greatest depth that was observed.

Both vertical and horizontal water clarity were measured at snorkel sites. Vertical water clarity was measured using the same protocol described above for electrofishing and seining surveys. Horizontal water clarity was estimated by two snorkel crew members, one extending the Secchi disk underwater, with the tape aligned parallel to the water surface, and the other observing the disappearing and reappearing distances as the disk was moved through the water. The horizontal measures were taken both into and away from the sun.

Analytical Methods. For the interim report, fish survey data were analyzed to characterize species composition and distribution, and to develop estimated linear abundance, richness, and diversity indices. Rough habitat associations were investigated on a reach scale, and the longitudinal distribution of each community assemblage was analyzed on a basin (upper and lower river segments) scale.

As a general descriptor of the observed fish community, analysis of native versus introduced species and anadromous versus resident species is presented at the segment scale. Estimated fish linear abundance is defined as the total number of fish species observed by reach, normalized to the total reach length. It is considered an estimate since the sampling methods described above are not designed to target absolute abundance for observed fish species. Estimated linear abundance is expressed as the number of fish per 100 meters. Following the collection of two years of data, estimated linear abundance data will be analyzed for potential correlations with physical habitat attributes, such as migration barriers and spawning habitat. Additionally, relative abundance will be expressed by site and will be analyzed across monitoring sites having similar habitat attributes and for which identical sampling methods are used.

Percent of total individuals observed by species is presented to identify whether certain species are relatively rare, given the available sampling method (e.g., snorkeling, seining, electrofishing). This statistic is presented at the river segment (upper vs. lower) and reach scale. Species richness is defined as the number of species detected within a given reach, while species diversity measures ecological diversity based on the number of species detected, weighted by the number of individuals of each species, also within a given reach. A high score indicates high ecological (species) diversity. Species diversity is measured using a transformation of the usual Shannon-Weiner index, which is symbolized by H' (also called Shannon-Weaver index or Shannon index; Krebs 1989). This transformed index, which was introduced by MacArthur (1965) is N_1 where $N_1 = 2^{H'}$. The advantage of N_1 over H' is that N_1 is measured in terms of species, whereas H' is measured in terms of bits of information (Nur et al. 1999). Thus, N_1 is more easily interpreted, and species diversity (measured as N_1) and richness can be compared. Where S = total species richness and p_i is the proportion of the total number of individuals for the *i*th species:

$$N_1 = e^{H'} \text{ and } H' = \sum_{i=1}^{i=S} (p_i)(\ln p_i)(-1)$$

For the interim report, longitudinal gradients in fish community assemblages were assessed by comparison of observed species distributions with expected distributions based on fish assemblage descriptions from Moyle (2002) and Brown *et al.* (2003) (Table 5-11). Fish communities are presented in graphical form for each sampling season to identify potential seasonal shifts in the extent of each assemblage or the predominance of a particular fish species within a given assemblage.

Further data analysis, to be presented in the final report following the second year of data collection, will include fish length frequency, distribution correlation with physical parameters and, when feasible, comparison with existing data and data collected as part of other Merced River survey efforts. As with BMI and avian results, fish monitoring data, interim products, and results will continue to be periodically presented at Merced River Stakeholders and Upper Merced River Watershed Council meetings.

Table 5-11. Fish community assemblage descriptions and associated fish species.

<table>
<tr><th colspan="2">Fish Community Assemblage</th><th>Description</th><th>Species Observed During 2006 Surveys (native species in bold type)</th><th>Reference</th></tr>
<tr><td colspan="2">Trout</td><td>Associated with higher elevations in the Sierra Nevada range. Primary species is the native rainbow trout, but can include introduced brown trout. Upstream limit is usually determined by natural migration barriers, such as Vernal Falls on the mainstem Merced River.</td><td>Brown trout,
O. mykiss[1]</td><td>Brown et al. (2003)</td></tr>
<tr><td colspan="2" rowspan="2">Foothill</td><td rowspan="2">Found at mid-range elevations in the foothills of the Sierra Nevada range. Serves as a transitional zone, where changes in temperature etc. are stressful to trout but conducive to more tolerant species. Mostly native species.</td><td>Hardhead,
Riffle sculpin,
Sacramento pikeminnow,
Sacramento sucker</td><td>Brown et al. (2003)</td></tr>
<tr><td>California roach,
Spotted bass</td><td>Moyle (2002)</td></tr>
<tr><td rowspan="4">Valley Floor</td><td>Lower Large Tributary (LLT)</td><td>Associated with valley floor elevations of the three, large east-side tributaries to the San Joaquin mainstem; the Stanislaus, Tuolumne, and Merced rivers (LLTs). Dominated by species adapted to slow, warmwater habitat.</td><td>Bluegill sunfish,
Channel catfish,
Largemouth bass,
Redear sunfish,
White catfish</td><td>Brown et al. (2003)</td></tr>
<tr><td rowspan="2">San Joaquin Mainstem #2 (SJ Main #2)</td><td rowspan="2">Comprised of introduced, warmwater species found in the mainstem San Joaquin River and commonly extending into lower reaches of LLTs. May not be present in LLTs during high flow years.</td><td>Brown bullhead,
Common carp,
Green sunfish,
Goldfish</td><td>Brown et al. (2003)</td></tr>
<tr><td>Bigscale logperch,
Black crappie,
Hitch
Kern Brook lamprey,
Mosquitofish</td><td>Moyle (2002)</td></tr>
<tr><td>San Joaquin Mainstem #1 (SJ Main #1)</td><td>Comprised of a second group of introduced species that do not generally extend into the LLTs (e.g., fathead minnow, threadfin shad, red shiner, and inland silverside), but may move into lower reaches of LLTs during low flow years.</td><td>None observed</td><td>Brown et al. (2003)</td></tr>
</table>

Fish Community Assemblage	Description	Species Observed During 2006 Surveys (native species in bold type)	Reference
Broad Geographic Range (BGR)	Found across a broad range of habitat conditions (e.g., temperature, flow) and multiple fish communities.	**Prickly sculpin,** Smallmouth bass	Brown et al. (2003)
Anadromous	Not assigned a specific range. Prior to construction of foothill dams, or other human-induced migration barriers, these species may have migrated though multiple zones.	**Chinook salmon,** ***O. mykiss*[1]** **Pacific lamprey,** Striped bass	Moyle (2002)

[1] *O. mykiss* observed below Crocker Hoffman dam has the potential to be anadromous.

5.2.3 BMI Study

Stream surveys of BMI are frequently conducted as indicators of water quality and overall aquatic ecosystem health (Barbour et al. 1999, Plafkin et al. 1989, Mebane 2001). The BMI component of the Merced River Alliance biological monitoring was designed to complement information available from recent and ongoing studies (Section 6.1.2) and to ensure compatibility with ongoing data collection efforts to the maximum extent possible. The intent of this study was to provide further information regarding BMI assemblages and aquatic habitat quality within the Merced River.

5.2.3.1 Objectives

The objectives of the BMI study are to: 1) gather information regarding BMI composition, distribution, and relative abundance in the Merced River watershed as an indicator of water quality and ecosystem health; 2) conduct seasonal BMI bioassessments using both targeted riffle and multi-habitat composite samples; 3) determine presence or absence of non-native, invasive aquatic invertebrate species including the Asiatic clam (*Corbicula fluminea*), Chinese mitten crab (*Eriocheir sinensis*), and New Zealand mud snail (*Potamopyrgus antipodarum*); 4) relate data generated by objectives 1-3 to ecological subregions (Miles and Goudey 1997; Omernik and Bailey 1997) and physical habitat variables in order to better understand the relationship between BMI assemblages and their physical environment, and; 5) address specific BMI hypotheses, as detailed in the next section.

5.2.3.2 Hypotheses

Hypotheses developed for Merced River Alliance BMI surveys build upon the results of recent BMI studies conducted in the region (Bergendorf 2005, Brown and May 2000a, Brown and May 2000b, Carter and Fend 2001, Gangloff 1998, Markiewicz et al. 2003, Ward and Stanford 1995). As stated in Section 4, addressing the following hypotheses is a secondary goal of the Merced River Alliance biological assessment monitoring, with collection of contemporary baseline data for fish, avian, and BMI species as the primary goal. BMI hypotheses will be addressed in the final report, following the second year of Merced Alliance biological data collection.

1. BMI samples taken from sites with relatively large amounts of woody debris (as quantified during the physical habitat assessment) will exhibit higher composite metric scores than those taken from sites without significant woody debris (Kaufman et al. 1999).

2. BMI taxonomic richness at the genus level will be greatest in riffles the foothill region above New Exchequer Dam, as compared with taxonomic richness measured in riffles located in either the mountain or valley floor regions of the Merced River (Brown and May 2000a).

3. Serial discontinuity in the longitudinal pattern of functional feeding group (FFG) relative abundance will be apparent at New Exchequer Dam, with increased relative abundance of collector-filterers just below the dam (Ward and Stanford 1995).

4. An increase in the relative abundance and richness of stonefly and other Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa will be apparent in the Dredger Tailings Reach as compared with the data collected in March 2005 following multiple years of "dry" to "normal" flows (Stillwater Sciences 2006b).

5. EPT richness will be greater in reaches where habitat restoration involving substrate renewal (e.g., gravel augmentation) or channel reconfiguration has occurred, as compared with otherwise similar reaches in which no restoration has occurred (Merz and Chan 2005).

6. Chinese mitten crab distribution in the Merced River will be limited to the lower sand-bedded reaches of the Merced River. Relative abundance will be greatest near the SJR confluence and will decrease upstream of the confluence (because the source of the invasion is upstream movement of crabs from the Sacramento-San Joaquin River estuary) (Bergendorf 2005).

7. If found, the New Zealand mud snail, which has not been documented in the Merced River to date (Post, pers. comm., 2006), will not exhibit any consistent longitudinal pattern in distribution and abundance (because introduction by humans may occur at any point within the Merced River corridor). Relative abundance will be highest in areas where recreational fishing activities are most prominent (e.g., Yosemite Valley, just upstream of Lake McClure on the mainstem).

8. Asian clam distribution in the Merced River will extend beyond that measured in 2003 by Brown et al. (in prep), to include locations in the upper river (i.e., the dams do not represent a barrier to upstream dispersal since birds or humans can serve as vectors of introduction to the upper portion of the watershed).

5.2.3.3 Methods

Merced River Alliance biological monitoring thus far includes analysis of taxonomic composition and relative abundance of BMI in the upper and lower segments of the Merced River. The BMI sampling approach for the Merced River Alliance BMAP (Stillwater Sciences 2006a) was designed to be SWAMP compatible and was, therefore, based on the BMI protocol adopted under the U.S. EPA's Environmental Monitoring and Assessment Program Western Pilot Study (EMAP-West) and the EPA wadeable stream assessment field operations manual (EPA 2004). Detailed information regarding the development and use of the EMAP-West methodology, including a comparison of its components to other BMI sampling protocols, is provided in Section 5.2.3.3 of the BMAP (Stillwater Sciences 2006a).

BMI monitoring sites were selected using the following criteria:

1. To take advantage of existing aquatic BMI and water quality monitoring data, especially those data taken at sites where restoration actions have been undertaken;

2. To be accessible;

3. To be proximal to fish monitoring sites, where applicable; and

4. To represent a range of ecological subregions (as defined by Miles and Goudey, 1997).

A total of 18 sites in the lower river segment and 20 sites in the upper river segment were chosen and sampled for BMI bioassessment monitoring in the fall (Table 5-12, Figure 5-5). During the second year of the study, these same sites will be sampled one time per year in the upper river segment (fall only) and two times per year in the lower river segment (late spring/early summer and fall). Monitoring sites were 500 m (1,640 ft) in length and placed at least 30.5 m (100 ft) upstream or downstream of any bridge or abutment that may influence the flow of the stream. Collectively the sites spanned six ecological subregions as discussed in criteria four (Table 5-12; Figure 5-5).

Table 5-12. Summary of BMI sampling design and monitoring site selection.

Ecological Subregion	BMI Monitoring Site ID*	Approximate RM	UTM[1]		Sampling Period[2]			Land Ownership/Administration
			Northing	Easting	Fall 2006	Summer 2007	Fall 2007	
Lower River								
Manteca Merced Alluvium	CON-B1*	1.0	4135764	680761	X	X	X	Private
	CON-B2*	3.5	4136816	681474	X	X	X	
	ENC-B1*	8.5	4136742	685859	X	X	X	
	ENC-B2*	12.5	4138044	690759	X	X	X	
	ENC-B3	14.5	4138515	691737	X	X	X	
	ENC-B4	17.5	4140623	697969	X	X	X	
	ENC-B5*	24	4143862	703042	X	X	X	
	GM2-B1	27	4144894	705521	X	X	X	
	GM2-B2	29	4146511	709359	X	X	X	
HardPan/Camanche Terraces	GM2-B3	32	4147626	711006	X	X	X	Merced County
	GM1-B1	36.5	4149843	715280	X	X	X	Private
	GM1-B2	39	4149826	717224	X	X	X	
	GM1-B3	44.5	4153267	725037	X	X	X	
	DTR-B1	46.5	4154261	725728	X	X	X	
	DTR-B2	48.5	4155858	727414	X	X	X	Henderson Park
	DTR-B3	50	4155287	729931	X	X	X	MeID/CDFG
	DTR-B4	51.5	4155485	731521	X	X	X	CDFG Hatchery
	MF-B1	53.5	4155146	735274	X	X	X	Private
Upper River								
Upper Foothills Metamorphic	UF3-B1	82	4165411	756613	X		X	BLM
	UF3-B2	86	4167616	761818	X		X	
	UF3-B3	87	4167362	763089	X		X	
	UF3-B4	90	4165348	766509	X		X	
	UF2-B1	92	4167065	768424	X		X	
	UF2-B2	94.5	4169331	770052	X		X	
	UF2-B3	97.5	4173299	771297	X		X	
	UF2-B4	99.5	4172916	773492	X		X	

Ecological Subregion	BMI Monitoring Site ID*	Approximate RM	UTM[1]		Sampling Period[2]			Land Ownership/Administration
			Northing	Easting	Fall 2006	Summer 2007	Fall 2007	
	UF1-B1	101	4172680	775585	**X**		X	SNF
	UF1-B2	102.5	4172706	777160	**X**		X	
	UF1-B3	104	4173703	778889	**X**		X	
Lower Batholith	LB-B1	109	4174812	784841	**X**		X	YNP
	LB-B2	113.5	4179044	789279	**X**		X	
	LB-B3	114.5	4179981	789730	**X**		X	
	LB-B4	115.5	4179833	791833	**X**		X	
	LB-B5	118	4179622	794336	**X**		X	
	YV-B1	123	4182423	799730	**X**		X	
Upper Batholith	YV-B2	124.5	4182581	801599	**X**		X	
	YV-B3	126	4182345	803026	**X**		X	
	GB-B1	126.5	4181738	803369	**X**		X	

* Site also monitored for the Chinese mitten crab.

1 UTM, Easting/Northing, taken in NAD 83.

2 "X" indicates the number of visits per monitoring site during the specified sampling period. Bold font indicates the sampling visit has already occurred.

Bioassessment Field Methods. Detailed quality assurance and quality control (QA/QC) measures for the Merced River Alliance biological monitoring are discussed in the BMAP (Stillwater Sciences 2006a). For BMI monitoring, Stillwater Sciences' biologists recorded all field survey information on datasheets, which were entered into a database immediately following each monitoring visit. Specific monitoring methods are described below.

Multi-habitat Composite Sample. The downstream end of each monitoring site was designated as transect "A" (Figure 5-6). Ten additional transects (labeled "B" through "K" moving upstream) were determined at intervals equal to 1/10 of the total monitoring site length (50 m). Each transect was sampled at one of three points (facing upstream, Left [L] = 25% of stream width, Center [C] = 50%, or Right [R] = 75%), which was selected systematically following a random start at Transect A. A stopwatch was used to randomly select the first sampling location (at Transect A) by noting the last digit on the watch – if the digit was 1 through 3, Transect A was sampled at the left point, 4 through 6, at the center point, and 7 through 9, at the right point. The remaining transects B through K were sampled following the sequence "L, C, R, L, C, R, etc." If a sampling point was located in water that was too deep, inaccessible, or otherwise unsafe, an alternate sampling point along the transect was selected. In such cases, an effort was made to equally represent the left bank, right bank, and mid channel habitat in the sample. A sample was collected from each of the 11 transects (Transects A-K) at the assigned sampling spots (L, C, R) using a D-frame kicknet with 500 μm mesh.

Riffle, run, and glide habitats (see Table 5-3 for aquatic habitat type definitions) were sampled in a similar manner. With the net opening facing upstream, the net was securely placed on the stream bottom to eliminate gaps under the frame. A quadrat of 0.09 m^2 (1 ft^2), equal to the area of the net, was disturbed for thirty seconds just upstream of the net opening. Large rocks that were less than 50% into the sampling area were pushed aside. Remaining substrate was either scrubbed by hand or kicked by foot, depending depth and velocity conditions, to dislodge organisms and wash them into the net. Where possible, mussels, snails, and sections of vegetation that fell entirely within the quadrat were removed by hand and included in the sample. After scrubbing or kicking, the substrate particles were removed from the sample area. Finer substrate within the quadrat was disturbed in an upstream to downstream pattern. After the sample was taken, the net was pulled up out of the water, then immersed in the stream several times to remove fine sediments and to concentrate organisms at the end of the net.

Due to the greater sampling depth necessary, pool habitat was sampled using a modified method. A quadrat equal to the area of the net (0.09 m^2) was disturbed either by foot or with the base of the net (depending on water depth). The net was then continuously swept through this area just above the channel bottom in a downstream to upstream motion for thirty seconds. The net was kept moving at all times so that organisms trapped in the net were not able to escape. If the sample area contained large amounts of vegetation, the net was swept through this vegetation. Large rocks that were less than 50% into the sampling area were pushed aside. Remaining substrate was either scrubbed by hand or kicked by foot, depending on depth, to dislodge organisms and wash them into the net. Where possible, mussels, snails, and sections of vegetation that fell entirely within the quadrat were removed by hand and included in the sample. After 30 seconds of sweeping, the net was removed from the water with a quick upstream motion to wash the organisms to the bottom of the net. The net was then immersed in the stream several times to remove fine sediments and to concentrate organisms at the end of the net. No water or material was allowed to enter the mouth of the net during this final step.

Targeted Riffle Composite Sample. Upon arrival at the monitoring site, the number of riffle habitat units contained in the stream reach was visually estimated. A riffle unit was considered to be riffle habitat with an area greater than 0.09 m^2 (1 ft^2). If there were less than 0.74 m^2 (8 ft^2) of riffle (eight riffle habitat units) habitat present within the monitoring site, a targeted riffle sample was not be collected. If there were at least 0.74 m^2 (8 ft^2) of riffle habitat present within the monitoring site, a total of eight samples were taken to form the targeted riffle composite. In cases where there were fewer than eight distinct riffles, more than one kick sample per riffle was collected (Figure 5-6). If there were more than eight riffles, one or more riffle units were skipped at random. In either case, an effort was made to spread sampling points throughout the reach as much as possible. The core area (excluding channel margins and upstream/downstream boundaries) of each riffle was defined and visually divided into nine equal quadrats in a 3x3 grid. One quadrat was randomly selected for a kick sample. If more than one sample was collected from a particular riffle, a second quadrat was randomly chosen and sampled. The remaining sampling protocols for targeted riffle composite samples followed those discussed above for riffle/run/glide habitats.

Sample Processing. Each composite sample was transferred into a labeled, plastic sample jar, containing 95% ethanol, by carefully inverting the net (Table 5-13). Residual organisms clinging to the net were removed by hand, using forceps if necessary, and placed in the jar. Any large objects in the net (such as rocks, sticks, and leaves) were carefully inspected for organisms before being discarded. Detritus was removed to the greatest extent possible, without losing any organisms. The net was thoroughly rinsed before proceeding to the next upstream sampling location.

Aquatic bioassessment samples were labeled with the project name, site identification, sample type, date and time sampled, preservatives used, constituent analyses required, and the sampler's name. Detailed notes were collected in the field during sampling, and a chain of custody form was completed daily upon the conclusion of sampling. The chain of custody form was subsequently shipped to the laboratory with the samples, where it was kept on file to document receipt of the samples.

Table 5-13. Container, sample size, type, preservation and storage for BMI samples.

Indicator	Container Type[1]	Min Sample Amt. (ml)[2]	Sample Type[3]	Sample Preservation	Max Hold Time
BMI	P, G	Variable	Kick-net composite	90% ethyl alcohol, dark away from extreme hot or cold	5 years

[1] Container — P = polyethylene or equivalent; G = glass
[2] Minimum Sample Quantity – plan at least two minimum sample quantities for reanalysis contingencies
[3] Sample Type — g = grab; d = deployable sampler

Exotics Survey Field Methods. Surveys to determine presence or absence of the New Zealand mud snail, Chinese mitten crab, and Asiatic clam were conducted at selected sites in the Merced River watershed. Inspection for the New Zealand mud snail and the Asiatic clam was conducted during laboratory analysis of samples taken throughout the watershed. Monitoring for the Chinese mitten crab was concentrated at five sites (Figure 5-1) in the lower reaches of the Merced. A passive habitat trap, found to be an effective method of capturing Chinese mitten crabs (Bergendorf 2003), was deployed and monitored biweekly for four months (July through October) at each of these sites. The design and construction of the traps paralleled that used by California Department of Fish and Game scientists to monitor known populations of the crab (Figure 5-7).

Site Characterization. The type of site characterization and physical habitat data collected was based on a modified version of the EMAP-West protocol and paralleled that used by the CVRWQCB staff in recent studies. Table 5-14 summarizes the site characterization data recorded at each monitoring site. All measurements were taken in accordance with the SWAMP accuracy, precision, recovery and completeness requirements outlined in Section 5.2.3.4 of the BMAP (Stillwater Sciences 2006a) (see also Appendix E of the SWAMP Standard Operating Procedures [http://www.swrcb.ca.gov/swamp/qamp.html#appendixe].

Table 5-14. Site characterization and physical habitat data collected during BMI monitoring.

Parameter	Method	Metric/Descriptor	Method Reporting Limit
Reach Scale			
Date/Start time/End time	N/A	Day/month/year	N/A
Location (UTM)	GPS unit	NAD 83	Northing

Parameter	Method	Metric/Descriptor	Method Reporting Limit
Epifaunal substrate	Visual estimation	Rank[1]	(0-20)
Embeddedness	Visual estimation	Rank[1]	(0-20)
Velocity/Depth regime	Visual estimation	Rank[1]	(0-20)
Sediment deposition	Visual estimation	Rank[1]	(0-20)
Channel flow status	Visual estimation	Rank[1]	(0-20)
Channel alteration	Visual estimation	Rank[1]	(0-20)
Frequency of riffles	Visual estimation	Rank[1]	(0-20)
Bank stability	Visual estimation	Rank[1]	(0-20)
Vegetative protection	Visual estimation	Rank[1]	(0-20)
Riparian zone width	Visual estimation	Rank[1]	(0-20)
Temperature[2]	*In situ* meter	°C	0.1 °C
Dissolved oxygen[2]	*In situ* meter	mg/L	0.0 mg/L
Specific conductivity[2]	*In situ* meter	Umhos/cm	1.0
pH[2]	*In situ* meter	s.u	0.1 s.u.
Gradient	Clinometer	Percent change	1%
Average Wetted width	Laser Rangefinder	meter	0.1 m
Length (horizontal	Laser Rangefinder	meter	0.1 m
Transect Scale			
Velocity[3]	Flow meter	meter/sec	0.1 ms^{-1}
Depth[3] (vertical distance)	Topset rod	meter	0.1 m
Canopy cover[3]	Spherical	Percent cover	5%
Woody debris density	Visual estimation	Percent of sample point and	5%
Embeddedness[4]	Visual estimation	Percent of sample point and	5%
Fines[4]	Visual estimation	Percent of sample point and	5%
Gravel[4]	Visual estimation	Percent of sample point and	5%
Cobble[4]	Visual estimation	Percent of sample point and	5%
Boulder[4]	Visual estimation	Percent of sample point and	5%
Bedrock[4]	Visual estimation	Percent of sample point and	5%

1 Site scale habitat condition categories are rated on a scale of 0-20 where optimal (16-20), suboptimal (11-15), marginal (6-10) and poor (0-5) for all parameters.
2 This parameter was taken in accordance with SWAMP requirements for accuracy, precision, recovery and completeness, as described in (http://www.swrcb.ca.gov/swamp/qamp.html#appendixe) and the BMAP (Stillwater Sciences 2006a).
5 Taken at the sample point (i.e., point along transect from which the sample is taken).
4 Taken at sample point and visually estimated along transect.

Photos and GPS readings were taken at the start and end of each reach. GPS readings are presented in Table 5-12 and photos will be presented in the final report. The average wetted width, average gradient, and total length (horizontal distance) were measured and calculated for each sample reach. Water quality parameters, including temperature, dissolved oxygen, specific conductance or conductivity, and pH were recorded at one transect along each sample reach using a YSI multiprobe.

Water quality parameters measured during BMI surveys were SWAMP-compatible (as detailed in Appendix E of the SWAMP Standard Operating Procedures [http://www.swrcb.ca.gov/swamp/qamp.html#appendixe]) and will be submitted for inclusion in the SWAMP database. A YSI multiprobe was used to measure in-situ water quality parameters, including water temperature, pH, conductivity, and dissolved oxygen (DO) (Table 5-14). Field calibration of the YSI multiprobe, based on elevation, was conducted daily. In addition, the YSI multiprobes were calibrated using standard Winkler methods before and after field work in an office setting. An example of the YSI 85 calibration data sheet is presented in Appendix E-5 of the BMAP (Stillwater Sciences 2006a). The multiprobe was placed in the stream slowly and carefully in order to prevent trapped air from affecting the readings. Once submerged the probe was moved around to dislodge bubbles and given at least 90 seconds to equilibrate before measurements were recorded.

Substrate composition and woody debris density was visually estimated along each transect in the sample reach. In addition, at the sample point along each transect, percent canopy cover was estimated using a spherical densiometer, velocity was measured with a flow meter, depth was recorded using a topset rod, and substrate was classified as fine (<0.06 mm), sand (>0.06–2 mm), gravel (>2–16 mm), coarse gravel (>16–64 mm), cobble (>64–250 mm), boulder (>250–4000 mm), or bedrock (>4000 mm).

Finally, physical habitat quality was assessed for each reach using the US EPA's Rapid Bioassessment Protocols (Barbour et al. 1999). The parameters assessed are summarized in Table 5-14 and the criteria for scoring these parameters are shown in Appendix E-6 of the BMAP (Stillwater Sciences 2006a). Ten habitat variables, such as available cover, embeddedness, channel flow status, and riparian and bank conditions were ranked on a scale of 0 to 20, for a total possible score of 200. For reference, habitat scores of 0 to 50 are considered "poor;" habitat scores of greater than 50 to 100 are considered "marginal;" habitat scores of greater than 100 to 150 are considered "suboptimal;" and scores of greater than 150 to 200 are considered "optimal"(Barbour et al. 1999). These habitat characterizations (i.e., poor, marginal, etc.) are based on the written criteria documented in Appendix E-6 of the BMAP (Stillwater Sciences 2006a). Optimal habitats contain a high diversity of habitats, low levels of embeddedness and sediment deposition, stable banks, and a well-developed riparian zone. Poor habitats are generally channelized and exhibit low habitat diversity, high sediment loads which fill channel bed interstitial spaces, high erosion rates, and narrow or non-existent riparian corridors.

Laboratory Methods. At the laboratory, each composite sample was rinsed in a standard No. 35 sieve (0.0196 in; 0.5 mm) and transferred to a tray with twenty, 4-in^2 (25-cm^2) grids. Samples were inspected for the New Zealand Mud Snail and Asiatic Clam and then subsampled using a stereomicroscope with magnifications of 10x to 20x.

Subsamples were transferred from randomly selected grids to Petri dishes where the BMI were removed indiscriminately and placed in vials containing 70% ethanol and 2% glycerol. In cases where BMI abundance exceeded 100 organisms per grid, half grids were delineated to assure that a minimum of three discreet areas within the tray of benthic material was subsampled. At least 500 BMIs were subsampled from a minimum of five grids, or five half grids. If there were more BMIs remaining in the last grid after 500 (± 5%) were archived, then the remaining BMIs were tallied and archived in a separate vial. This was done to assure a reasonably accurate estimate of BMI abundance based on the portion of benthos in the tray that was subsampled. These "extra" BMIs were not included in the taxonomic lists and metric calculations. Estimates of sample abundance were made by extrapolating the total number of organisms subsampled from a delineated area (grids) of the subsampling tray to the total area (total grids) occupied by benthos within the subsampling tray.

The debris from the processed grids was placed in a remnant jar and preserved in 70% ethanol for later quality control testing. Subsampled BMIs were identified using standard aquatic BMI identification keys (e.g., Kathman and Brinkhurst 1998, Merritt and Cummins 1996, Stewart and Stark 1993, Thorp and Covich 2001, Wiggins 1996) and other appropriate references. All organisms retained on a 0.5 mm screen were removed from the subsample and archived in labeled vials with a mixture of 70% ethanol and 2% glycerol. Identification of BMIs was accomplished with the aid of Zeiss Stemi-2000C stereomicroscopes with Dolan Jenner fiber optic light sources. Identifications were made using anywhere from 6.5x to 100x, or more when necessary. In some cases BMI parts were slide mounted and examined under a compound microscope using 100x or 200x magnification. A standard level one taxonomic effort was used as specified in the California Aquatic Macroinvertebrate Laboratory Network (CAMLnet) short list of taxonomic effort, January 2003 revision. Exceptions were made for early instar/ young organisms and organisms in poor condition; in these cases, organisms were identified to the lowest taxonomic resolution possible.

The subsampling procedure was supplemented to accommodate an estimate of BMI biovolume. Biovolume measurements were made by calculating the volume of liquid displaced by the subsampled BMIs from each sample prior to sorting by taxon. Initially, ethanol-preserved BMIs were transferred to water prior to volumetric displacement. However, due to excessive organism degradation, subsampled BMIs were instead transferred to a 35% ethanol solution prior to volumetric displacement measurements. Surface liquid was removed from the BMIs using blotting paper after the BMIs were transferred to a 5.0 ml graduated cylinder. The blotting paper was rolled into a cylinder of suitable diameter to facilitate insertion into the graduated cylinder to the level of the BMIs. The graduated cylinder was then inverted to facilitate the wicking effect of the blotting paper. The endpoint of removing surface liquid from the BMIs occurred when the wicking action of the blotting paper ceased. A 35% ethanol solution was dispensed from a 10 ml capacity burette to the graduated cylinder to the 5.0 ml mark. The volume of organisms was determined by subtracting the volume of liquid/organism mixture contained in the graduated cylinder (5.0 ml) from the volume of liquid dispensed from the burette. For example, if 3.2 ml of ethanol solution were dispensed from the burette to fill the 5.0 ml graduated cylinder, then the volume of the BMIs was 5.0-3.2=1.8 ml. After biovolume measurements, the BMIs were preserved in an 80% ethanol, 18% water and 2% glycerol solution.

The use of this procedure for estimating biovolume was conducted to supplement the estimated BMI abundance values. Biovolume may serve as a reproducible, non-destructive surrogate for the more costly and destructive measurements of biomass derived from dry weight. Additional testing to evaluate precision of the biovolume procedure is in progress.

As measure of quality control and assurance, ten percent of the processed composite samples will be randomly selected by the taxonomist, using standard randomization procedures, and submitted to CDFG for independent verification of the identification and number of BMI. In addition, 10 percent of the remnant samples will be examined for organisms that may have been overlooked during subsampling. If more than 5 percent of the remnant samples evaluated contain more than 10 percent of the total organisms originally subsampled, then corrective action will be implemented. Corrective action is an investigation of the source of the problem and a recalculation of metrics if deemed necessary. Corrective action will include special considerations for samples that contain a combination of dense algae and easily fragmented annelid worms.

Analytical Methods. To assess data generated during the first year of sampling, we focused on processing BMI data by tabulating a suite of metric values and documenting taxonomic composition for each site. In addition, spatial patterns of sites were plotted as a function of BMI metrics , taxonomic composition, and physical habitat assessments. A more focused evaluation of BMI assemblage response to physical habitat variables including the evaluation of hypotheses described in section 1.1.1.2 will be done after the second year of data is compiled.

For evaluating site variation as a function of BMI metrics, a composite metric score (based on multiple biological metrics) was formulated for each monitoring site. The metrics used for the scores were EPT Taxa, Coleoptera Taxa, Percent Collector-Filterer plus Collector-Gatherer Individuals, Percent Non-Gastropoda Scrapers, and Percent Tolerant Taxa (Table 5-15). These metrics were screened from 77 metrics to evaluate metric responses in streams with hydropower projects in the Sierra Nevada region of California and were found to measure distinct attributes of BMI assemblages with high signal-to-noise ratios while minimizing redundancy with other metrics (Rehn etal. *in review*). Several of these metrics were also found to be reliable responders to disturbance by Karr and Chu (1999). Karr and Chu identified human activities contributing to disturbance of aquatic ecosystems, which include land use, effluent discharge, water withdrawal, discharge from reservoirs, sport and commercial fisheries and introduction of alien species. These factors subsequently influence flow regime, physical habitat structure, water quality, energy source and biological interactions.

The composite metric score approach to evaluating BMI metric-based data is to normalize and sum the differences between sample metric values and the grand mean of the metric values for the five metrics (see formula below), then compare the resulting score between the various sampling sites. The output of the composite metric score analysis is shown as a plot, which is composed of four parts: 1) sites are shown on the x-axis; 2) the normalized composite metric score values are shown on the y-axis where their vertical position on the plot corresponds to their composite metric score; 3) geometric symbols are used to differentiate multihabitat composite (MHC) samples and targeted riffles composite (TRC) samples; and 4) a dashed, horizontal line crossing through "0" on the y-axis represents the grand mean of the normalized scores. For reference, if there was no variation in composite metric scores for a group of sites, then the composite metric score plot would show points (sites) plotted on the normalized mean line (site metric values identical to the grand mean metric value). As inter-site variation in composite metric scores increase, sites will score above and below the mean line, potentially revealing patterns in the distribution of sites.

The formula for computing the composite metric scores is as follows:

$$\text{Composite Metric Score} = \sum \pm(\mathbf{x}_i - x_i)/sem_i$$

Where:

$\mathbf{x}_i$ = sample value for the i-th metric within a group of sites
x_i = grand mean of the samples within a group sites for the i-th metric
sem_i = standard error of the mean for the i-th metric
± = a plus sign denotes a metric that decreases with response to impairment (e.g., EPT Taxa) while a minus sign denotes a metric that increases with response to impairment (e.g., Percent Tolerant Taxa).

Table 5-15. Metrics used to describe BMI assemblages.

Metric [1]	Description	Response to Disturbance
1. Taxonomic Richness	Total number of distinct taxa identified to a consistent taxonomic level.	Decrease
2. # of EPT Taxa[2]	Number of taxa in the orders Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly).	Decrease
3. # of Coleoptera Taxa[2]	Number of taxa within the order Coleoptera (beetle).	Decrease

Metric [1]	Description	Response to Disturbance
4. Shannon Diversity Index	General measure of sample diversity that incorporates richness and evenness.	Decrease
5. % CF+CG Individuals[2]	Percentage of BMIs within the collector-filterer and collector-gatherer functional feeding groups.	Increase
6. % Non-Gastropoda Scrapers[2]	Percentage of BMIs within the scraper functional feeding group excluding gastropod scrapers.	Decrease
7. % Tolerant Taxa[2]	Percentage of taxa that are highly tolerant to water and/or habitat quality impairment as indicated by CTVs of 8, 9 or 10.	Increase
8. Estimated Abundance (#/m^2)	Estimate of the number of BMIs in a sample based on the proportion of BMIs subsampled and expressed as number of BMIs per square meter of benthos sampled.	Variable
9. Estimated Biovolume (ml/m^2)	Volume of BMIs in a subsample and estimated to whole sample by extrapolation (as described above); expressed as mls of BMIs per square meter of benthos sampled.	Variable

[1] CAMLnet, January 2003 revision used as source for functional feeding group designations and California Tolerance Values (CTVs).

[2] Metrics used for composite metric scores.

Non-metric multidimensional scaling (NMS) ordination was used to evaluate spatial patterns of the sites based on taxonomic composition using ecological subregion (Figure 5-4) as a grouping variable. The ordination was restricted to multihabitat composite samples. PC-ORD version 4 software (McCune and Mefford 1999) was used to perform NMS including the generation of an ordination plot. Ordination plots are useful for exploring relationships between environmental variables, BMI metrics and taxonomic composition and its use will be further evaluated for application to the complete data set after the second year of the study.

A third preliminary analysis was done for evaluating differences in BMI abundance (#/m^2) and biovolume (ml/m^2) between multihabitat and targeted riffle composite samples at sites where both types of samples were collected. The non-parametric Wilcoxon paired-sample test was used to evaluate significant differences instead of the parametric paired-sample t-test because the differences in sample pair values for both abundance and biovolume did not meet assumptions of normality. The Wilcoxon paired-sample test has 95% of the statistical power as the paired-sample t-test (Zar 1984).

5.2.4 Avian Study

The Merced River Alliance avian surveys have been designed to complement information available from current and ongoing studies (Section 6) and to ensure compatibility with ongoing data collection efforts to the maximum extent possible. This approach is intended to provide further information regarding landbird species currently established in the riparian corridor of the Merced River. Because birds respond to changes in the environment over multiple spatial scales (Temple and Weins 1989), they are ideal study organisms for monitoring and evaluating ecosystem restoration and management (Carignan and Villard 2002). It is anticipated that species composition relative to habitat types and use patterns will positively influence the nature of future restoration activities and inform riparian re-vegetation options throughout the Merced River riparian corridor.

While all species are recorded during Merced River Alliance avian monitoring activities, the standard methods presented here under-represent some species such as nocturnal birds or raptors. Although included among the species of concern found in the Merced River watershed (Appendix C, Table C-1 of the BMAP [Stillwater Sciences 2006a]), nocturnal birds and raptors can not be adequately surveyed for abundance or density without special surveys or nest searches, which are beyond the scope of this study plan. Descriptive statistics are reported for these species if they are observed, however discussion of trends or analysis of inter-site differences is not possible.

5.2.4.1 Objectives

The objectives of the baseline avian monitoring are to: 1) document avian community species composition (native and non-native) and relative abundance in the Merced River riparian corridor during the breeding season (as the primary focus) and during the fall migration and winter season (as the secondary focus); 2) evaluate the influence of riparian vegetation patch size, composition, and structure on the species composition and distribution of bird species nesting in the corridor; 3) provide baseline data that can be integrated with ongoing surveys being conducted on the San Joaquin, Tuolumne, and Sacramento rivers, and; 4) address specific avian hypotheses, as detailed in the next section. The relationship between bird species presence and vegetation characteristics is also investigated.

5.2.4.2 Hypotheses

The proposed avian hypotheses focus on the relationship between habitat variables and avian species diversity and relative abundance. Hypotheses developed for avian species incorporate ideas detailed in the Riparian Habitat Joint Venture (2000), Siegel and DeSante (2003), and Heath and Ballard (2003). As detailed in Section 4, addressing the following hypotheses is a secondary goal of the Merced River Alliance biological assessment monitoring, with collection of contemporary baseline data for fish, avian, and BMI species as the primary goal. Avian hypotheses will be addressed in the final report, following the second year of Merced Alliance biological data collection.

1. Adjacent land use characteristics (e.g., agriculture, industrial mining, urban development, managed forest) along the upper and lower segments of the Merced River are relatively less important to songbird species occurrence than species-specific vegetation composition (e.g., tree species richness, understory layer) of the local riparian patch.

2. In the lower segment of the Merced River corridor, overall bird species diversity and relative abundance will be greater in habitats possessing well-developed shrub and herbaceous understory vegetation (e.g., blackberry, mugwort) than in those having a simple overstory canopy structure (e.g., cottonwood, valley oak) without an understory layer.

3. In the upper portion of the Merced River watershed, bird species diversity and relative abundance will be greater in riparian habitats located within a matrix of Montane Chaparral habitats that have recently experienced fire (within 1–2 years).

4. In the upper river segment, diversity of obligate riparian species will be positively related to riparian zone width and the percentage of riparian vegetation (versus upland vegetation) within a site.

5.2.4.3 Methods

The avian sampling design is summarized in Table 5-16 and described in more detail in the remainder of this section. Standardized methodologies for monitoring landbirds (Nur et al. 1999) are used to assess avian community species composition, distribution, and potentially demographics in the Merced River watershed. Point counts are used to estimate avian community species abundance and composition during the breeding season, while area searches (a modified point count method) are used during migration and over-wintering periods. Site reconnaissance during 2006 indicated that mist netting will not be the most cost effective tool for assessing avian demographics in the Merced River watershed. While site dimensions and canopy structure at several sites were identified as adequate to accommodate proper deployment and alignment of the recommended 8-12 mist nets (Ralph et al. 1993), observed avian density will not likely support the necessary capture rate of approximately two birds per net per day. Instead, spring point count survey information will be used to indicate breeding status (species recorded as signing during all three visits, and observations of nests and nesting behavior including food and/or material carry, territorial display, dependent fledglings), and survey efforts during the fall and winter area searches have been increased three to four times beyond that described in the monitoring plan (Stillwater Sciences 2006a). Avian habitat characteristics are assessed using relevé plots, or circular plots centered on an established census point.

While the avian point count surveys were designed to be conducted throughout the Merced River watershed a minimum of three (3) times during each breeding season for 2006 and 2007 (Stillwater Sciences 2006a), heavy rains, high river flows, and flooding of survey areas caused the 2006 breeding season surveys to begin several weeks later than originally anticipated. For this reason, each spring 2006 site was visited twice, with the exception of three sites along the upper river segment (YV-A3, UGB-A1, UGB-A2) which were visited only once (Table 5-16, Figure 5-8). Monitoring sites UF2-A1 and LB-A1 were not visited at all during spring 2006 due to the weather delays, however these sites were visited during fall area searches and will be sampled during the 2007 breeding season.

Area searches were designed to be conducted in the upper portion of the watershed once during the fall (September–October) and once in the lower portion of the watershed during the winter (November–January) (Stillwater Sciences 2006a), however since mist netting will not be included during 2007 surveys, the frequency of visits to the fall and winter area search locations was increased to four visits during the fall and three visits during the winter (Table 5-16). Monitoring sites UF3-A1 and UF2-A1 were surveyed only three times during fall 2006.

Avian survey sites were chosen throughout the watershed using the following criteria:

1. To encompass a variety of habitat conditions and adjacent land uses;
2. To be accessible; and
3. To take advantage of existing avian species data where possible.

The majority of land in the lower Merced River corridor is privately owned (Stillwater Sciences 2002), and property access permission is not often granted when special-status species may be involved. For this reason, publicly-owned sites were chosen for sampling in the lower Merced River corridor whenever possible (Table 5-16). Privately owned sites were included as well, with their ultimate availability for sampling dependent on landowner access agreements. The upper portion of the watershed is predominantly managed by US Forest Service and National Park Service land (Figure 3-1), agencies which have formal application procedures for scientific collector permits.

Table 5-16. Summary of avian sampling design and monitoring site selection.

Avian Monitoring Site ID	Approx. RM	UTM[1]		Sampling Period[2]						Land Ownership/Administration
		Northing	Easting	May/June 2006	Fall 2006	Winter 2006	May/June 2007	Fall 2007	Winter 2007	
Lower River										
CON-A1[3]	2	4136235	680610	**X X**	**XXXX**	**X**XX	X X X	XXXX	XXX	Hatfield State Park
CON-A2	3.5	4136285	680903	**X X**			X X X			Private
ENC-A1[3]	12	4137580	690469	**X X**			X X X			Hagaman County Park
ENC-A2	13-17	4140057	694344	**X X**			X X X			Private
ENC-A3[3]	23.5	4143311	702591	**X X**	**XXXX**	**X**XX	X X X	XXXX	XXX	McConnell State Park
GM2-A1	27	4144817	706114	**X X**			X X X			Private
GM1-A1	37	4149958[4]	715157[4]	**X X**			X X X			Private
GM1-A2	45	4153225	724663	**X X**	**XXXX**	**X**XX	X X X	XXXX	XXX	Private
DTR-A1[3]	48	4155712	728425	**X X**	**XXXX**	**X**XX	X X X	XXXX	XXX	Henderson County Park
DTR-A2[3]	51	4154976	730689	**X X**	**XXXX**	**X**XX	X X X	XXXX	XXX	CDFG (Merced River Ranch)
MFR-A1	51.5	4155239	732588	**X X**			X X X			MeID
MFR-A2	53.5	4155779	735260	**X X**			X X X			Private
Upper River										
UF3-A1	90.5	4164894	765028	**X X**	**XXX**		X X X	XXXX		BLM
UF2-A1[5]	96.5	4172473	771940		**XXX**		X X X	XXXX		BLM
UF1-A1	102.5	4172708	777144	**X X**	**XXXX**		X X X	XXXX		SNF
LB-A1[5]	108.8	4174136	782070		**XXXX**		X X X	XXXX		SNF
LB-A2	114.5	4179484	789296	**X X**			X X X			SNF
LB-A3	117.5	4179749	794549	**X X**	**XXXX**		X X X	XXXX		YNP
YV-A1	120.5	4181523	798710	**X X**	**XXXX**		X X X	XXXX		YNP (Yosemite Valley)
YV-A3	124.5	4182669	801960	**X**	**XXXX**		X X X	XXXX		YNP (Yosemite Valley)
UGB-A1	130.5	4181946	807628	**X**	**XXXX**		X X X	XXXX		YNP (Little Yosemite Valley)
UGB-A2[5]	134	4183146	813937	**X**			X X X			YNP (Echo Valley)

1 UTM, Easting/Northing, taken in NAD 83.
2 "X" indicates the number of visits per monitoring site during the specified sampling period. Bold font indicates the sampling visit has already occurred.
3 These sites have pre-existing avian data from earlier PRBO surveys.
4 Due to the large size of the sample site, two GPS measurements at different locations within the site and averaged.
5 Sites not sampled during 2006 breeding season due to weather delays. These sites will be sampled during 2007 breeding season.

Multiple parameters were measured in order to meet the objectives for the avian study (Table 5-17). Photos and GPS locations were taken of each site.

Table 5-17. Parameters measured during avian monitoring.

Parameter	Method	Metric/Descriptor	Method Reporting Limit
Community Composition and Distribution			
Species identification	Visual and/or audio (song) identification	Species name	N/A
Distance to individual	Visual estimation	Meter	5 m
Age of individual[1]	Visual estimation	Years	0.5 year
Sex of individual[1]	Visual inspection	Male or female	N/A
Number of individuals	Visual estimation	Number	1
Longitudinal avian assemblage	Location in the watershed	River mile (RM)	N/A
Habitat Assessment: Relevé plot characteristics			
Date/time	N/A	Day/month/year	N/A
USGS 7 ½ minute quad sheet	N/A	N/A	N/A
Latitude/Longitude	GPS	Degree, minute	N/A
Two most dominant habitat types	Visual estimation	% cover and descriptive code	N/A
Average aspect	Visual estimation[2]	Degrees (magnetic or true)	1
Average slope	Visual estimation[2]	0 = horizontal, 90 = vertical	N/A
Standing and running water	Visual identification	Presence/absence	N/A
Snags with dbh[3] >10 cm	Visual estimation	Total number	1
Snags with dbh[3] <10 cm	Visual estimation	Total number	1
Logs with diameter >10 cm	Visual identification	Total number	1
Adjacent land use and habitat	Visual identification	General description	N/A
Habitat Assessment: Vegetative layer characteristics			
Tree layer: vegetation layer between 5 m and highest tree height	Visual estimation & circumference measurement	% cover of layer, % cover of each species, minimum and maximum dbh	0.1 cm
Shrub layer: woody and non-woody plants within 0.5 to <5 m in height	Visual estimation & circumference measurement	% cover of layer, % cover of each species, minimum and maximum dbh	0.1 cm
Herb layer: small shrubs and other woody and non-woody plants within 0 to <0.5 m	Visual estimation	% cover of layer, % cover of each species,	N/A

Parameter	Method	Metric/Descriptor	Method Reporting Limit
Total woody layer: all woody vegetation combined across height categories	Visual estimation	% cover of layer, dominant species	N/A
Potentially identified sublayers (within tree or shrub layer)	Visual estimation & vertical distance	Average height of upper and lower bounds of vegetation, % cover, dominant species	0.1 m

[1] For mist netting only.

[2] High-resolution DEM is not available for the majority of the Merced River riparian corridor, however where available, it will be used to validate visual estimations.

[3] dbh is the diameter at breast height.

Field Methods. Detailed quality assurance and quality control (QA/QC) measures for the Merced River Alliance biological monitoring are discussed in the BMAP (Stillwater Sciences 2006a). For avian monitoring, PRBO biologists recorded all field survey information on datasheets, which were entered into a database immediately following each monitoring visit. PRBO biologists followed data entry and QA/QC procedures outlined in the Palomarin Handbook (PRBO 2004, also available in Appendix C-2 of the BMAP [Stillwater Sciences 2006a]). Specific monitoring methods are described below.

Point Counts. The point count is a census method used to generate information on the yearly changes of bird populations at fixed points, differences in species composition between habitat types, and abundance patterns of species. It is an efficient and data-rich method for bird surveys (Ralph et al. 1993) and as such has been adopted for use by U.S. Fish and Wildlife Service as the standardized approach for monitoring landbirds (Nur et al. 1999). Point counts involve an observer standing in one spot and recording all birds seen or heard at either a fixed distance or an unlimited distance. Counting may be repeated many times at a given point.

In 2006, a minimum of three and a maximum of 14 point count locations were established at each avian monitoring site (Appendix J, Table J-1, Figure 5-8). Each sampling station was separated by at least 200 m (656 ft) to avoid point count overlap and census bias, and to allow for >99% detection of individuals (Ralph et al.1993). Each point was surveyed by trained PRBO staff biologists with experience in the identification of Western U.S. bird species by sight, song, and calls. Point locations were surveyed on 1 or 2 mornings, at least 10 days apart (See Appendix J, Table J-2 for survey dates for each monitoring site). In 2006, a total of 173 points were established at 20 total monitoring sites.

At each sampling station, the Variable Circular Plot (VCP) method (Figure 5-9a) was used to delineate a 360° plot, with the observer at the center or "point." Within the VCP, the distance to each detection (variable) was recorded within 10 m (33 ft) of the observer, from 10 to 20 m (33-66 ft), from 20 to 30 m (66-98 ft), from 30 to 40 m (98-131 ft), from 40 to 50 m (131-164 ft), from 50 to 75 m (165 – 248 ft), and from 75 to 100 m (248 – 330 ft). Detections beyond 100 m (330 ft) were specified. The distance recorded is the distance from the point to the first location an individual is observed, measured to the point at which a plumb line would hit the ground if hung from the location at which the bird was observed. This distance was measured as though a tape were laid across the ground, including any intervening topographic features. Birds that were flying over but not using the habitat at the site were recorded as "fly-overs." Birds observed foraging aerially over the plot were counted (e.g., foraging raptors and swallows).

Point counts lasted five minutes per sampling station. Surveys were conducted from local sunrise until no later than 4 hours past sunrise during peak singing hours. Behavioral cues which alerted the observer to the individual bird were recorded, as well as indications of breeding status. Every effort to avoid double counting individuals was made. Juvenile birds were recorded as such, and were excluded from analyses. No attracting devices or recordings were used. Point counts were not conducted during poor weather conditions, such as high winds or rain, when probability of detection was reduced.

Area Searches. The area search method consists of a series of three 20-minute point counts in which the observer moves through a somewhat restricted area. With this method, unfamiliar calls can be tracked down and quiet birds can be found. As shown in Figure 5-9b, the sampling sites were delineated to provide three separate search areas (or plots), each approximately 0.03 km^2 (7.4 acres) in forest or dense woodland, and 0.1 km^2 (27.7 acres) or greater in more open habitats (Ralph et al. 1993).

During the 2006 fall migration, 13 area search sites were surveyed between August 15 and October 31. Area searches were carried out no later than four hours after dawn. Periodically, the search areas were sampled in the reverse direction to avoid bias due to temporal changes in bird activity levels. Numbers of birds of each species seen, heard, or both seen and heard in the search area were recorded during the 20-minute search period. When observed, birds outside the search area were recorded separately.

Avian Habitat Assessment Using Relevé Plots. Relevé plots are used to provide information on vegetation, association, and major structural characteristics that have a logical relationship with bird requirements for feeding and nesting (Ralph et al. 1993). As shown in the Appendix E of the BMAP (Stillwater Sciences 2006a) example data sheet, plant species were documented during relevé plot sampling. The relevé plots possessed a 50 meter (164 feet) radius, and were centered on a VCP. Relevé plot sampling was conducted following morning point counts and occurred during the May through June survey period. Vegetation relevé plots are generally conducted once every three years in stable habitats (Julian Wood, PRBO pers. comm. 2005). Therefore, the relevés were conducted during the 2006 survey and will only be repeated in 2007 if the habitat appears to have undergone significant change. Relevé data will be presented in the final report.

Analytical Methods. Point count and area search data were analyzed to characterize species distribution, develop avian species abundance, richness, and diversity indices. Results of testing for correlation with vegetation data will be included in the final report. The index values were calculated by a PRBO statistician familiar with the analysis methodology. The abundance index is presented as the mean number of detections within the 50 meter (164 ft) radius of the VCP. For the final report, if there are sufficient detections for model building, distance sampling methods will be used to estimate the probability of detection for common species beyond the 50 meter (164 ft) radius (Buckland et al. 2001, Thompson 2002, and Rosenstock et al. 2002). For these species, the abundance index will be presented beyond 50 meters (164 ft).

Species richness is defined as the number of species detected within 50 meters (164 ft). The richness index will also include detections beyond 50 meters (164 ft), if sufficient detections are made to satisfy the assumptions of the model.

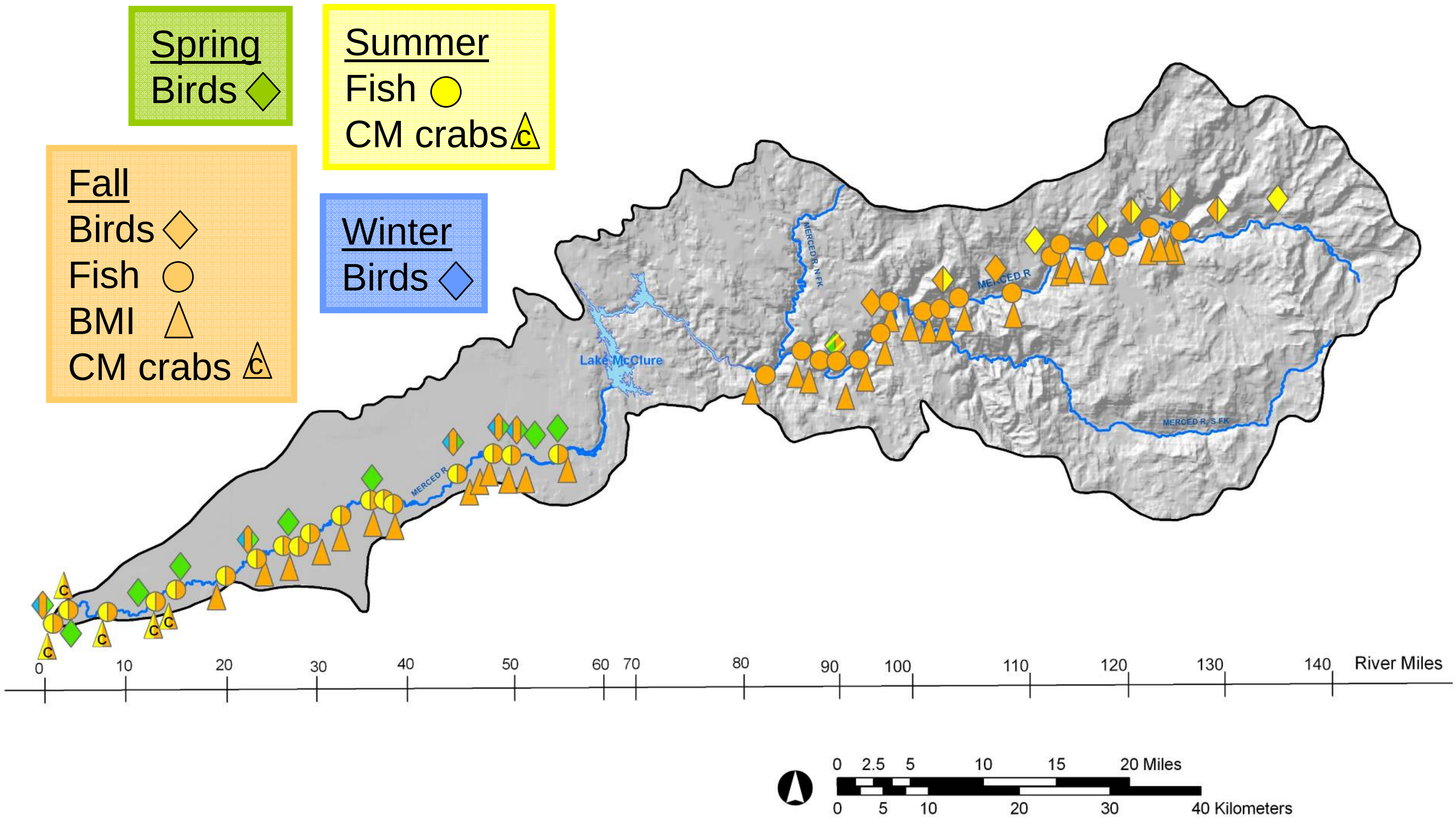
Species diversity measures ecological diversity based on the number of species detected within the 50 meter (164 ft) VCP radius, weighted by the number of individuals of each species. A high score indicates high ecological (species) diversity. Species diversity is measured using a transformation of the usual Shannon-Weiner index, which is symbolized by H' (also called Shannon-Weaver index or Shannon index; Krebs 1989). This transformed index, which was introduced by MacArthur (1965) is N_1 where $N_1 = 2^{H'}$. The advantage of N_1 over H' is that N_1 is measured in terms of species, whereas H' is measured in terms of bits of information (Nur et al. 1999). Thus, N_1 is more easily interpreted, and species diversity (measured as N_1) and richness can be compared. Where S = total species richness and p_i is the proportion of the total number of individuals for the *i*th species:

$$N_1 = e^{H'} \text{ and } H' = \sum_{i=1}^{i=S} (p_i)(\ln p_i)(-1)$$

For the final report, point count abundance data will be used with selected bird species to explore what, if any, habitat characteristics or other physical parameters are good predictors of avian abundance and diversity. Habitat variables will include major cover types (e.g., percent cover of trees, shrubs, annual grasses and other groups), and pair wise correlations will be used as a preliminary tool to identify additional significant variables which can be investigated in later analyses. For some species, a priori vegetation characteristics will be chosen and entered into a stepwise regression to control for the effect of each variable.

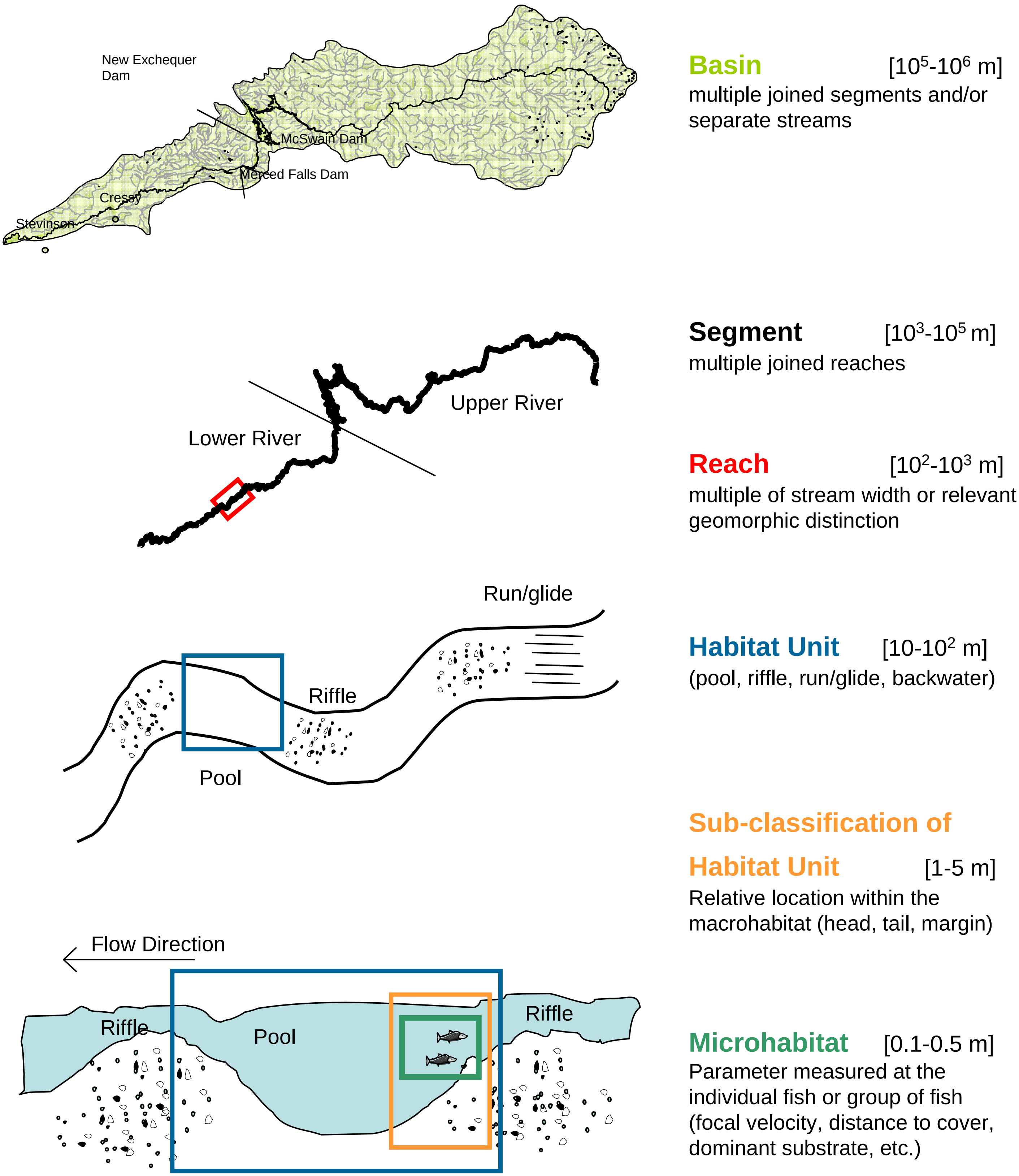
In addition to the consideration of raptor species within the larger avian dataset, raptors were analyzed as a separate group. The analysis included flyovers, which, as discussed above, are not typically included in a statistical analysis of the data. A raptor summary table is presented, detailing all species observed during point counts and the location of observation. For the final report, a map of coordinates for all raptor nests located during point counts and area searches within the study sites will be provided.

Where appropriate, PRBO will compare 2006 and 2007 data with previous bird monitoring conducted by PRBO in the lower Merced River in 1999 and 2004 (PRBO 2004, Stillwater Sciences 2006b). These results will be included in the final report. Stillwater Sciences' will assist with any additional analyses as needed.



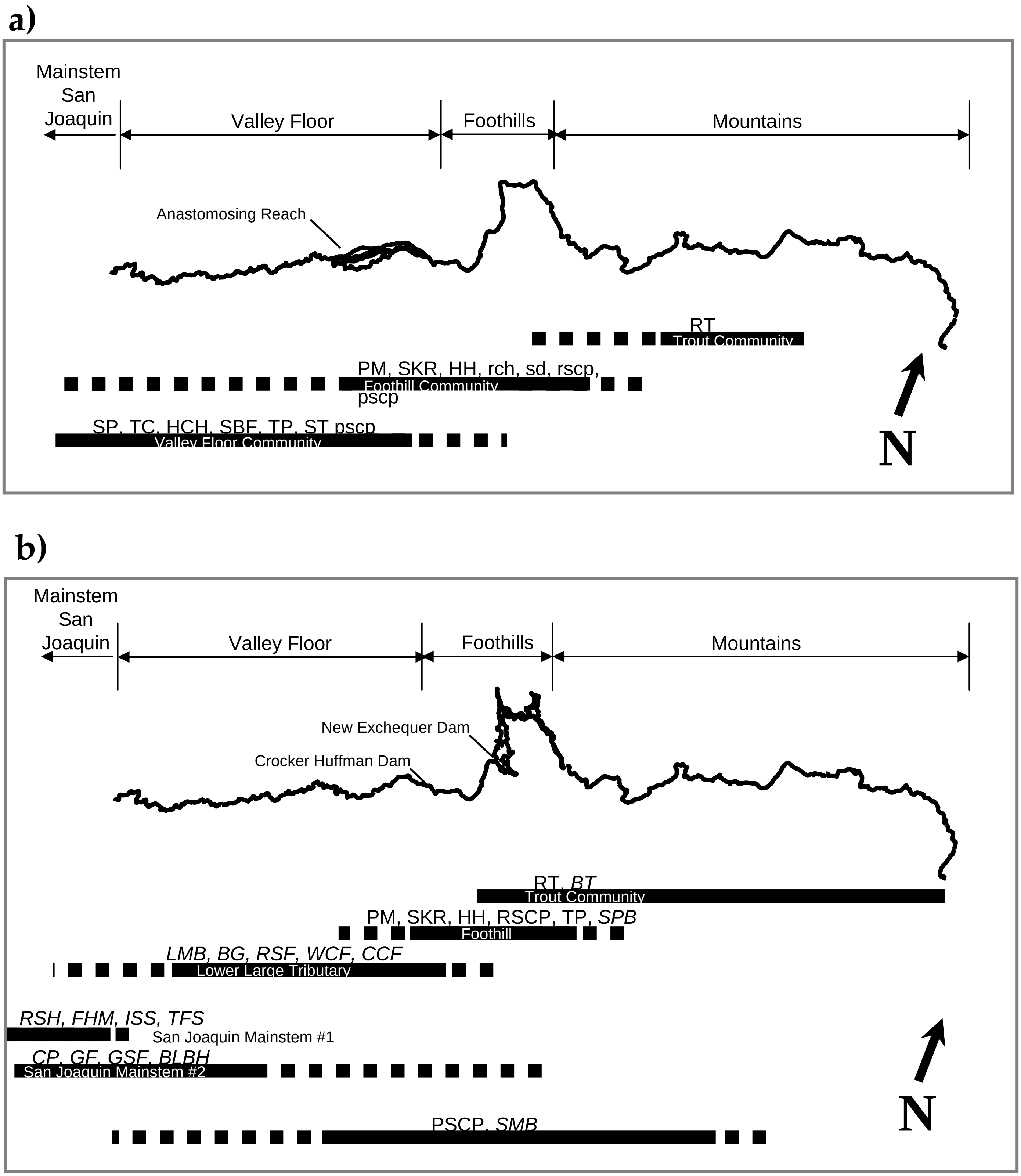
Stillwater Sciences

Figure 5-1. Biological assessment monitoring sites on the Merced River (includes all resources) during 2006. Two or more colors for a given symbol indicate monitoring site was visited during multiple seasons.



Stillwater Sciences

Figure 5-2. Aquatic habitat mapping scales applied to the Merced Alliance biological monitoring and assessment. Habitat scales follow Fausch et al. (2002) for basin, segment, reach, and habitat unit. Remote aquatic habitat mapping took place at the scale of the habitat unit. Sub-classifications of habitat units and microhabitat parameters were included during seasonal fish monitoring events and were species-specific e.g., for juvenile salmonids.



Stillwater Sciences

Figure 5-3. Conceptual model of Merced River resident fish distribution. Adapted from Brown et al. (2003). **a) Natural conditions. b) Current conditions.** Solid bars indicate areas dominated by the community. Dashed bars indicate where component species may be present in lower abundance. Italics indicate an introduced species. Lower case indicates species associated with, but not consistently part of, the natural communities. See Table B-4 (Stillwater Sciences 2006a) for species abbreviation key.

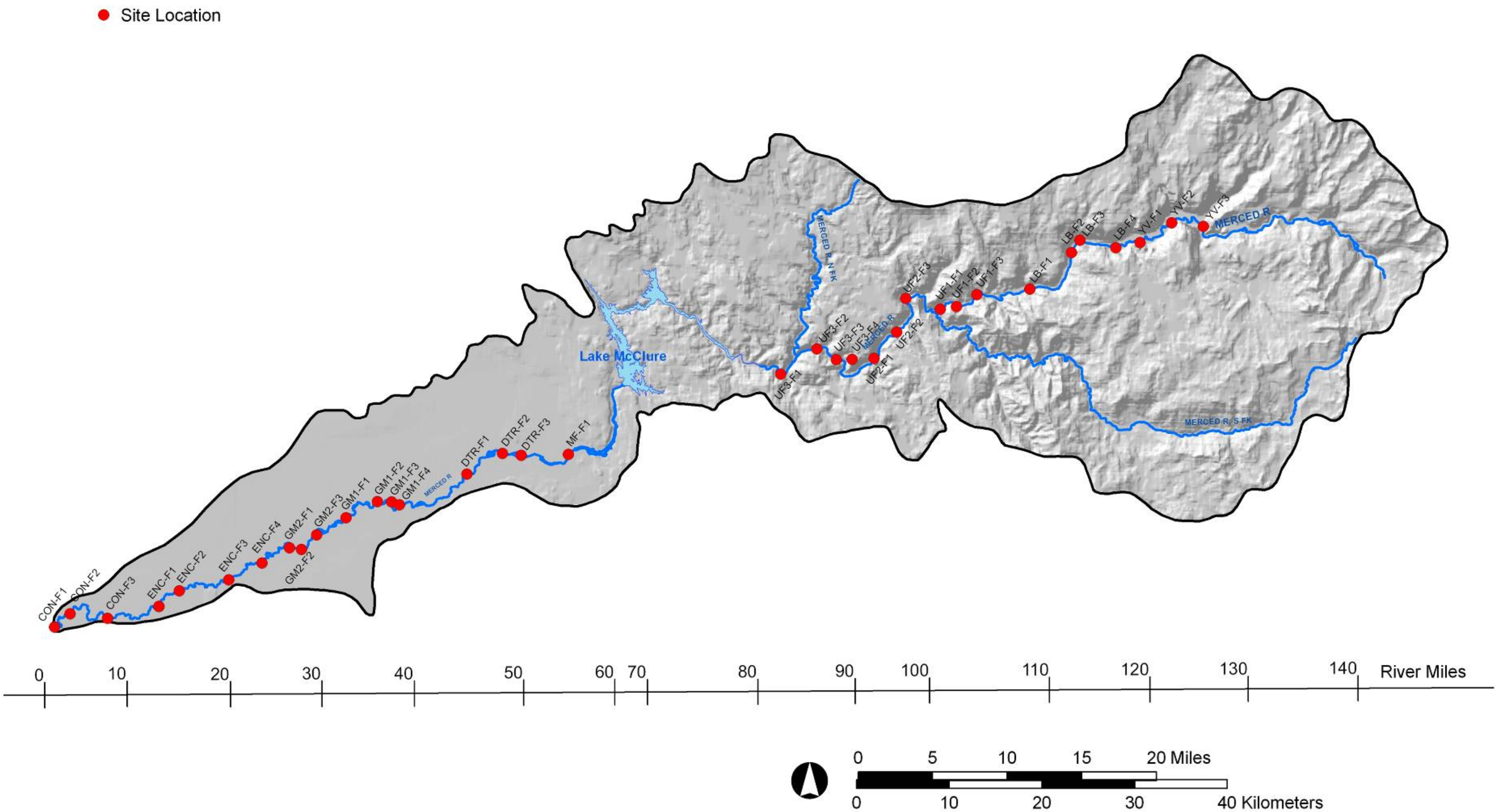


Figure 5-4. Fish monitoring sites along the Merced River during 2006.

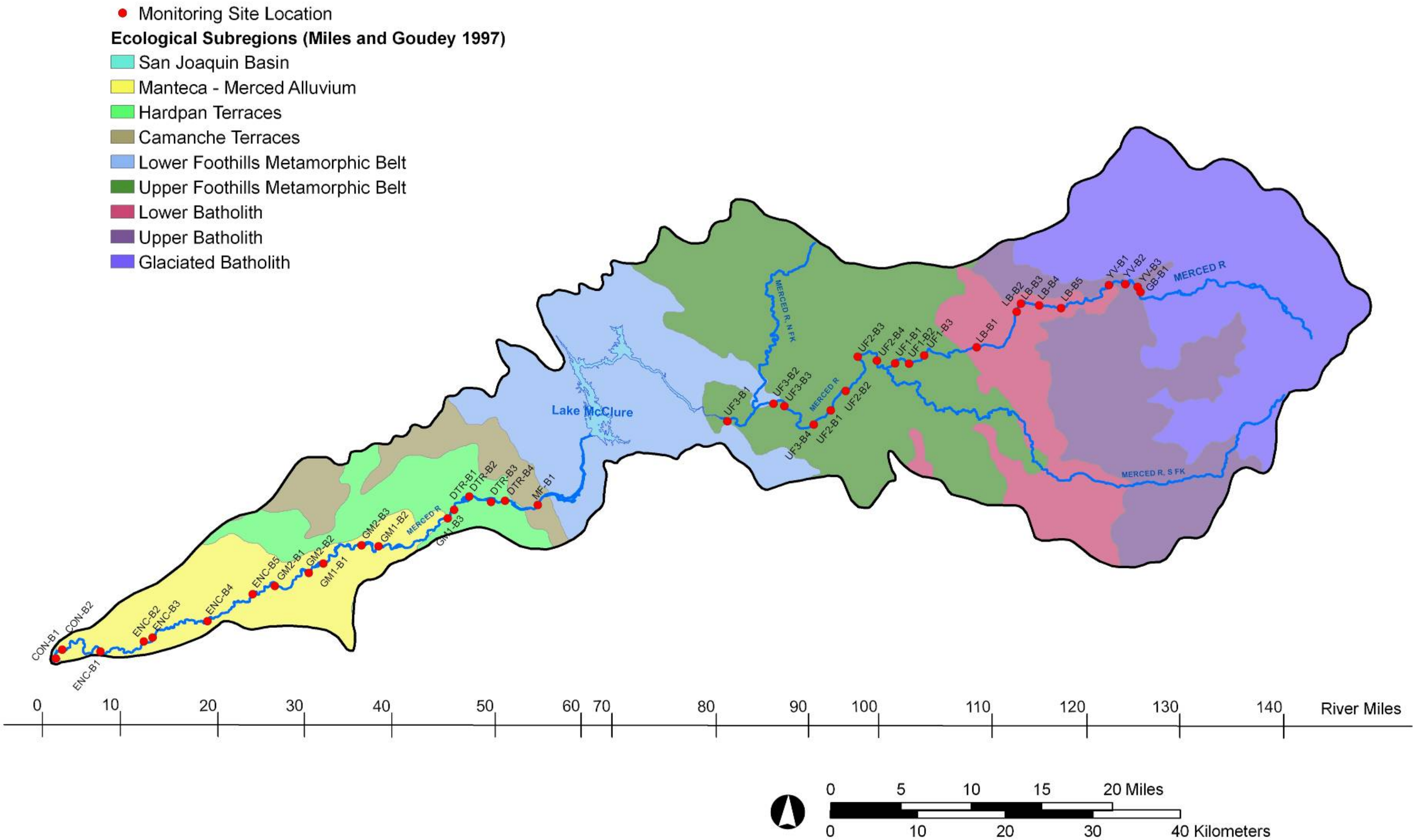
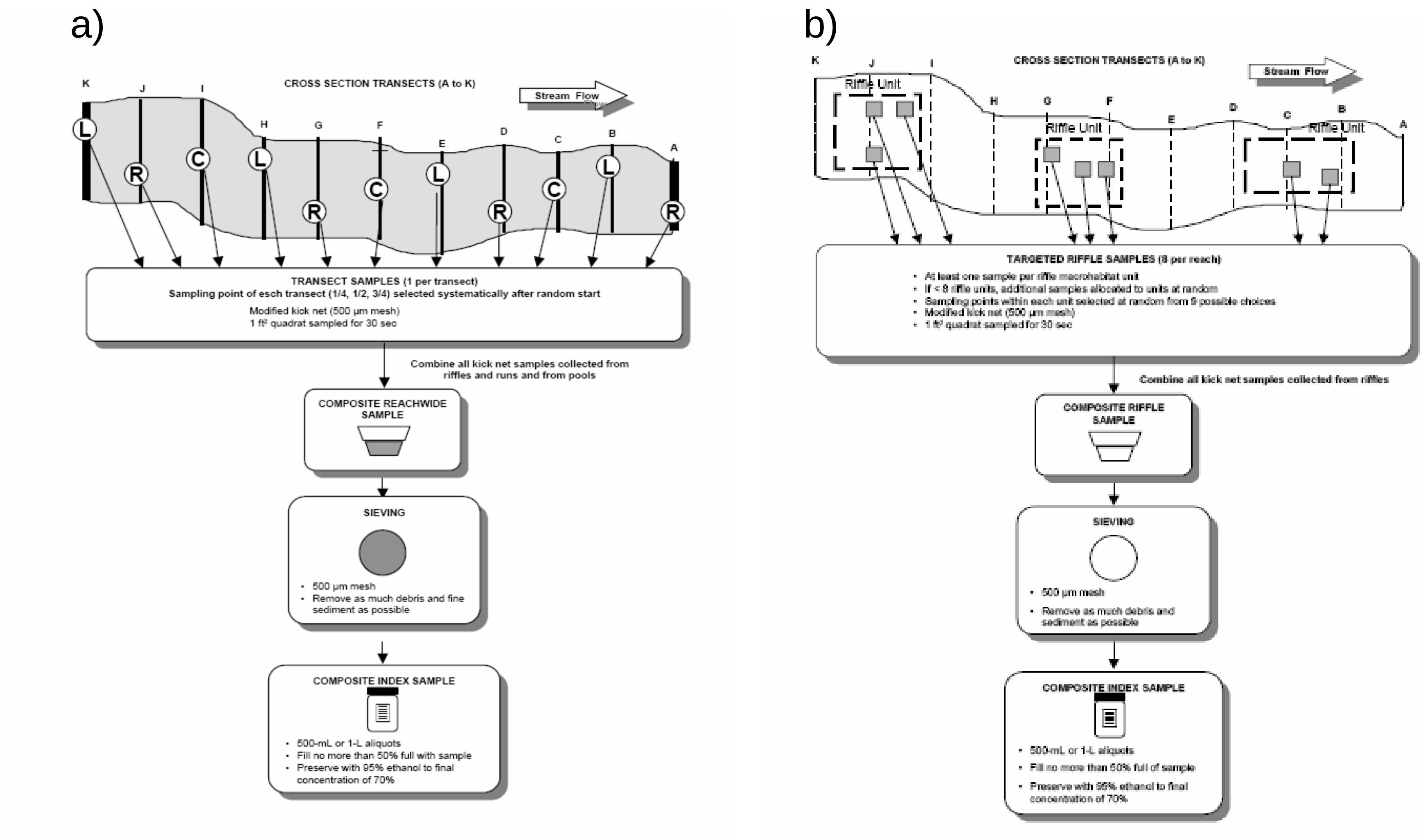


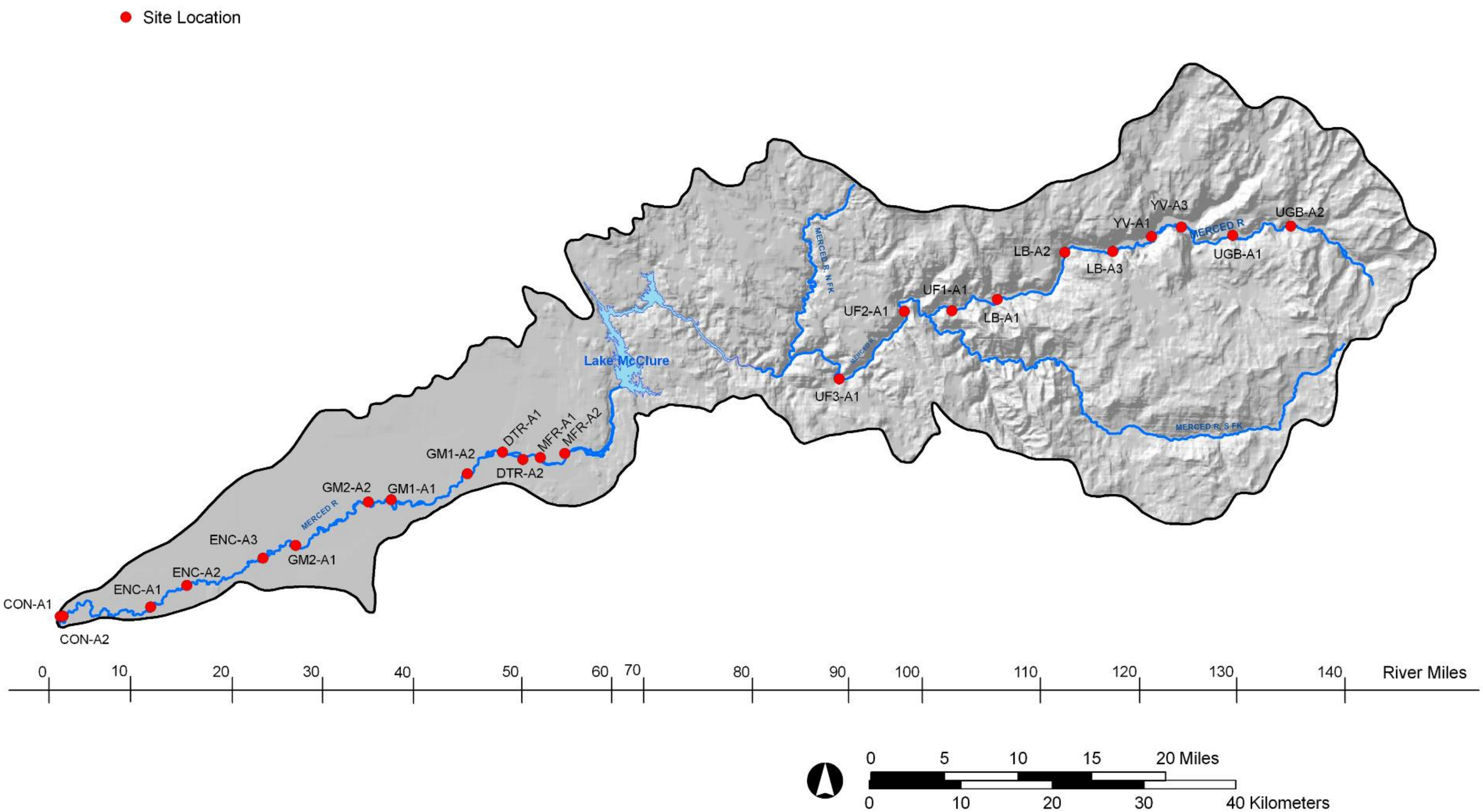
Figure 5-5. BMI monitoring sites and ecological subregions of the Merced River.



Stillwater Sciences

Figure 5-6. Diagrams detailing BMI sampling methods. a) Multi-habitat composite sample (EMAP 11-transect method). **b) Targeted riffle composite sample (TRC) method.** Source: US EPA Wadeable Streams Assessment, Western Pilot Study (2001).

Figure 5-7. Photograph of Chinese mitten crab trap. Image taken following deployment in the lower Merced River during summer 2006.



Stillwater Sciences

Figure 5-8. Avian monitoring sites along the Merced River during 2006.

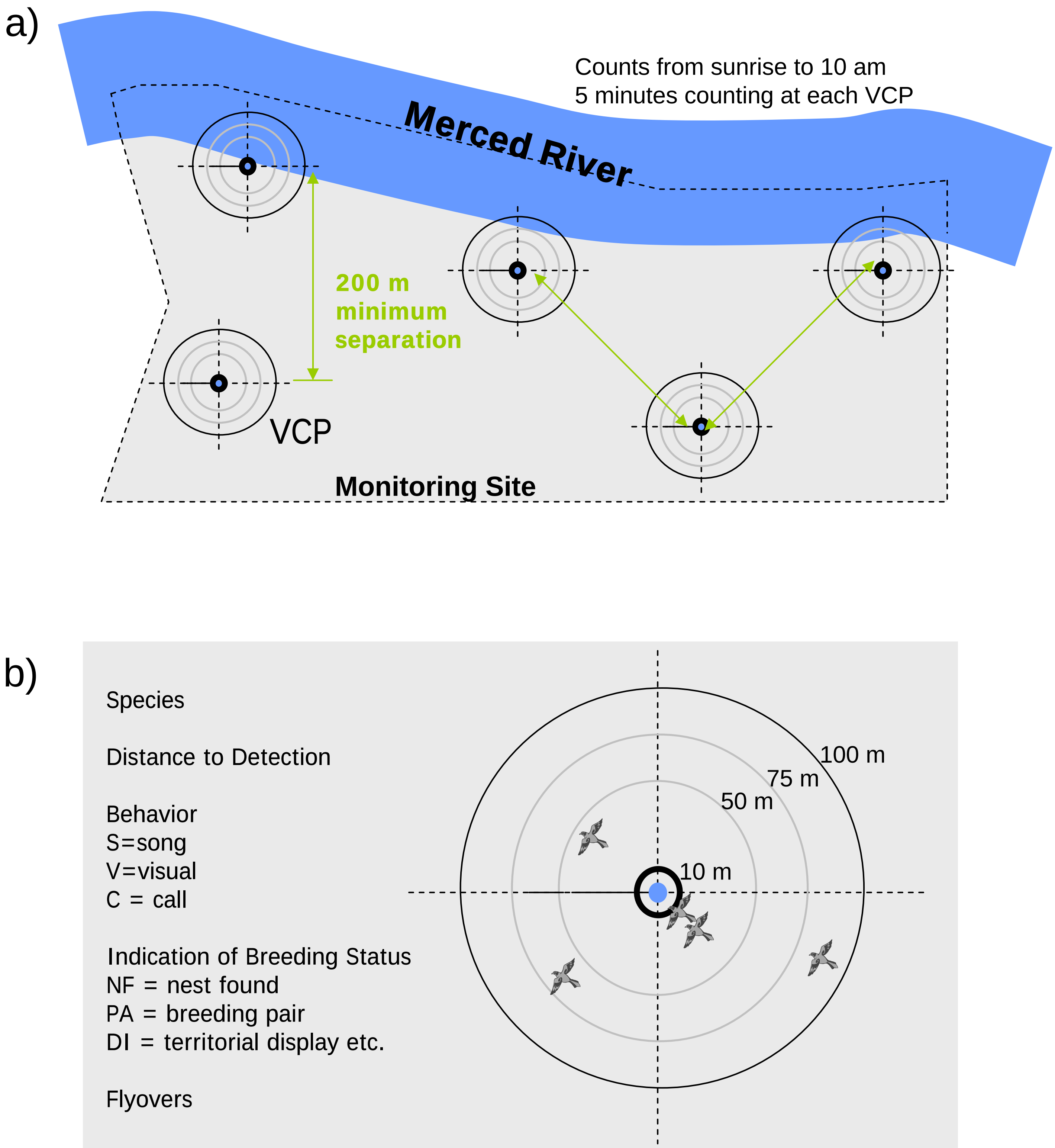


Figure 5-9. Detail of a variable circular plot (VCP) point count used for avian breeding surveys. a) VCP monitoring site with multiple point count locations at least 200 m apart. b) The blue dot in the center of the VCP indicates the location of the observer during point counts, with detection bands out to 100 m. Examples of the type of data taken in the field are listed to the left of the VCP detail.

6 COMPILATION AND SYNTHESIS OF EXISTING DATA

Existing biologic and water quality data for the upper and lower Merced River potentially provides an historical context to our contemporary understanding of baseline biological conditions within the river. Data that are compiled within this task include that from work undertaken by agencies, individual researchers, and watershed-related groups. The information presented in the following section represents a compilation to date, but does not exhaust possible sources of data that could inform study design or the interpretation of results. Compilation and synthesis of existing fish, bird, and BMI data, and related physical and water quality data, is an ongoing effort that will be continued throughout the Merced River Alliance Project. The following section presents a synthesis, not a re-analysis, of existing data. Limited re-analysis of existing data will be necessary to allow direct comparison with data collected during the Merced River Alliance Project. Results of any re-analysis will be presented in the final project report.

Data from the sources listed in the following sections, or additional sources which may be located, will be provided by the agencies or individuals identified. Stillwater Sciences assumes that data contained within reviewed reports is of sufficient scientific quality (sampling protocols, accuracy, and precision) and has undergone quality assurance / quality control procedures to render it adequate for the desired application. Where potential errors in the data are identified, Stillwater Sciences will work to rectify the error in consultation with the source. Information is compiled, to the extent practicable, for display on base maps and GIS data layers for further analyses.

6.1.1 Existing Fish Data

The majority of data on fish in the river has been gathered during studies assessing Chinook salmon outmigration timing, abundance, and survival in the lower Merced River and through surveys conducted in Yosemite National Park. Table 6-1 includes sources and ongoing studies that have been reviewed for the BMAP (Stillwater Sciences 2006a) and updated for this interim report (Note: these references are not necessarily repeated in the reference list). Additional studies co-led by CDFG and Merced Irrigation District (Merced ID) are either planned or currently underway on the Merced River, with descriptions and timing detailed in the Merced River Memorandum of Understanding (Appendix A, Table A-2 of the BMAP [Stillwater Sciences 2006a]). In most cases, data from these studies was not available for inclusion in this data compilation.

Table 6-1. Existing fish data sources reviewed for the Merced River Alliance biological assessment.

Author	Year	Title	Publication Information
Bertetta, F.	1992	Summer fish population survey Upper Merced River watershed	Report to Wilderness Manager Ron Mackie, Yosemite National Park, California
Botti, S.	1977	Status of fish populations in 102 planted lakes.	Unpublished file report, U.S. Department of the Interior, National Park Service, Yosemite National Park, California
Brown, L., T. Ford, M. Saiki, J. May, and J. Merz	2005	Monitoring, Research, and Assessment Components (CMARP) for River Resident Fish Species.	http://calwater.ca.gov/Programs/Science/cmarp/a7a10.html
Brown, L.R.	1996	Aquatic Biology of the San Joaquin-Tulare Basins, California: Analysis of Available Data Through 1992.	U.S. Geological Survey Water-Supply Paper 2471, 89 p.: USGS National Water-Quality Assessment Program San Joaquin - Tulare Basins NAWQA.
Brown, L.R.	2000	Fish communities and their associations with environmental variables, lower San Joaquin River drainage, California.	Environmental Biology of Fishes 57: 251-269.
Brown, L.R. and T.M. Short	1999	Biological, habitat, and water quality conditions in the Upper Merced River Drainage, Yosemite National Park, California, 1993–1996.	USGS Water-Resources Investigations Report 99-4088.
Brown, L.R., C.R. Kratzer, and N.M. Dubrovsky	1999	Integrating Chemical, Water Quality, Habitat, and Fish Assemblage Data from the San Joaquin River Drainage, California.	Chapter 3 in Scow, K. M., Fog G. E., Hinton D.E., and Johnson M.L. Integrated Assessment of Ecosystem Health Lewis Publishers, Boca Raton, Florida.
CDFG	2003	Merced River Current Fish Counts. Weekly Anadromous Fish Count.	http://www.dfg.ca.gov/lands/fh/weekly_counts/merced.htm
CDFG	2003	Adult Return-Estimates of Spawning Population Merced River. 1940-2002.	Query StreamNet Database – searched database on July 25, 2005 for fish. http://query.streamnet.org
CDFG	2003	Hatchery-Returns Estimates of Spawning Population Merced River. 1970-1995.	Query StreamNet Database – searched database on July 25, 2005 for fish. http://query.streamnet.org
CDFG	2003	Hatchery-Weir Counts Estimates of Spawning Population Merced River. 1979-1989.	Query StreamNet Database – searched database on July 25, 2005 for fish. http://query.streamnet.org
CDFG	2001	AFRP. Riffle Atlas – San Joaquin Tributaries (Merced, Stanislaus, and Tuolumne Rivers).	http://www.delta.dfg.ca.gov/afrp/project.asp?code=1999-20
CNDDB	2005	Upper Merced_CNDDB_042605 – All Species List (Amphibians, Plants, etc.)	Searched Rarefinds 3.0.5 on 26 April, 2005 for plants and animals by selected USGS quads.

Author	Year	Title	Publication Information
Dubrovsky, N.M., C.R. Kratzer, L.R. Brown, J.M. Gronberg, and K.R. Burow	1998	Water Quality in the San Joaquin-Tulare Basins, California, 1992-95.	USGS National Water Quality Assessment (NAWQA) Program data. http://water.usgs.gov/pubs/circ/circ1159/
Holdeman, S.	2005	Personal communication with Steve Holdeman, Fisheries Biologist, Stanislaus National Forest, California, by Maia Singer, Stillwater Sciences, Berkeley, California.	Fish surveys of North Fork Merced River and tributaries, and mainstem Merced River, limited data available on resident management indicator species. August 30.
Kisanuki, T.T. and T.A. Shaw	1992	Merced River habitat typing, underwater fish observations, and habitat restoration. Report AFF1-FRO-92-03.	USFWS (U.S. Fish and Wildlife Service), Coastal California Fishery Resource Office, Arcata, CA.
Knapp, R.A.	2003	Yosemite Lake Survey, 2000-2002, Final Report to the National Park Service	Sierra Nevada Aquatic Research Laboratory, U.C. Santa Barbara. June 1.
Lindley, S.T.	2003	California Central Valley steelhead. Preliminary conclusions regarding the updated status of listed ESUs of West Coast salmon and steelhead: draft report	Pages B90-B99. National Marine Fisheries Service, West Coast Salmon Biological Review Team (Individual authors not specified in publication).
Lindley, S.T., R. Schick, B.P. May, J.J. Anderson, S. Greene, C. Hanson, A. Low, D. McEwan, R.B. MacFarlane, C. Swanson, and J.G. Williams	2004	Population structure of threatened and endangered Chinook salmon ESUs in California's Central Valley Basin.	NOAA (National Oceanic and Atmospheric Administration) Technical Memorandum NMFS (National Marine Fisheries Service).
Merced ID	2005	Merced River juvenile salmon capture counts. Merced, California.	http://www.mercedid.org/salmon/totals.html
Merced ID and Natural Resource Scientists, Inc. (NRS)	2003	Merced River Wing Dam Gravel Monitoring 2000-2002.	Final Report, March 2003. Conducted by Merced Irrigation District and Natural Resource Scientists. Merced, California. Anadromous Fish Restoration Program. 40 p.
NPS (National Park Service)	2002	Fish species of Yosemite National Park.	Species list only (no counts). http://www.nps.gov/yose
Stillwater Sciences	2006	Baseline Monitoring of the Merced River Dredger Tailings Reach.	Stillwater Sciences, Berkeley, CA.
Stillwater Sciences	2002	Merced River Corridor Restoration Plan.	Prepared by Stillwater Sciences, Berkeley, California, for CALFED, Sacramento, California.

Author	Year	Title	Publication Information
USFWS (U.S. Fish & Wildlife Service)	2002	Comprehensive Assessment and Monitoring Program (CAMP) Annual Report 2000.	Prepared by CH2M-Hill, Sacramento, CA. http://www.fws.gov/pacific/sacramento/fwr/2000_CAMP_Report.pdf
USFWS	1997	Identification of the instream flow requirements for Fall-run Chinook salmon in the Merced River.	Final report prepared by USFWS Ecological Services, Sacramento Field Office. 69 p. http://www.delta.dfg.ca.gov/afrp/documents/MR_Spawning_Report_March_1997.pdf
USFWS	2000	Instream Flow, Merced River Robinson Reach Investigation, 2000 Annual Report.	Annual Report prepared by USFWS, SFWO, Energy, Power, and Instream Flow Branch. September 2000. 4 p. http://www.delta.dfg.ca.gov/afrp/documents/MR_annual_rep_2000.pdf
USFWS	2002	Instream Flow, Merced River Robinson Reach Investigation, 2002 Annual Report.	Prepared by USFWS, SFWO, Energy, Power, and Instream Flow Branch. February 2002. 4 p. http://www.delta.dfg.ca.gov/afrp/documents/MR_annual_rep_2001.pdf
Vogel, D.A.	2003	Merced River water temperature feasibility investigation reconnaissance report.	Report to US Fish & Wildlife Service, Anadromous Fish Restoration Program.
Williams, K.	2005	Personal communication with Kevin Williams, Fisheries Biologist, Sierra National Forest, Bass Lake Ranger District, California, by Maia Singer, Stillwater Sciences, Berkeley, California.	2005 Fish surveys of South Fork Merced River, limited data available. 22 August.

6.1.1.1 *Data Compilation and Summary*

Figure 6-1 illustrates the locations of known existing fish studies or monitoring sites along the upper and lower Merced River, and Appendix B of the BMAP (Stillwater Sciences 2006a) summarizes fish species observed in both segments.

At the time of this draft data compilation, the following sources have not been included in the dataset:

- Sierra National Forest fish surveys incidental to herpetofauna surveys;
- Stanislaus National Forest fish surveys incidental to herpetofauna surveys; and
- Expanded juvenile Chinook salmon RST data from NRS (Natural Resource Scientists)/MeID.

Continuing efforts are being made by Stillwater personnel to obtain these sources so that the associated data can be included in the final report.

Anadromous Fish Data. Previous and ongoing studies of anadromous fish populations in the Merced River include a mix of Central Valley, Sacramento/San Joaquin Delta, and Pacific Ocean fisheries assessments. The U.S. Fish and Wildlife Service (USFWS), California Department of Fish and Game (CDFG), US Bureau of Reclamation (USBR), Pacific Fishery Management Council (PFMC), and Merced Irrigation District (Merced ID) monitor and collect particular, and sometimes overlapping, information on anadromous fish stocks which exist (or are expected to exist under natural conditions) in the Merced River during some portion of their life history. Table 6-1 summarizes the various anadromous fish monitoring programs carried out by these agencies or organizations and gives primary source locations. Due to the large quantity of individual data types and sources for anadromous fish data, and the availability of existing summaries (USFWS 2002, see below), only select anadromous fish data are re-summarized in the interim report.

Table 6-2. Ongoing anadromous fish monitoring programs relevant to the Merced River.

Species/Race	Life-History Stage	Fish Monitoring Programs	Agency/ Organiza-tion	Years Sampled	Primary Source Location (secondary or summary source location)
Fall-run Chinook Salmon (*Oncorhynchus tshawytscha*)	Adult	Carcass counts	CDFG	1940-present	CDFG Grandtab[1] (http://www.streamnet.org as well as CAMP reports)
		Hatchery marking[2]	CDFG	1970-present	http://www.streamnet.org
		Hatchery returns[2]	CDFG	1970-present	http://www.streamnet.org (CAMP reports)
		Ocean harvest	PFMC		http://www.rmis.org (CAMP reports)
		Redd surveys[3]	CDFG	1988-present	theyne@dfg.ca.gov
	Juvenile	Rotary screw trapping	Merced ID	1998 to present	http://www.mercedid.org/ salmon/count.html (1998-2000 data avail)
Steelhead (*Oncorynchus mykiss*)[4]	—	—	—	—	—
American Shad (*Alosa sapidissima*)[4]	—	—	—	—	—

1 Summary of the Annual Reports of Chinook Salmon Stocks in California's Central Valley, as taken from the CDFG annual Administrative Reports of the Inland Fisheries Division.
2 Merced River Hatchery is located immediately downstream of Crocker-Huffman Dam (RM 52).
3 From 1988-2004, counts are intermittent and by section. From 1992-2004 counts are regular (weekly) and by riffle.
4 Although these species have been observed in the lower reaches of the Merced River (see Appendix B of the BMAP [Stillwater Sciences 2006a]), there are currently no established monitoring programs to estimate their populations. The Merced River and adjacent riparian habitat downstream of Crocker-Huffman Dam were included in the final critical habitat designation for steelhead in 2005 (NOAA 2005).

In the Comprehensive Assessment and Monitoring Program (CAMP) Annual Reports, USFWS and USBR synthesize the results of monitoring performed to estimate the natural production of anadromous fish in 14 target watersheds of the Sacramento/San Joaquin Bay Delta, including the Merced River. The target watersheds represent approximately 97% of the total fall-run Chinook salmon production in California (USFWS 1997). The CAMP reports summarize the following three elements of anadromous fish stocks in the region: 1) adult abundance estimates, 2) trends in abundance, and 3) assessment of progress toward meeting AFRP's production targets. The most recent CAMP Report is from 2000.

For the Merced River, the only currently established anadromous fish monitoring program is for fall-run Chinook salmon. Estimated natural Chinook production during

1995-2000 is shown in Figure 6-2, using data presented in USFWS (2002). Total production of Chinook in the Merced River in 2000 is estimated at 17,991, of which 1,619 (~9%) is attributed to production from the Merced River Hatchery. These numbers are derived from analysis of both in-river estimates and hatchery returns (USFWS 2002). The 2000 total production estimate is less than the Merced River production target of 18,000, and it is 2.4% of the total production target (737,600) for the 14 watersheds analyzed. Progress toward meeting production goals is assessed using a rolling five-year comparison of natural production to baseline and restoration targets. Based on this approach, the Merced River, along with the Stanislaus and Tuolumne rivers, is classified as "not rebuilding" for Chinook stocks during 1995-2000 (USFWS 2002).

The 2000 CAMP report also gives the estimated total numbers of juvenile fall-run Chinook emigrating from the Merced River during 1999 as 199,166, or 172.1 per returning adult female (USFWS 2002). At the time of the 2000 CAMP Report issuance, Merced ID juvenile Chinook data for 2000 was not yet available. Appendix B, Table B-2 of the BMAP (Stillwater Sciences 2006a) details the Merced ID raw rotary-screw trap (RST) data for 1999-2005. Expanded estimates of Merced River juvenile outmigration beyond 1999 are not available at this time, but are expected to be summarized in the next CAMP Report (USFWS 2002).

Juvenile Chinook snorkel surveys and habitat mapping were conducted by Stillwater Sciences in March 2005 at multiple monitoring sites in the Dredger Tailings Reach (RM 45.3 to 52) of the lower river. The surveys were conducted as a portion of the CALFED Merced River Phase IV Baseline Monitoring effort (Stillwater Sciences 2006b).

Resident Fish Data. As defined in the CALFED Comprehensive, Monitoring, Assessment, and Research Program (CMARP) for river resident fish species, resident fish include juveniles of migratory species that remain in the river for at least one full calendar year, in addition to those species completing their entire life cycle in the river. A conceptual model of resident fish in the San Joaquin River Drainage, which includes the large east-side tributaries of Stanislaus, Tuolumne, and Merced rivers, has been put forth by Brown et al. (2003). The current conditions model is largely based on published (Brown 1998, Jennings and Saiki 1990, Saiki 1984) and unpublished data collected by L. Brown, T. Ford, M. Saiki, J. May, and J. Merz (as given in Brown et al. 2003) during the past decade. As described in the CMARP document, there are limitations to these studies including, similar but not identical collection methods, differing analysis methods, differing spatial and temporal study scales, and generally short study duration (< 3 years). Despite these limitations, the Brown et al. (2003) model represents a comprehensive existing data synthesis for river resident fish species in the San Joaquin River Drainage, and as such it was adopted for the Merced River Alliance BMAP (Stillwater Sciences 2006a) (Figure 5-3a). The natural conditions model (Figure 5-3b) is based on the standard model of Central Valley native California stream fish assemblages as initially developed by Moyle and Nichols (1973) and Moyle (1976), and is also presented in Brown et al. (2003).

Resident fish data for the lower river is available from USGS National Water-Quality Assessment Program (NAWQA) studies conducted during 1992-1995 (http://ca.water.usgs.gov/sanj/) and is summarized in various agency reports and publications (Brown 1996, Brown 2000, Brown et al. 1999, Dubrovsky et al.1998). Results from these studies indicate that the majority of the lower Merced River, as a part of the Lower Large Tributary group of the San Joaquin River Drainage, is characterized by high percentages of introduced species, including largemouth bass, redear sunfish, and white catfish (Appendix B, Table B-1 of the BMAP [Stillwater Sciences 2006a]; Figure 5-3b). High percentages of native species, including Sacramento pikeminnow, hardhead, Sacramento sucker, and prickly sculpin, were found at the upper end of the lower reach, near Crocker-Huffman Dam. This distribution was found to be flow-related, in that high discharges in 1995 in the Merced and Tuolumne Rivers were accompanied by higher percentages of resident and migratory native species (Dubrovsky et al. 1998).

Resident fish data from the upper river is limited to Yosemite National Park. Historically, the lakes and streams of Yosemite National Park were fishless above 1,800 m (6,000 ft). For the mainstem Merced River, this corresponds to roughly the Nevada Falls location (~RM 128), just downstream of Little Yosemite Valley where the river sits slightly above 1,800 m. In the mid 1800's, stocking by recreational groups began to introduce fish into formerly fishless lakes and streams in the Park. A predecessor to CDFG began stocking in the early 1900s and became the exclusive fish-stocking organization by the 1940's. In 1972, the National Park Service banned artificial stocking within Park boundaries, however limited stocking by CDFG continued until 1991 (Knapp 1996). Overall, approximately 75% of Yosemite National Park's lakes and at least 60% of its streams were stocked with trout (Elliot and Loughlin 1992, Wallis 1952; cited from Knapp 1996).

In stocked, formerly fishless lakes in Yosemite National Park, the trout community was dominated by rainbow trout, a species native to the park, which were present in about 75% of the stocked lakes (Botti 1977). Data was collected on species, reproductive status, number, and size of fish using creel census and snorkeling spawning habitat. Notes were also made on basic aquatic plants and food availability was examined using general BMI surveys. Brook trout, an introduced species, were present in approximately 35% of the lakes and golden and brown trout were present in less than five percent of the lakes. A 1977 survey, six years after stocking had stopped, showed that 40% of formerly fishless lakes could not support a fish population and returned to a fishless state. Presence of the native rainbow trout decreased most dramatically, declining to 30%. Brook, brown, and golden trout presence also decreased slightly (Botti 1977). These lakes continued to lose fish species, with over half of the formerly stocked lakes being fishless by 1992 (Elliot and Loughlin 1992, Wallis 1952; cited from Knapp 1996).

Fish populations in stocked streams were more stable; approximately 95% became self-sustaining (Elliot and Loughlin 1992, Wallis 1952; cited from Knapp 1996).

Fish surveys in Yosemite Valley include a CDFG study in the early 1990's and a study by Brown and Short (1999) designed to expand on the 1993–1995 USGS NAWQA studies in the upper Merced River. Results of both surveys indicated low fish species richness in Yosemite Valley. The CDFG study was carried out to inventory Valley fish populations and determine the impacts of altered instream and streamside habitat on those populations. Twelve sections of the Merced River, each 100 meters in length, were surveyed using boat and backpack electrofishing and snorkeling. Results indicated over 1,300 rainbow trout and 2,700 brown trout per mile. Rainbow trout densities were greatest in high- and medium- gradient boulder habitat with pocket water and runs, while brown trout were the most common in pooled cobble, moderate gradient grave-cobble-boulder pocket water, and wide gravel-sand runs and pools with woody debris. Both young-of-year and adult Sacramento sucker were found throughout the Valley reach.

Brown and Short (1999) reported that at Yosemite Valley sites, only three species of fish, brown trout, rainbow trout, and Sacramento sucker were observed (Table 6-3). Low numbers of trout, particularly brown trout, were attributed to difficult snorkeling conditions, and perhaps differences in distribution between years. Many of the suckers seen were small young of-the-year, so despite high observed numbers, sucker biomass was relatively low. Additionally, the authors concluded that high discharge and low water temperatures in 1995 likely delayed spawning compared to 1993 and 1994 resulting in individuals too small to be detected by the surveying techniques used. These results, combined with the apparent importance of physical barriers (e.g., bridges) in determining species distributions, led the authors to conclude that fish community structure was not a useful indicator of habitat and water quality in Yosemite National Park.

Table 6-3. Number (and percentage) of fish species observed during surveys in Yosemite National Park at various locations, 1993–1995.

Site	Sample Date	Rainbow Trout	Brown Trout	Sac. Sucker[2]	Small-mouth Bass	Spotted Bass	Sac. Pike-minnow	Riffle Sculpin
Merced River Sites[1]								
Happy Isles Bridge	09/16/1993	41 (28)	27 (18)	81 (54)	0	0	0	0
Happy Isles Bridge	08/17/1994	100 (43)	58 (25)	72 (31)	0	0	0	0
Happy Isles Bridge	09/06/1995	13 (72)	5 (28)	0	0	0	0	0
Pohono Bridge	08/18/1994	23 (20)	23 (20)	70 (60)	0	0	0	0
Pohono	09/06/1995	12 (5)	13 (5)	227 (90)	0	0	0	0

Site	Sample Date	Rainbow Trout	Brown Trout	Sac. Sucker[2]	Small-mouth Bass	Spotted Bass	Sac. Pike-minnow	Riffle Sculpin
Bridge								
Highway 140 Bridge	08/19/1994	20 (4)	3 (1)	315 (59)	13 (2)	0	156 (29)	24 (5)
Foresta Road Bridge	08/19/1994	5 (3)	3 (2)	61 (31)	97 (49)	1 (1)	26 (13)	5 (3)
Upstream of Briceburg	08/16/1994	0	0	10 (8)	104(79)	2 (2)	15 (11)	0
Tributary Sites[1]								
Tenaya Creek below Mirror Lake	08/17/1994	51 (70)	15 (21)	7 (10)	0	0	0	0
Tenaya Creek near Group Camp	08/17/1994	10 (11)	78 (87)	2 (2)	0	0	0	0
South Fork Merced River near Wawona	08/18/1994	52 (49)	1 (1)	54 (50)	0	0	0	0
South Fork Merced River above confluence	08/16/1994	0	0	0	76 (99)	0	1 (1)	0

[1] Source: Brown and Short 1999

[2] High numbers of small young-of-the-year suckers observed at multiple sampling sites.

6.1.1.2 Data Synthesis

A total of 45 species have been observed in the Merced River (Appendix B, Table B-1 of the BMAP [Stillwater Sciences 2006a]). In both the upper and lower river, introduced fish comprise the majority of species observed; in the lower river, only 12 of 38 total species (32%) are native to the watershed. In the upper river, only 6 of 25 total fish species (24%) are native, with the majority of non-native species currently stocked in Lake McClure for recreational purposes. Of the twelve native species observed in the lower river, four have federal status; steelhead/rainbow trout (*Oncorhynchus mykiss*) is listed as threatened under the Federal Endangered Species Act (FESA), Chinook/King salmon (*Oncorhynchus tshawytscha*) is proposed for listing under FESA, and Pacific lamprey (*Lampetra tridentata)* and Kern Brook lamprey (*Lampetra hubbsi*) are listed as Federal Species of Concern. The California Department of Fish and Game also lists hardhead and Kern brook lamprey as California Species of Special Concern. Hitch (*Lavinia exilicauda*), a valley-floor native species, has been observed near the confluence of the lower Merced River (Brown et al., NAWQA surveys 1993–1995), potentially at the upstream limit of its range. In the upper river, no fish species are listed. Although steelhead, the anadromous form of rainbow trout, are listed, they cannot pass upstream of the dams. *O. mykiss* in the upper river are therefore considered rainbow trout, which have no federal or state listing status. Hardhead are a species of concern, but are not listed under state or federal ESAs.

A combination of in-channel and floodplain habitat alterations, water quality degradation, and stocking of non-native species for recreational purposes, appears to be responsible for the current distribution of fish species in the Merced River. As discussed in Section 3.3.2, spring-run Chinook salmon were eliminated from the basin by the late 1940s (Skinner 1962), while fall-run Chinook salmon were not as vulnerable to habitat loss and alteration resulting from the construction and operation of foothill dams. However, as detailed in the most recent CAMP report (USFWS 2002) Chinook stocks are classified as "not rebuilding" during 1995-2000 and are far below AFWS goals. Native fish species, both resident and non-resident, continue to be present at low percentages throughout the Merced River.

6.1.2 Existing BMI Data

Previous studies of BMI assemblages have been conducted in both the upper and lower segments of the Merced River, including sites in Yosemite National Park and near the confluence with the San Joaquin River. Table 6-4 includes sources and ongoing BMI studies that have been reviewed for this report (Note: these references are not necessarily repeated in the reference list).

Table 6-4. Existing BMI data sources reviewed for the Merced River Alliance biological assessment.

Author	Year	Title	Publication Information
L.R. Brown and T.M. Short	1999	Biological, Habitat, and Water Quality Conditions in the Upper Merced River Drainage, Yosemite National Park, California, 1993–1996	USGS Water-Resources Investigations Report 99-4088 Sacramento, California
Brown, L.R. and J.T. May	2000a	BMI assemblages and their relations with environmental variables in the Sacramento and San Joaquin River drainages, California, 1993–1997	U.S. Geological Survey Water-Resources Investigations Report 00-4125, National Water-Quality Assessment Program.
Brown, L.R., and J.T. May	2000b	BMI assemblages on woody debris and their relations with environmental variables in the Lower Sacramento and San Joaquin drainages, California	Environmental Monitoring and Assessment 64: 311-329
Brown, L.R., and J.T. May	2004	Periphyton andBMI communities at five sites in the San Joaquin River Basin, California, during June and September, 2001	U.S. Geological Survey Scientific Investigations Report 2004-5098.
Carter, J.L. and S.V. Fend	1997	Interannual Distribution and Abundance of Lotic Invertebrates from Five Habitats of the Merced River in Yosemite Valley, Yosemite National Park, 1992-1995	Open File Report 97-584. Prepared in cooperation with Yosemite National Park, National Park Service. Menlo Park, CA: USGS.

Author	Year	Title	Publication Information
Carter, J.L. and S.V. Fend	2001	Inter-annual changes in the benthic community structure of riffles and pools in reaches of contrasting gradient	Hydrobiologia 459: 187-200.
Herbst, D.B., E.L. Silldorff, and S.D. Cooper	2003	The influence of introduced trout on native aquatic invertebrate communities in a paired watershed study of High Sierran streams	Final Report to The Nature Conservancy, Ecosystem Research Program (#HO-CSD-050600-CA) and the University of California Water Resources Center (#W-930).
Markiewicz, D., K. Goding, V. de Vlaming, and J. Rowan	2003	BMI bioassessment of San Joaquin River tributaries: Spring and Fall 2002	California SWRCB. Available at: http://www.swrcb.ca.gov/rwqcb5/available_documents/waterqualitystudies/SJR02_Bioassess_final_083005.pdf
Silldorff, E.L.	2003	Stream invertebrate responses to trout introductions: results from large-scale studies in the central Sierra Nevada and Yosemite National Park	Dissertation, University of California, Santa Barbara.
Stillwater Sciences	2006	Baseline Monitoring of the Merced River Dredger Tailings Reach	Stillwater Sciences, Berkeley, CA.

6.1.2.1 *Data Compilation and Summary*

Figure 6-3 illustrates the locations of existing BMI studies and/or monitoring sites along the upper and lower Merced River. Over the past 15 years, BMI communities have been monitored at multiple sites using a variety of different sampling methods. A summary of these studies and sampling methodologies is presented in Table 6-5.

Table 6-5. Existing BMI study sites located on or near the Merced River.

Collecting Parties	Years Sampled	General Sampling Location	Number of Sites	Methodology Summary
J.L. Carter and S.V. Fend	1992-1994	Yosemite National Park	8	Multi-habitat composite[1]
D.B. Herbst, E.L. Silldorf, and S.D. Cooper	2000-2001	Yosemite National Park	42	Multi-habitat composite[1]
L.R. Brown and T.M. Short[2]	1994-1996	Upper and Lower Merced River	19	RTH, QMH, DTH[3]
Stillwater Sciences	2005	Dredger Tailings Reach of Lower Merced River	8	CSBP

Collecting Parties	Years Sampled	General Sampling Location	Number of Sites	Methodology Summary
D. Markiewicz, K. Goding, V. de Vlaming, and J. Rowan	2002[4]	Lower Merced River	4	Modified CSBP and EPA Multi-habitat
L.R. Brown and J.T. May	2001	Merced River at confluence with San Joaquin River	1	RTH, QMH[3]

[1] Two habitat types sampled per reach (riffle and pool) with 5 kicknet samples per habitat type. Kicknet samples (each 0.09 m^2) were then composited to form one sample per habitat type.

[2] Some results reported in Brown and May 2000a. Three sites located on tributaries to the Merced River, 2 sites on the Tuolumne River, and 1 site on the Stanislaus River.

[3] RTH - Richest Targeted Habitat composite sample: 5 kicknet samples (including cleaning of large rocks and disturbing substrate 10 cm down), 0.25 m^2 per sample, collected from one riffle and composited. DTH – Depositional Targeted Habitat sampling (used for backwaters): 7.6 cm diameter sampler inserted 10 cm into substrate. Sediment sieved through 420-µm mesh. QMH – Qualitative Multiple Habitat sampling: all habitat types sampled using D-frame kick net with 210-µm mesh and a variety of methods to dislodge organisms, including brushing, kicking, scraping, and hand picking.

[4] Additional data collected in 2003 and 2004 is not yet available.

The earliest known BMI studies in the upper river were carried out in the 1990s. During 1992-1994, Carter and Fend studied inter-annual variation in BMI assemblages as a function of discharge and habitat in Yosemite Valley. Results indicated that benthic community composition is affected by both the magnitude of the annual peak discharge and the duration and timing of the period of extended high flow, and that the differences are reflected in both riffle and pool habitats (Carter and Fend 2001). As part of the National Water-Quality Assessment (NAWQA) Program of the U.S. Geological Survey (USGS), Brown and Short (1999) carried out BMI and benthic algae collections to assess water quality conditions of the Merced River. After several years of monitoring, the researchers concluded that 1) BMI and algae communities are more appropriate bioindicators than fish in the relatively undisturbed environmental setting of the upper Merced River, and 2) water quality is very good, despite high levels of human activity in some areas within Yosemite National Park.

More recently, Herbst et al. (2003) conducted a study of the impact of introduced trout on native BMI communities, using pairings of adjacent streams with and without fish in Yosemite National Park (see Section 6.1.1.1 for a discussion of historically fishless streams in the Park). Study sites were located along the mainstem Merced River, Merced River tributaries, and the Tuolumne River. The sites were 150 m in length, from which five riffle locations and five pool locations were sampled to form a single composite. Results indicated that BMI communities differed significantly in streams with and without trout. Greater diversity of total taxa and of large invertebrate predators was characteristic of fishless streams, while trout streams contained a greater total percentage of chironomidae (midges) than fishless streams. Additionally, several groups of primarily endemic invertebrates (*Neothremma* and Tricladida flatworms) had abundances one to two orders of magnitude lower in streams where trout were present.

The Merced River was also included in a larger study of BMI assemblages in the Sacramento and San Joaquin River Valley drainages (Brown and May 2000a,b). During 1994-1996, BMI data was collected from both the upper and lower segments of the Merced River, as well as from other locations throughout the western Sierra Nevada and California Central Valley. The authors reported that BMI assemblages on snags, in addition to those found in riffles, may be useful in family level bioassessments of environmental conditions in valley floor habitats. For the riffle samples, elevation was the most important factor determining BMI assemblage structure, while for the snag samples, other factors including land use, conductivity, and mean dominant substrate were key.

BMI studies focusing on the lower segment of the Merced River have included the effects of agricultural pollution and flow variation on BMI assemblages, as well as a study of a dredge-mining impacted reach. In a 2001 study, catalyzed by concern about agricultural pesticides, Brown and May (2004) sampled periphyton and BMI assemblages as an indicator of water quality from five sites in the San Joaquin River Basin. Results of the study indicated that the Merced River BMI community near the confluence with the San Joaquin was dominated by insects, and thus more similar to BMI communities in the Tuolumne and San Joaquin rivers than either Salt Slough or Orestimba Creek. The latter two sites exhibited greater conductivity (as a surrogate for salinity) and were dominated by non-insects. There was no evidence of major differences between June and September sampling for either BMI or periphyton communities.

Using BMI data collected from both riffle and pool habitat in the lower river, Markiewicz et al. (2003) showed that relative abundance of short-lived BMI was greatest at lower Merced River sites dominated by agricultural runoff. The researchers hypothesized that contaminant pulses and flow decreases prevented long-lived BMIs from surviving at these locations. Markiewicz et al. also noted increasing EPT percentages in sites moving upstream of major agricultural activity on the lower river. While downstream sites had relatively fewer pollution-sensitive taxa, the substrate at these sites was also less favorable for most EPT taxa because it consisted of more sand and less gravel and cobble (Markiewicz et al. 2003).

In spring 2005, Stillwater Sciences conducted a bioassessment survey at multiple monitoring sites in the Dredger Tailings Reach. The surveys were conducted as a portion of the CALFED Merced River Phase IV Baseline Monitoring effort to inform restoration actions within a larger watershed context. Sampling was carried out at eight different riffle sites (Table 6-5) following CSBP protocols. Richness, composition, tolerance, functional feeding group, and abundance metrics were calculated for the data. A total of 55 distinct BMI taxa were found, including 22 EPT taxa. Orthoclad midges and the mayfly, *Tricorythodes*, were numerically dominant at all sites. Tolerance Values for all sites fell within a moderate range (4.8–5.5) indicating moderately tolerant BMI assemblages. There was no observed relationship between richness, composition, or tolerance metrics and site location, indicating that habitat quality is consistent within the DTR. The study also included three gravel augmentation or wing dam sites among the eight sampling locations, but results indicated no relationship between measured metrics and the frequency of site disturbance, several months following the most recent disturbance. However, there did appear to be a small effect of the upstream foothill dams on functional feeding groups in the DTR, with the relative abundance of collector-filterers decreasing with distance downstream from the dams.

Water quality data sources have been compiled in Section 6.1.4 and may also used to support interpretation of results from the Merced River Alliance BMI study.

6.1.2.2 Data Synthesis

BMI communities have been studied in multiple locations along the Merced River, across several habitat types and associated land uses, and under multiple flow conditions. However, as shown in Table 6-5, the studies have been conducted using a variety of sampling methodologies, making inter-study comparisons difficult. As discussed in Section 5.2.3, the Merced River Alliance BMI study plan involves a single bioassessment sampling methodology applied throughout the river, which will expand on results provided by existing data. Additionally, metrics parallel to those presented in the Merced River Alliance monitoring plan (Table 5-15, Section 5.2.3.3) will be calculated for existing data sets (where possible, assuming similar methodologies) and presented in the interim and/or final biological assessment report.

Despite the variety of sampling methods used, a general synthesis of the existing BMI information is possible. Bioassessment studies using BMI assemblage data have indicated that water quality is very good in the upper segment of the Merced River, despite anthropogenic impacts from high–use areas in Yosemite National Park, and good in the upper portion of the lower Merced River (Dredger Tailings Reach) just below the series of foothill dams. In contrast, water quality in the lowest reaches of the Merced River is impacted by agricultural runoff and pesticide application, which may include a response the lower river BMI assemblage.

Existing studies have also shown that BMI community structure throughout the Merced River is shaped by flow variation and discharge, water quality, elevation, land use, and food web dynamics. In the upper segment of the Merced River, the presence of non-native trout affects BMI community structure, particularly with regard to large BMI predators and endemic species. In the lower segment, agricultural pollution, flow variation, and the presence of foothill dams all appear to affect BMI community structure in distinct ways.

6.1.3 Existing Avian Data

The majority of data on birds in the Merced River riparian corridor has been gathered through site specific monitoring of baseline conditions, as incidental observations, and through surveys conducted in Yosemite National Park. Table 6-6 includes sources and ongoing studies that have been used to review existing avian data (Note: these references are not necessarily repeated in the reference list).

Table 6-6. Existing avian data sources reviewed for the Merced River Alliance biological assessment.

Author	Year	Title	Publication Information
Archives of the Museum of Vertebrate Zoology, University of California	2005	Query Merced – Avian Species List searched database on 21 July, 2005 for plants and animals.	http://elib.cs.berkeley.edu/mvz/index.html
BLM (Bureau of Land Management)	1979	Unpublished, untitled BLM data from Peggy Cranston, Wildlife Biologist	Totals of birds, mammals, and herpetofauna from Peggy Cranston
California Partners in Flight, Study Area Database	2005	Query Merced River sites – searched database on September 6, 2005 for birds.	http://www.prbo.org/calpif/data.html
CNDDB	2005	Query Merced River _CNDDB_042605 – All Species List (Amphibians, Plants, etc.)	Searched Rarefinds 3.0.5 on 26 April, 2005 for plants and animals by selected USGS quads
Gaines, D.	1988	Birds of Yosemite and the East Slope	Artemesia Press, Lee Vining, CA
Holdeman, S.	2005	Personal communication. Fisheries Biologist, Stanislaus National Forest, California.	No known Stanislaus NF avian data conducted in Merced River drainage. 30 August
Siegel, R.B. and D.F. DeSante	2002	Avian inventory of Yosemite National Park (1998-2000): Final Report.	The Institute for Bird Populations, Point Reyes Station, California, 100 p.
Siegel, R.B. and D.F. DeSante	2003	Bird communities in thinned versus unthinned Sierran mixed conifer stands.	Wilson Bulletin 115(2): 155-165
Stillwater Sciences	2006	Baseline Monitoring of the Merced River Dredger Tailings Reach.	Stillwater Sciences, Berkeley, CA.
USDA Forest Service, Sierra National Forest	unknown	Spotted owl point locations and spotted owl protected activity centers, GIS shapefiles.	N/A
Verner, J., and L.V. Ritter	1983	Current status of the brown-headed cowbird in the Sierra National Forest.	Auk 100: 355-368. http://elibrary.unm.edu/sora/Auk/v100n02/p0355-p0368.pdf

Author	Year	Title	Publication Information
Williams, K.	2005	Personal communication with Kevin Williams, Fisheries Biologist, Sierra National Forest, Bass Lake Ranger District, California, by Maia Singer, Stillwater Sciences, Berkeley, California.	Other than for spotted owl, no known Sierra NF avian data conducted in Merced River drainage. 22 August.

6.1.3.1 Data Compilation and Summary

Figure 6-4 illustrates the locations of existing avian studies or monitoring sites along the upper and lower Merced River, and Appendix C of the BMAP (Stillwater Sciences 2006a) summarizes avian species observed in both segments. Table 6-7 summarizes the number of species detected, diversity, mean number of individuals, and species richness, where available, at monitoring sites throughout the upper and lower Merced River. Data collected from the lower Merced River and Yosemite National Park represent studies carried out within the past one to seven years, while the BLM data was collected incidental to other wildlife observations that occurred during the late 1970s. In addition to the aforementioned studies, data from the University of California, Berkeley Museum of Vertebrate Zoology (MVZ) and the California Natural Diversity Database (CNDDB) date as far back as 1915 and help to characterize avifauna throughout the Merced River watershed.

The most recent avian survey in the lower segment of the Merced River occurred in 2004–2005, when Stillwater Sciences investigated avian use of three common habitat types in the Dredger Tailings Reach. The surveys were conducted as a portion of the CALFED Merced River Phase IV Baseline Monitoring effort to inform restoration actions within a larger watershed context. Using multiple relevé plots at two monitoring sites within the DTR, Henderson Park and Merced River Ranch, the study catalogued more than 50 species at each site over two years. The study also showed that of the three habitat types sampled, mixed riparian habitat and wetland swale habitat provided similar avian habitat in terms of number of individuals, species richness, and species diversity. Gravel tailings habitat was of significantly lower quality than either mixed riparian or wetland swale habitat (Stillwater Sciences 2006b). Further analysis of the data indicated that although wetland swales and mixed riparian habitat exhibited similar metric values, the two types of habitat supported different avian communities. Additionally, a greater number of unique bird species (17) were observed in wetland swale habitat, as compared with mixed riparian habitat (2), for the combined site data.

Table 6-7. Avian species observed in the Merced River watershed.

Site	Species Detected	Points per Transect	Species Diversity	Mean # of Individuals	Species Richness
Lower River (RM 0-65)					
Lower Merced River (MVZ)[1]	134				
Lower Merced River (CNDDB)	5				
Henderson Park (HEPA)[2]	12				
Henderson Park (HEPA)[3]	57	10-11	6.3± 0.6	14.2± 1.8	7.5± 0.8
Merced Falls Avenue (MEFA)[2]	9				
Merced River Ranch (MERR)[3]	60	8-14	6.0± 0.7	16.7± 3.0	7.4± 0.9
Calaveras Material Inc. (CMIN)		8	4.5	15.5	5.5
Hatfield State Park (GJHA)		7	6.4	14.0	7.3
Henderson Park (HEPA)		2	2.6	5.5	3.0
McConnell State Rec Area (MSRA)		9	6.1	14.3	7.6
Upper River (RM 65-headwaters)					
Upper Merced River (MVZ)	102				
Upper Merced River (CNDDB)	8				
BLM - North Fork Merced Area[4] (RM 67.1 to 94.0)					
Timbrush Chapparal	26				
Picture Gallery	42				
#9 Mine	41				
N Fork Merced	47				
Halls Gulch	33				
Sherlock Oak Riparian	39				
Total # of species	**85**				
Yosemite National Park[5] (RM 105.5 to headwaters, organized from high to low elevation)					
Barren	40	80			1.5
Subalpine/Alpine Meadow	42	136			3.1
Whitebark Pine	30	140			1.7
Whitebark Pine-Lodgepole Pine	28	75			3.6
Whitebark Pine-Mountain Hemlock	26	39			2.3
Mountain Hemlock	37	104			4.3
Western Juniper	38	39			3.4
Western White Pine	38	48			5.0
Lodgepole Pine	67	494			4.3
Montane/Alpine Riparian Shrub	31	38			3.4
Quaking Aspen	41	27			6.7
Red Fir	66	277			6.1
Jeffrey Pine	65	138			4.7
Jeffrey Pine-Red Fir	42	73			5.4
Montane Meadow	56	107			7.6
White Fir	46	50			6.4
White Fir-Mixed Conifer	59	261			6.0
Giant Sequoia	27	8			8.4
Douglas-fir Mixed Conifer	39	32			5.4
Montane Chaparral	68	76			6.2
Black Oak	53	39			6.8

Site	Species Detected	Points per Transect	Species Diversity	Mean # of Individuals	Species Richness
Ponderosa Pine	46	19			6.4
Ponderosa Pine-Mixed Conifer	77	228			6.7
White Alder	12	2			4.5
Canyon Live Oak	46	46			4.2
Live Oak	9	1			10.2
Foothill Pine	34	14			3.5
Mixed Chaparral	48	32			7.0
Recent Burn	40	23			5.4
Total # of species	**149**				

NOTE: Data collected from multiple studies was collected using different methods; not all sites located in riparian corridor.

[1] Data collected from field notes and inventory of collected specimens from the Archives of the Museum of Vertebrate Zoology, UC Berkeley, pre 1940-present.

[2] Data collected from PRBO 1998 Rapid Assessment 6/12/1998.

[3] Data collected from Stillwater Sciences 2004-2005 Point Count Surveys (Stillwater Sciences 2006b). Values given in Table 6-7 are summed across three habitat types (mixed riparian, wetland swale, and dredger tailings). Standard errors are given in parentheses.

[4] Data collected from BLM (Bureau of Land Management). 1978. Unpublished, untitled data. BLM data from Peggy Cranston, Wildlife Biologist, Totals of birds, mammals, and herpetofauna.

[5] Data collected from Siegel, R.B. and D.F. DeSante. 2002. Avian inventory of Yosemite National Park (1998-2000): Final Report. The Institute for Bird populations, Point Reyes Station, California, 100p. Species richness based on detections per hectare. p 38-81.

6.1.3.2 Data Synthesis

Greater than 200 avian species have been observed throughout the Merced River corridor and in Yosemite National Park (Appendix C, Table C-1 of the BMAP [Stillwater Sciences 2006a]). In the lower river segment, 134 species have been recorded, while 192 species have been recorded in the upper segment. In both the upper and lower river, native bird species comprise the vast majority of species observed; in either the lower or upper portions of the watershed, fewer than 2% of the total species are non-native.

Multiple species in both the upper and lower segments are considered state or federal Species of Special Concern, including burrowing owl (*Athene cunicularia*), tricolored blackbird (*Agelaius tricolor*), merlin (*Falco columbarius*), and Vaux's Swift (*Chaetura vauxi*). In the upper river segment, seven species are either state or federally listed (bald eagle, golden eagle, peregrine falcon, Swainson's hawk, great grey owl, spotted owl, and willow flycatcher) and 17 are species of concern (state or federal). Five species in the lower river segment have state or federal status (bald eagle, Swainson's hawk, least Bell's vireo, and willow flycatcher) and 14 are species of concern (state or federal).

Of the 16 avian species included in the Riparian Habitat Joint Venture (RHJV) focal species list for riparian-associated birds in California, 14 species, or 88%, have been observed in the Merced River watershed since 1915 (Appendix C, Table C-1 of the BMAP [Stillwater Sciences 2006a]). Only bank swallow and yellow-billed cuckoo are included on the RHJV riparian focal species list but have never been recorded in the Merced River watershed. Recent detections of the RHJV riparian-associated species are fewer however, with 5 species (~30%) observed in the lower portion of the Merced River watershed within the past decade, and 10 species (~60%) observed in the upper portion of the watershed (Yosemite) within the past 7 years. While the focal species list does not include all riparian-associated avian species in California, it does include species that meet 5 specific criteria. The species considered (RHJV 2000):

1. Use riparian vegetation as their primary breeding habitat in most bioregions of California;
2. Warrant special management status—endangered, threatened, or species of special concern on either the federal or state level;
3. Have experienced a reduction from their historical breeding range;
4. Commonly breed throughout California's riparian areas; and
5. Have breeding requirements that represent the full range of successional stages of riparian ecosystems.

In the lower river segment, the apparent decline in RHJV riparian-associated species within the past decade, combined with the results from the recent Stillwater Sciences (2006) study indicating the contrast between mixed riparian, wetland swale, and dredger tailings habitat for avian use, suggests that availability of riparian habitat may be limiting associated bird species in the river corridor. This apparent trend is not easily discernible from existing upper river avian data. As shown in Table 6-7, the range of observed species richness (1.5 to 10.2) in Yosemite National Park is greater than that of sites monitored in the lower river segment (3.0 to 7.6). However, it is difficult to draw conclusions from these values as the studies had varied objectives and in some cases were conducted using different methods. The Siegel and DeSante (2003) study was not limited to the mainstem Merced River corridor or to riparian vegetation types, whereas the lower river studies occurred in close proximity to the river channel and, in the case of PRBO 1998 Rapid Assessment sites, occurred at locations pre-selected to have a greater diversity of vegetation.

For Yosemite National Park, an analysis could be conducted that would link finer resolution Park vegetation types (NPS, in progress) to the Siegel and DeSante (2003) habitat types throughout the Park. This would require buffering the channel network to determine Yosemite National Park vegetation types that occur in close proximity to the primary river channel, and then matching these vegetation types to the Siegel and DeSante habitat types. As this analysis would help to interpret the Siegel and DeSante data in the context of the mainstem river corridor and would help with monitoring site selection for the Merced River Alliance biological assessment monitoring, it will be conducted as part of study plan development but is not included in the current synthesis.

6.1.4 Existing Flow, Water Temperature, and Water Quality Data Sources

Although not included in the original scope of the project, compilation of existing flow, water temperature, and water quality data sources was included in the BMAP (Stillwater Sciences 2006a) because these parameters affect aquatic habitat quality. Existing water quality data is listed as one of the site selection criteria for fish and BMI monitoring sites (Sections 5.2.2.3 and 5.2.3.3); flow is a measurement parameter for fish habitat characterization (Table 5-10); flow (discharge) is the prime parameter used for the analysis of hydrologic alteration during BMI habitat quality assessment (Table TBD); and, the effect of water temperature on fish distribution (e.g., steelhead) in the lower river is included among the secondary fish study hypotheses.

Figure 6-5 illustrates the locations of California Data Exchange Center (CDEC) and/or USGS gaging stations, as well as the locations of Merced ID, CDFG, and DWR thermographs along the upper and lower Merced River. Appendix D of the BMAP (Stillwater Sciences 2006a) summarizes gaging station information located in both segments. Table 6-8 summarizes existing sources for water temperature and water quality data on the Merced River.

Table 6-8. Existing water temperature and water quality data sources on the Merced River.

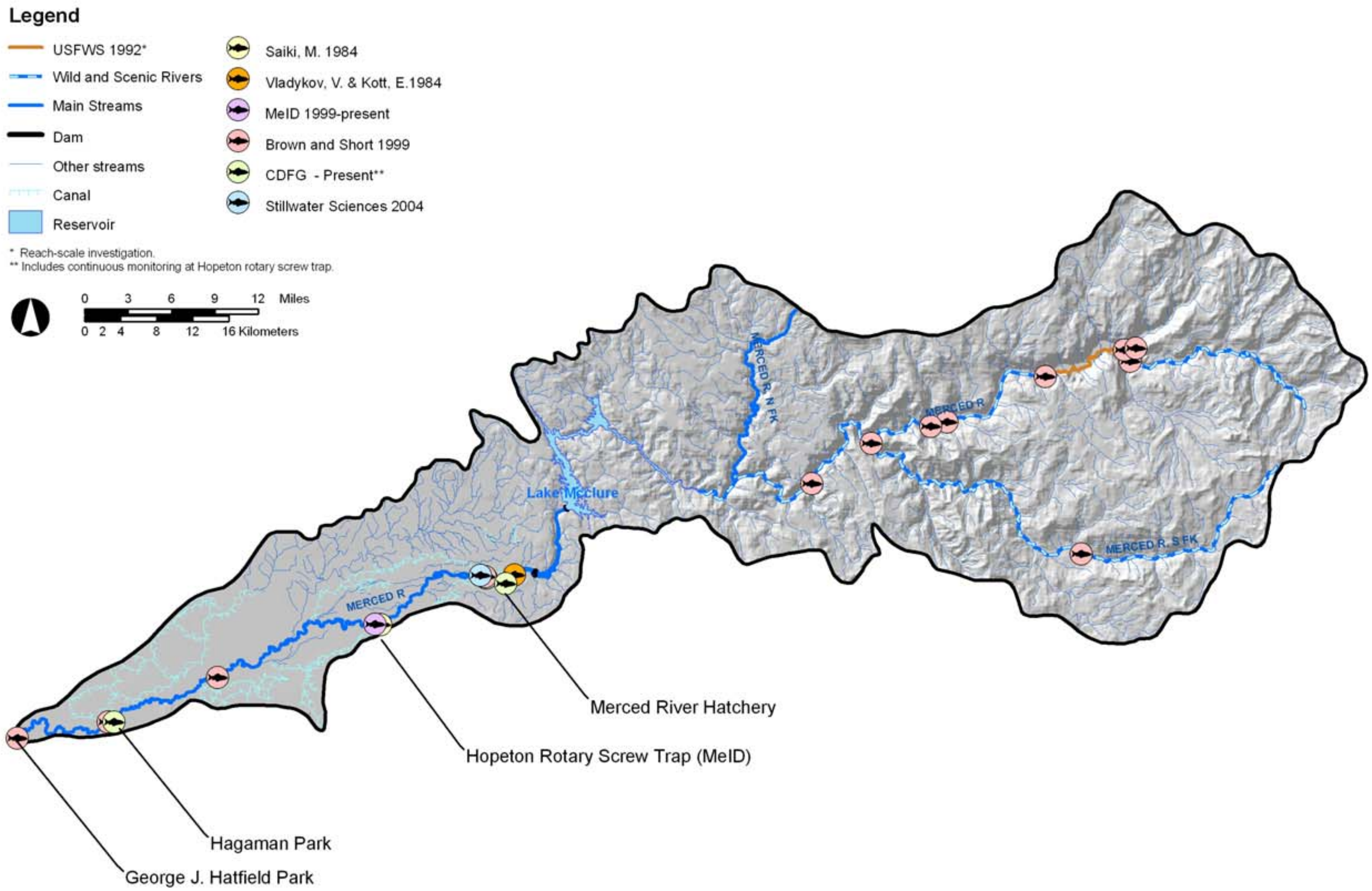
Author	Year	Title	Publication Information
Brown, L.R., C.R. Kratzer, and N.M. Dubrovsky	1999	Integrating chemical, water quality, habitat, and fish assemblage data from the San Joaquin river drainage, California.	Chapter 3 in Scow, K. M., Fog G. E., Hinton D.E., and Johnson M.L. Integrated Assessment of Ecosystem Health Lewis Publishers, Boca Raton, Florida.
Brown, L.R., and T.M. Short	1999	Biological, habitat, and water quality conditions in the Upper Merced River Drainage, Yosemite National Park, California, 1993–1996.	USGS Water-Resources Investigations Report 99-4088.
Dubrovsky, N.M., C.R. Kratzer,L.R. Brown, J.M. Gronberg, and K.R. Burow	1998	Water quality in the San Joaquin-Tulare basins, California, 1992–95.	USGS National Water Quality Assessment (NAWQA) Program data. http://water.usgs.gov/pubs/circ/circ1159/
NPS (National Park Service)	1994	Baseline water quality data inventory and analysis, Yosemite National Park. Water Resources Division and Servicewide Inventory and Monitoring Program.	Technical Report, NPS/NRWRD/NRTR-94-03, September. http://nrdata.nps.gov/YOSE/nrdata/water/baseline_wq/docs/YOSEWQAA.pdf
Pereira, W.E., Domagalski, J.L., Hostettler, F.D., Brown, L.R. and Rapp, J.B.	1996	Occurrence and accumulation of pesticides and organic contaminants in river sediment, water and clam tissues from the San Joaquin River and tributaries, California.	Environmental Toxicology and Chemistry 15(2): 172–180.
Stillwater Sciences	2004	Mercury assessment of the Merced River Ranch.	Stillwater Sciences, Berkeley, California.
Upper Merced River Watershed Council	2006	Appendix data from citizens water quality monitoring project	Upper Merced River Watershed Council
Vogel, D.A.	2003	Merced River water temperature feasibility investigation reconnaissance report.	Report to U.S. Fish and Wildlife Service, Anadromous Fish Restoration Program. December 29, 2003.

6.1.5 Existing Geomorphic Cross-Section Data Sources

Table 6-9 summarizes existing sources for geomorphic cross-section data in the Merced River. The majority of surveys have been conducted in the lower river. Although the existence of cross-section data is not a requirement for monitoring site selection, it can be used to complement habitat mapping information collected by analysis of aerial photographs, video, and/or on-the-ground reconnaissance.

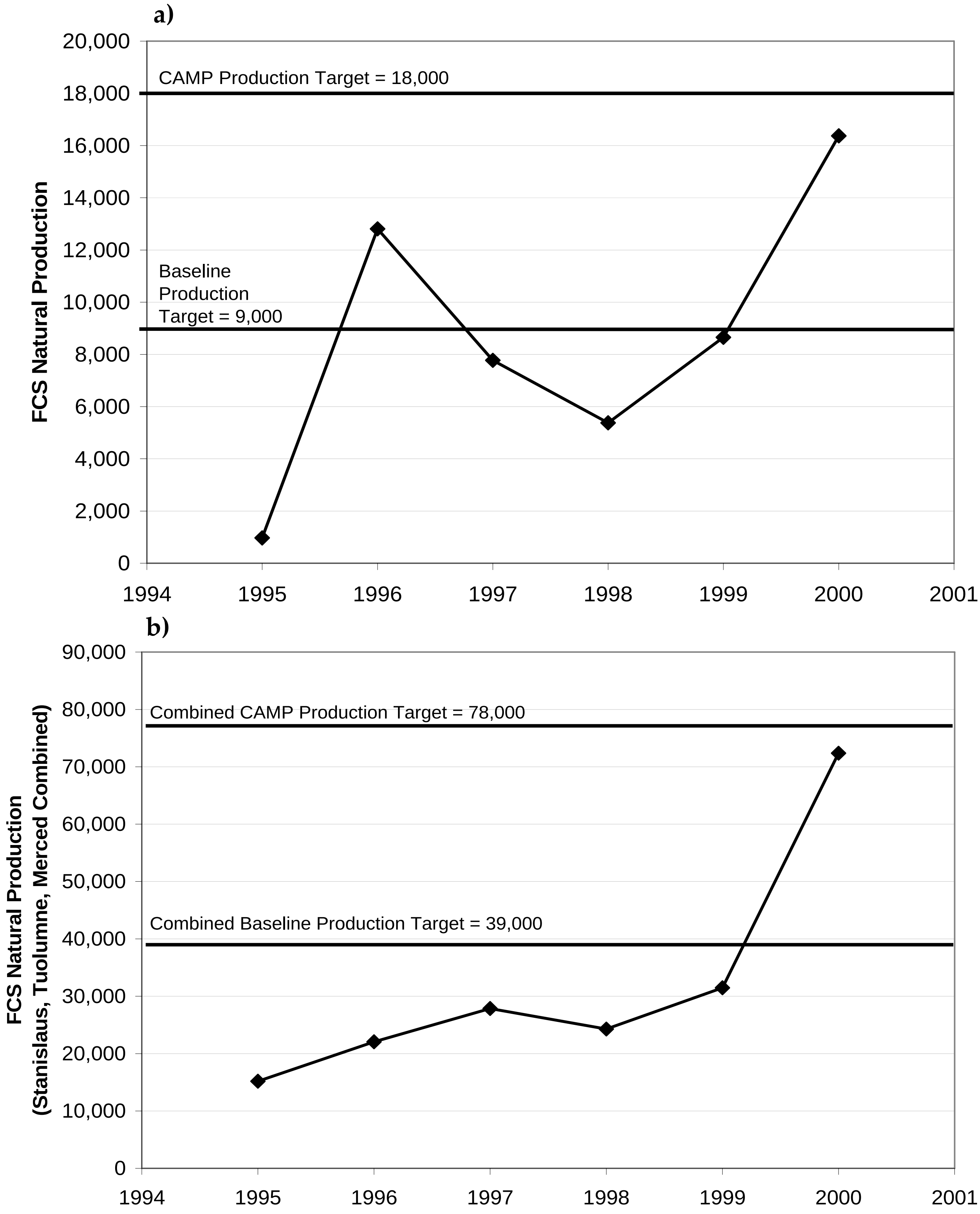
Table 6-9. Existing geomorphic cross-section data sources on the Merced River.

Author	Year	Title	Publication Information	Number of Cross-Sections (RM)
Blodgett, J.C. and G.L. Bertoldi	1968	Determination of channel capacity of the Merced River downstream from Merced Falls Dam; Merced County California	USGS Open File Report	149 (RM 0 to 52)
Vick, J.C.	1995	Habitat rehabilitation in the Lower Merced River: A geomorphic perspective	M.S. Thesis: University of California at Berkeley, Department of Landscape Architecture	22 (RM 27 to 52), with 16 re-occupied from Blodgett and Bertoldi (1968)
Stillwater Sciences	2004	Channel and floodplain surveys of the Merced River Dredger Tailings Reach	Prepared for CALFED ERP, Sacramento, California	40 (RM 43.5 to 52)
Madej, M.A, V. Ozaki, C. Jones, and G. Gibbs	1997	Channel changes in the Merced River following the January, 1997 flood	USDOI, U.S. Geological Survey Biological Resources Division and Redwood National and State Parks	44 (RM 119-124)



Stillwater Sciences

Figure 6-1. Monitoring site locations for existing fish data on the Merced River.



Stillwater Sciences

Figure 6-2. Fall-run Chinook salmon production estimates, production targets, and estimates of natural production for the Merced River (1995-2000). Data plotted from USFWS & USBR (2002). a) Merced River only. b) Combined Stanislaus, Tuolumne, and Merced rivers.

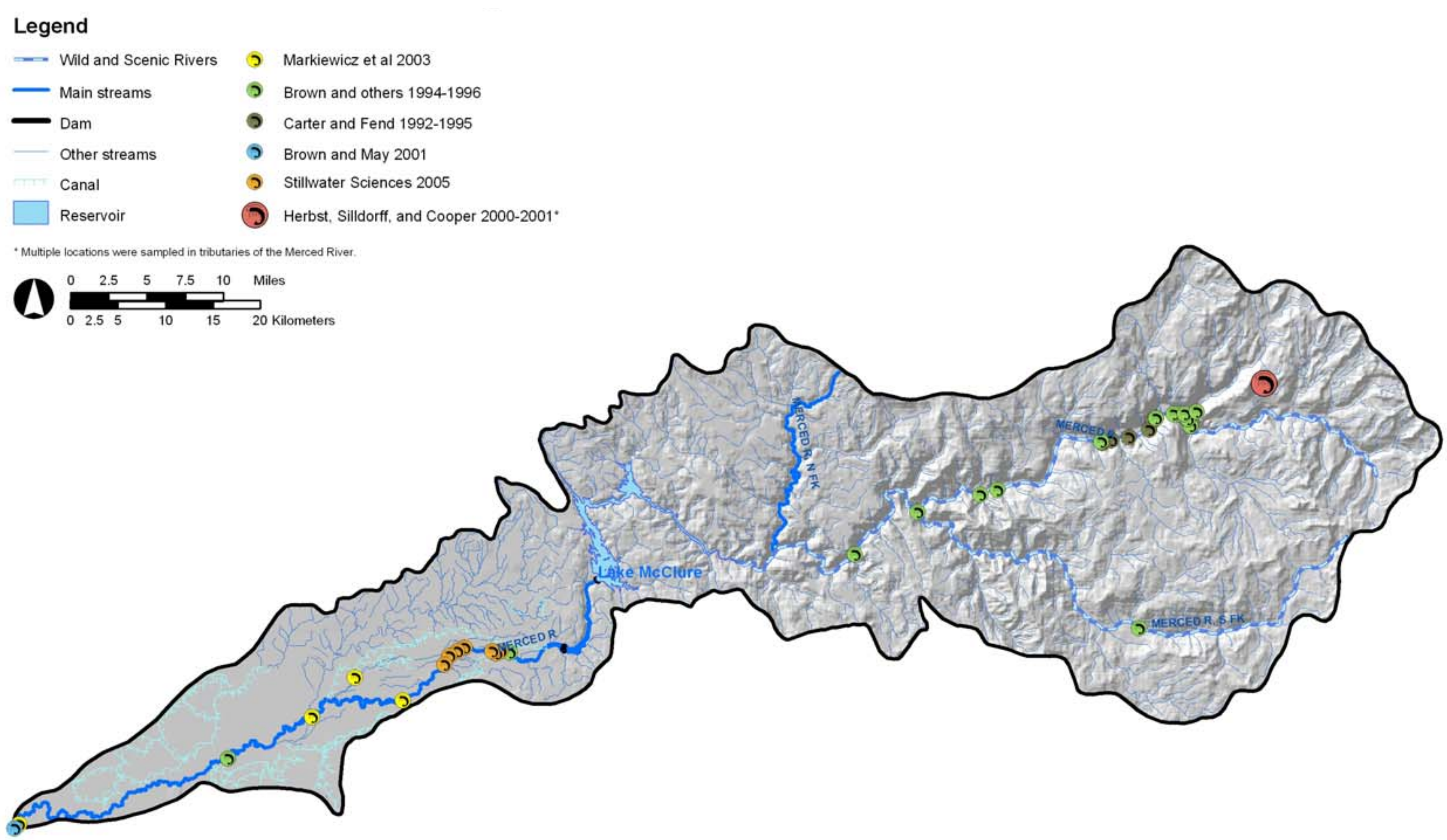


Figure 6-3. Monitoring site locations for existing BMI data on the Merced River.

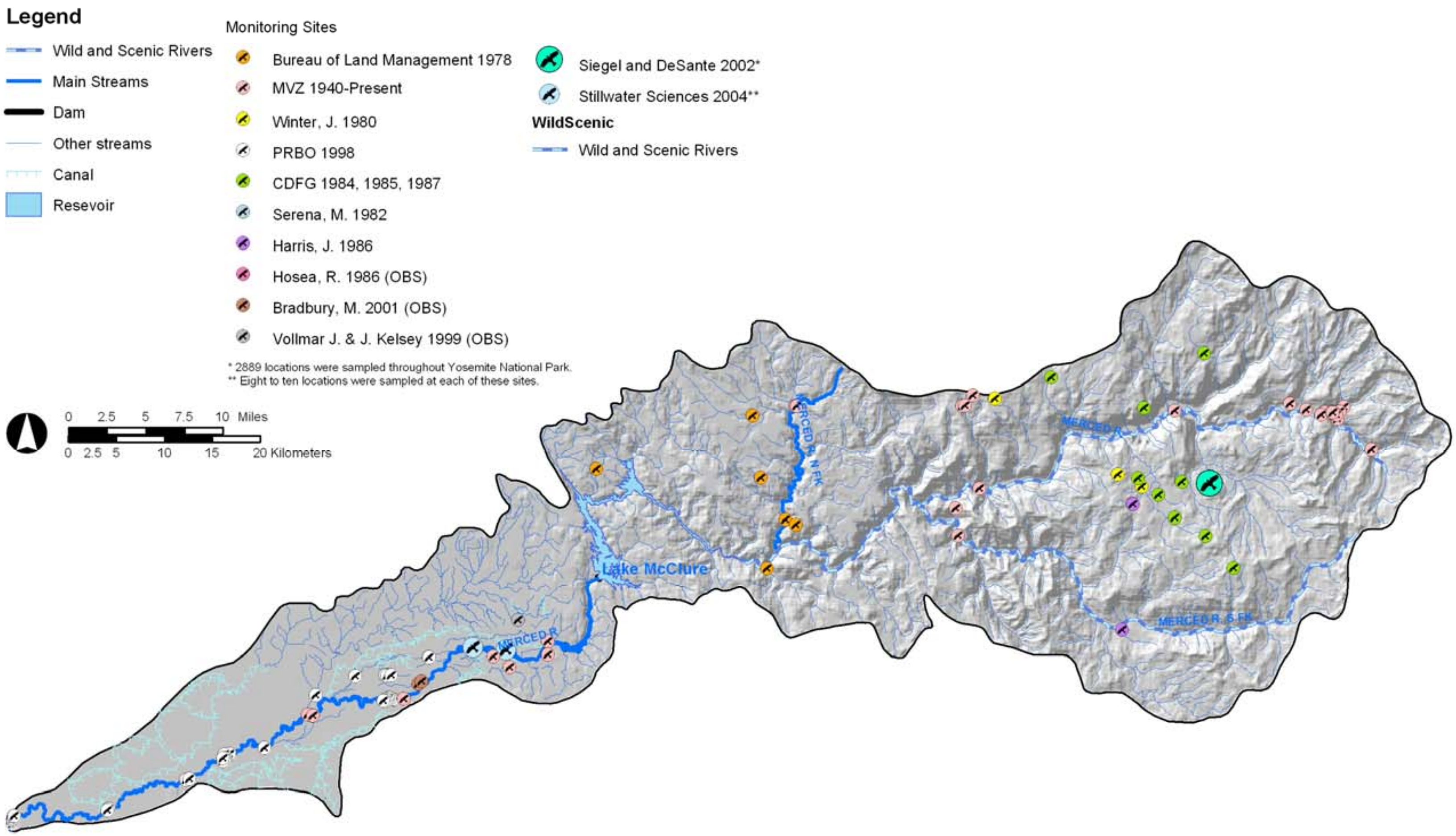
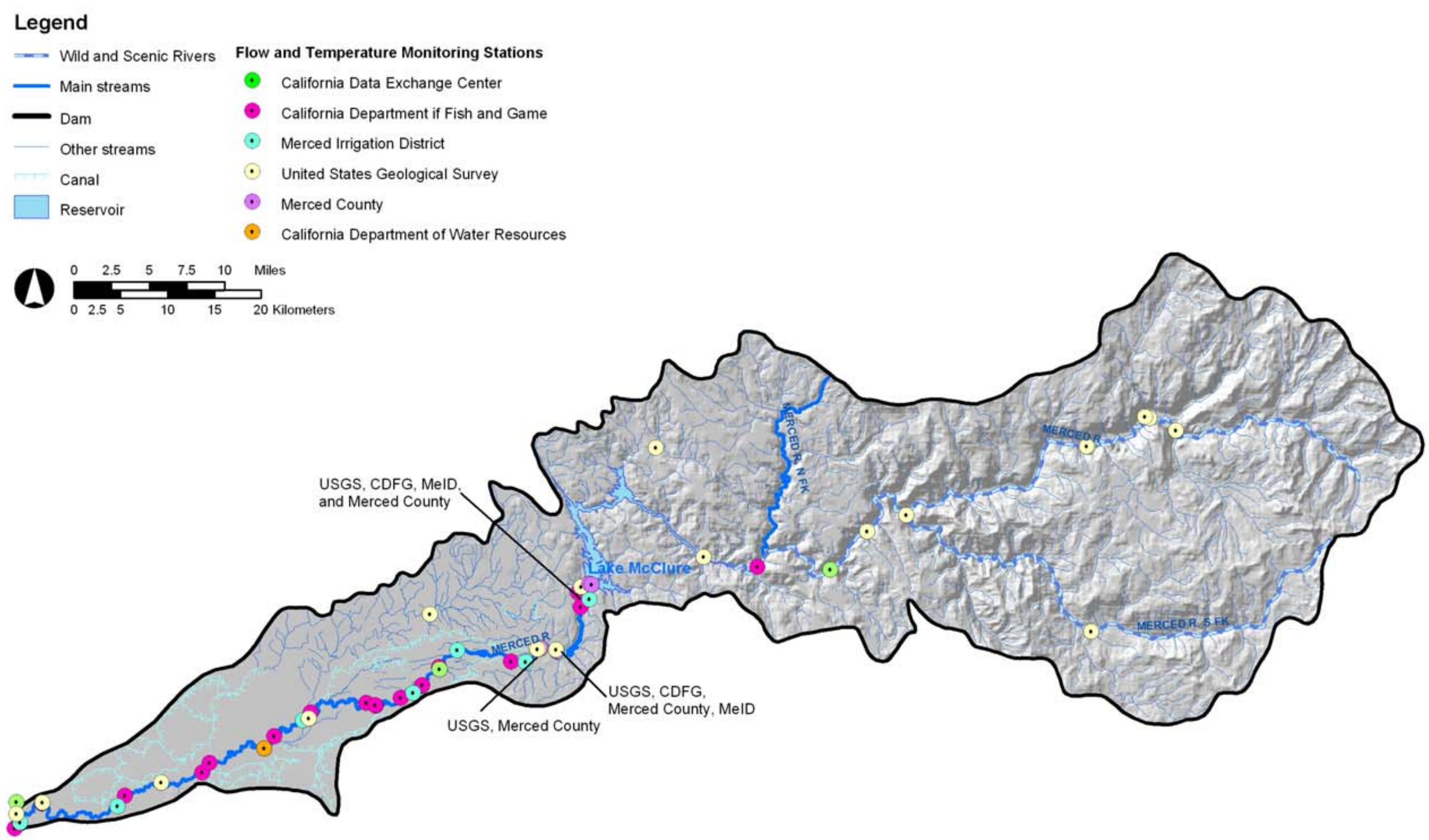


Figure 6-4. Monitoring site locations for existing avian data on or near the Merced River.



Stillwater Sciences

Figure 6-5. Existing flow and temperature monitoring stations on the Merced River.

7 NEW DATA

7.1 Coarse-scale Aquatic Habitat Mapping

As described in Section 5.2.1, aquatic habitat mapping of the mainstem Merced River was conducted using low altitude helicopter videography in all six reaches of the lower river segment (RM 0 to 54.3) and three of six reaches of the upper river segment (RM 79.9 to 105.6). As helicopter flights are not generally permitted in Yosemite National Park, on-the-ground mapping methods were used to characterize discrete portions of the remaining three reaches in the upper river segment, including the Lower Batholith (RM 105.6 to 118.7), Yosemite Valley (RM 118.7 to 126), and Glaciated Batholith (RM 126 to headwaters) reaches. The Merced River aquatic habitat maps are available as a series of 34 tiles and accompanying summary spreadsheets at the Merced River Digital Library (www.mercedriverwatershed.org/projects/stillwater).

Remote and on-the-ground aquatic habitat mapping was conducted under minimum flow conditions, during October and November 2005, in order to: 1) facilitate evaluation of low-flow fish migration barriers, 2) maximize access and safety during fieldwork, and 3) evaluate habitat composition during the seasonal period of greatest habitat heterogeneity. Coarse-scale habitat types used for the aquatic habitat assessment were defined using a simplified version of standard habitat classifications commonly described in the literature (Table 5-3). Results of this assessment are presented in the following paragraphs, summarized by reach. As analysis of aquatic habitat data at the basin and segment scale is intended to reveal larger patterns in habitat distribution that suggest mechanisms of fish population regulation (Fausch et al. 2002, Ward 1998), hierarchical classification of habitat types (Hawkins et al. 1993) and analysis at the basin and segment scales will be included in the final report following completion of the 2007/2008 fish surveys. The Lake McClure Reach (RM 54.3 to 79.9) includes predominantly lacustrine habitat of the foothill reservoirs Lake McSwain and Lake McClure, and is not considered further in the data presentation.

There were minor differences between original river mile calculations, developed using a 1:100K stream network model, and the estimated lengths of river reaches derived during coarse-scale aquatic habitat mapping. Small discrepancies were observed between the sum of the individual units in a given reach and the distance between designated reach breaks; for reaches in the lower river segment, summed habitat unit measurements were within 3.5% of total designated reach length, while for the upper river segment, summed habitat unit measurements were within 2.5% of total designated reach length. In general, an assumed measurement error of 5% can be applied to a given habitat unit length but because estimated widths are calculated from the lengths based on a whole number ratio, widths will have a larger assumed measurement error. Pool depth was visually estimated and channels were then classified as "deep" (>1.2 m [>4 ft]) or "shallow" (< 1.2 m [<4 ft]). As with any flow-dependent measurement, current aquatic habitat conditions on the Merced River may vary significantly from that shown in the aquatic habitat maps.

7.1.1 Lower River

Aerial video mapping of the lower Merced River took place on October 3-5, 2005 at approximately the normal summer baseflow conditions (2.8–5.6 m^3s^{-1} [100–200 cfs]) (Section 5.2.1.2).

7.1.1.1 Confluence Reach (RM 0 to 8.1)

Beginning at the confluence with the San Joaquin River, the Confluence Reach is subject to backwater effects from the larger San Joaquin and contains the most extensive and continuous stands of native vegetation remaining along the Merced River corridor. The reach is characterized by gravel/sand/silt substrate and a confined and deep channel. The dominant bank substrate throughout the reach is also gravel/sand/silt (Table 7-1). Under the low flow conditions mapped during Fall 2005, the Confluence Reach is principally of a run habitat type (Figure 7-1a), with summed run habitat comprising 10,125 m (33,220 ft) (77%) of the total reach and 14 of 29 total habitat units (48%). The second most common habitat type in this reach is the lateral scour pool, by length (16% of total) and by frequency (10 of 29 total habitat units). As shown in Figure 7-2, the median calculated channel width under low flow conditions in the Confluence Reach is 37 m (120 ft), with a full range of 17-68 m (57-224 ft). Large woody debris (LWD) density is 9.5 LWD/mi, or 78 pieces throughout the reach (Figure 7-3).

Table 7-1. Bed and bank substrate by reach for the lower and upper Merced River.

Reach	Most Common Dominant Bed Substrate	Second Most Common Dominant Bed Substrate	Bank Substrate[1]
Lower River (RM 0 to 54.3)			
Confluence (CON)	Gravel/sand/silt	None	Gravel/sand/silt
Encroached (ENC)	Gravel/sand/silt	None	Vegetation
Gravel Mining 2 (GM 2)	Gravel/sand/silt	None	Vegetation
Gravel Mining 1 (GM 1)	Gravel/sand/silt	Cobble	Vegetation
Dredger Tailings (DTR)	Gravel/sand/silt	Cobble	Vegetation
Merced Falls (MFR)	Gravel/sand/silt	Cobble	Vegetation
Upper River (RM 79.9 to headwaters)			
Upper Foothills 3 (UF 3)	Cobble	Gravel/sand/silt	Cobble
Upper Foothills 2 (UF 2)	Boulder	Cobble	Bedrock
Upper Foothills 1 (UF 1)	Boulder	Cobble	Boulder
Lower Batholith[2] (LB)	Boulder	Bedrock	Bedrock
Yosemite Valley[2,3] (YV)	Sand	Gravel	Sand
Glaciated Batholith[2] (GB)	Gravel	Sand	Sand

[1] As bank substrate was determined via helicopter videography in the Lower Merced River and all three Upper Foothills reaches, vegetation blocked direct viewing of the bank substrate and was recorded in lieu of a substrate.
[2] The Lower Batholith, Yosemite Valley, and Glaciated Batholith reaches were mapped using on-the-ground techniques. Only discrete portions of the reaches were mapped.
[3] The Yosemite Valley reach was mapped in two discrete segments due to time and accessibility constraints.

7.1.1.2 Encroached Reach (RM 8.1 to 26.6)

The Encroached Reach is the longest of the twelve reaches in the Merced River and is highly affected by agricultural levees along its full extent. The reach contains a roughly equal frequency of run (20 of 41 total units) and lateral scour pool habitat (18 of 41 total units), however runs are the predominant habitat type by length at 26,620 m (87,320 ft) or 87% of the total reach distance. The Encroached Reach is moderately confined with an entirely gravel/sand/silt bed substrate. Due to extensive vegetation cover, it was not possible to determine the dominant bank substrate in most of the units. While bank vegetation is common (Table 7-1), almost all of the native riparian vegetation in the Encroached Reach is located within the agricultural levees, and for much of the reach, vegetation width is one tree wide. Median channel width is 32 m (105 ft), with a range of 18-81 m (59 ft to 267 ft) (Figure 7-2). As shown in Figure 7-3, LWD density is relatively high at 7.9 LWD/km (12.8 LWD/mi), or 242 pieces observed throughout the reach.

7.1.1.3 Gravel Mining 2 Reach (RM 26.6 to 32.3)

The Gravel Mining 2 Reach extends from RM 26.6, just downstream of the Santa Fe Boulevard Bridge, to the Shaffer Road Bridge (RM 32.2). This reach includes the confluence with Dry Creek (RM 32.7) and several in-channel and floodplain aggregate mining pits. Dry Creek drains a 285-square kilometer (110-square mile) watershed to the north of the river and is the only major tributary to the river downstream of Crocker-Huffman Dam (Stillwater Sciences 2001). The creek enters the mainstem Merced River at an in-channel mining pit (habitat unit number 45).

The channel in the Gravel Mining 2 Reach is confined and deep, with runs occurring as the most frequent habitat type, comprising 20 of 46 total units and 38% (3,440 m [11,290 ft]) of total reach length (Figure 7-1a). Mid-channel pools are the second most common unit type by frequency (13 of 46 total units) but are the most common by length, representing 43% (3,950 m [12,950 ft]) of total reach length. Of the 13 mid-channel pool units observed in the Gravel Mining 2 Reach, four are large, flooded gravel pits. These pits also represent the widest aquatic habitat units within the reach, with a median width of 98 m (323 ft), compared to the reach-wide median width of 31 m (100 ft) (Figure 7-2). The deep mid-channel gravel pits were frequently observed to have large floating algal mats at the water surface. Four off-channel gravel pits are also present throughout the reach at RM 29.5, 30, 31.5, and 32.2.

The dominant bed substrate in the Gravel Mining 2 Reach is gravel/sand/silt for every unit mapped (Table 7-1). Extensive vegetation cover prevented the identification of the most common bank substrate. The riparian corridor width in the Gravel Mining 2 Reach is wider than that of the Encroached Reach, at approximately 15 m (50 ft) on each bank in most places (Stillwater Sciences 2001). LWD density is 4.7 LWD/km (7.6 LWD/mi), with 43 pieces throughout the reach at the time of sampling (Figure 7-3).

7.1.1.4 Gravel Mining 1 Reach (RM 32.3 to 44.7)

The Gravel Mining 1 Reach extends from Shaffer Road Bridge to approximately 1.2 miles downstream of the Snelling Road Bridge. As in the Gravel Mining 2 Reach, the river channel and floodplain have been extensively mined for aggregate (sand and gravel) both on the floodplain and in the river channel. In the Gravel Mining 1 Reach, the channel is confined and deep and the most common dominant bed substrate is gravel/sand/silt sand for all habitat types except low gradient riffles (Table 7-1). Cobble is present in 17 of 37 low gradient riffle units, and thus represents the second most common dominant bed substrate for the reach. Aquatic habitat the Gravel Mining 1 Reach is represented fairly evenly by four habitat types; runs, mid-channel pools, lateral scour pools, and low gradient riffles. As shown in Figure 7-1a, runs are the most common habitat type by frequency and by length, although they only represent 42 of the 125 mapped units and 39% of the total reach length. The number of low gradient riffles (37) is higher than that of mid-channel pools (26) and lateral scour pools (20), however by length, mid-channel pools are more common at 27% of total reach length.

As in Gravel Mining 2 Reach, flooded, off-channel gravel pits are present throughout this reach. There are also two large gravel pits within the main channel, one that is 240 m (800 ft) wide and 580 m (1900 ft) long at approximately RM 41.1, and another that is 200 m (650 ft) wide and 150 m (500 ft long) at approximately RM 39.3. The median channel width is 26 m (85 ft) (Figure 7-2). Thick algal mats were present at the time of sampling in the smaller of the two gravel pits, as in most of the off-channel gravel pits. LWD density is 6.8 LWD/km (11.0 LWD/mi), with a total of 136 pieces observed in the reach at the time of sampling (Figure 7-3).

7.1.1.5 Dredger Tailings Reach (RM 44.7 to 51.3)

The Dredger Tailings Reach extends from RM 44.7, approximately 1.2 miles downstream of the Snelling Road Bridge, to Crocker-Huffman Dam. The channel in this reach is confined by piles of dredger tailings, which have replaced the natural floodplain soils and floodplain forest and have increased floodplain elevation along the river. Low gradient riffles and runs are the two most common habitat types in this reach; 21 of 58 total units are low gradient riffles and 18 are runs (Figure 7-1a). While not high in number, several long, deep mid-channel pools are present in the reach. Consequently, this habitat type is the second most common habitat type by length at 34% of the total reach length. Gravel/sand/silt is the most common dominant bed substrate (40 units) while cobble is the second most common dominant bed substrate (13 units) (Table 7-1). There are three small diversion dams in the reach; the largest dam at RM 51.2 creates a deep mid-channel pool and causes the river to widen to 240 m (800 ft) just upstream of the diversion point, or roughly eight times the median reach width of 30 m(100 ft) for the reach (Figure 7-2). LWD density is 4.5 LWD/km (7.2 LWD/mi) or 49 pieces for the reach (Figure 7-3).

7.1.1.6 Merced Falls Reach (RM 51.3 to 54.3)

The Merced Falls Reach is formed by Crocker Huffman Dam (RM 51.3) at the downstream end and Merced Falls Dam (RM 54.3) at the upstream end of the reach. The reach is relatively short, having only eight habitat units extending over 4,860 m (15,930 ft), and the channel is entirely confined and deep (>1.2 m [4 ft]). However this portion of the river functions as a distinct reach characterized by flow releases from upstream dams and withdrawals from the Merced Irrigation District's diversion structure at Crocker Huffman Dam. The range of channel flow (<2.8 m^3/s [100 cfs] to >280 m^3/s [10,000 cfs]) is relatively greater and flows change more frequently as compared with other reaches of the lower Merced River, resulting in the potential for highly variable aquatic habitat conditions. The number of mid-channel pools (3) and low gradient riffles (3) are equal, however the deep (>10 ft) mid-channel pools represent 77% of total reach length (Figure 7-1a). Gravel/sand/silt is the most common dominant bed substrate (3 of 8 units), while cobble is the second most common dominant substrate (2 of 8 units) (Table 7-1). Bed substrate was not visible in the three units immediately below the Merced Falls Dam due to poor visibility. The median channel width is 51 m (166 ft). Vegetation was present on the bank throughout the reach and prevented any identification of dominant bank substrate.

7.1.2 Upper River

As discussed in Section 5.2.1.2, helicopter videography of the Upper Foothills reaches (3, 2, and 1) was conducted on November 15, 2005 at flows of 3.62 m^3/s (128 cfs). Additionally, ground mapping of discrete sections of the Lower Batholith, Yosemite Valley, and Glaciated Batholith reaches in Yosemite National Park took place from November 15-22, 2005 at flows of 0.71-1.27 m^3/s (25-45 cfs) (Section 5.2.1.2). On-the-ground methods provided additional detail about habitat features in the mapped units; for example, gravel, silt, and sand bed substrates were separated into distinct categories during on-the-ground mapping. It was not possible to ground map entire reaches within Yosemite National Park boundaries due to accessibility and time constraints.

7.1.2.1 Upper Foothills 3 Reach (RM 79.9 to 91.3)

The Upper Foothills 3 Reach extends from Lake McClure, upstream of the reservoir's influence, to the Briceburg Bridge. The channel is confined throughout with an even mix of habitat units greater than 1.2 m (4 ft) deep and units <1.2 m (4 ft); with a median channel width of 25 m (82 ft) with range of 9-62 m (31-203 ft) (Figure 7-2**)**. Low gradient riffles (54 of 153 total units) are the most frequent habitat type, followed by runs (50 of 153), and mid-channel pools (37 of 153) (Figure 7-1b). By length, mid-channel pools were the most heavily represented habitat type at 42% of the total reach length. Cobble is the predominant bed substrate, found throughout the numerous low gradient riffles in the reach, while gravel/sand/silt is the subdominant bed substrate. Deposits of fine sediment were noted in the downstream portions of the reach, presumably due to backwater effects from typical fluctuations in reservoir levels. For the first time, bedrock is noted as the dominant substrate for an individual habitat unit. Bed substrate was not visible in several mapped units due to glare. The most common dominant bank substrates for the reach are bedrock and cobble (Table 7-1). No LWD was observed in the Upper Foothills 3 Reach (Figure 7-3).

7.1.2.2 Upper Foothills 2 Reach (RM 91.3 to 100.6)

The Upper Foothills 2 Reach begins at Briceburg Bridge and ends at the confluence of the mainstem and the South Fork Merced River. The channel is confined and deep throughout the reach. The most common habitat types in the reach are runs (49 of 145 total units) and low gradient riffles (46 of 145), while by length runs (40%) and mid-channel pools (33%) are the most common (Figure 7-1b). Boulder and cobble substrates are predominate throughout the reach (Table 7-1), with boulder present in most low and high gradient riffles and cobble present in most runs and mid-channel pools. Bedrock substrate is also present in many mid-channel pools. The median channel width is 20 m (66 ft). One piece of LWD was observed in the reach (0.066 LWD/km [0.11 LWD/mi]) (Figure 7-3).

7.1.2.3 Upper Foothills 1 Reach (RM 100.6 to 105.6)

The Upper Foothills 1 Reach begins at the confluence of the mainstem and the South Fork Merced River and ends at Foresta Road Bridge near the entrance to Yosemite National Park. Low gradient riffles (27 of 77 total units) and mid-channel pools (24 of 77 total units) are the most common aquatic habitat types in the reach (Figure 7-1b). Low gradient riffles and mid-channel pools are also the most common unit by length, representing 42% and 35% of the total reach length, respectively. Boulder is the most common dominant bank and bed substrate in the reach (Table 7-1). The median channel width is 20 m (66 ft). No large woody debris was observed in the reach (Figure 7-3).

7.1.2.4 Lower Batholith Reach (RM 105.6 to 118.7)

On-the-ground mapping was conducted in the Lower Batholith Reach from RM 112.7 to RM 114.6. Mid-channel pools are the most common habitat type in the mapped section by frequency and by length, representing 24 of 74 total units and 51% of total length (Figure 7-1b). Boulder is the dominant substrate in 30 of the 75 units, followed by bedrock, which is the dominant substrate in 22 units. Boulder is also the most common subdominant substrate (22 units). Bedrock is the most common dominant bank substrate. The median width of the area mapped is 14 m (47 ft) and the width varies from 6-30 m (19-100 ft) (Figure 7-2). The Lower Batholith Reach has the highest diversity of habitat types of any mapped reach in the Merced River. It has the only mapped occurrences of pocket water and plunge pools. Cover was present in 62% of the units and redds were observed in several units. Large woody debris was more common in this reach than in the other Upper Merced River reaches (Figure 7-3), at 4.8 LWM/km (7.8 LWD/mi).

7.1.2.5 Yosemite Valley Reach (RM 118.7 to 126.0)

The Yosemite Valley Reach, beginning downstream of Pohono Bridge and extending to the Happy Isles Bridge (RM 126), was mapped in two discrete segments in an effort to map as much of the reach as possible using on-the-ground techniques within project time constraints. Segment A begins at the downstream end of the reach (RM 118.7) and ends at approximately RM 123.2. Segment B begins at RM 124.6 and ends at the Happy Isles Bridge. In mapped sections, runs and lateral scour pools are the most common habitat types, with 34 and 33 units respectively. Mid-channel pools, lateral scour pools, and runs are the most common by length, representing 41%, 27%, and 26% of the total mapped distance, respectively (Figure 7-1b). Throughout the reach, sand is the most common dominant substrate, found primarily in mid-channel and lateral scour pools, while gravel is the sub-dominant substrate (Table 7-1). The median width in the mapped sections is 19 m (62 ft), with a range of 8-43 m (25-140 ft) (Figure 7-2) In general, gravel substrate is common in runs while boulder and cobble are most common in high and low gradient riffles. 345 pieces of large woody debris were observed in the mapped sections, for an average of 7.9 LWD/km (12.8 LWD/mi) (Figure 7-3).

7.1.2.6 Glaciated Batholith Reach (RM 126 to headwaters)

The Glaciated Batholith reach begins at the easternmost edge of Yosemite Valley (RM 126) and continues to the headwaters of the Merced River. Due to the difficult access conditions and time constraints, only 0.8 miles including six habitat units, were mapped in this reach, beginning in the Little Yosemite Valley at RM 130 and ending at the downstream end of the Bunnel Cascade (RM 131). In Little Yosemite Valley, the reach was surrounded by a wooded meadow with many trees showing signs of fire damage. There was a large amount of large woody debris in the river, typically present in large debris jams which blocked the entire channel and prevented the channel from being mapped safely. Of the habitat units mapped, three of the six units and 93% of the sub-reach length were mid-channel pools (Figure 7-1b). Gravel is the most common dominant substrate in the mapped sub-reach, while sand is the second most common dominant substrate (Table 7-1). The most common bank substrate is sand. The median width is 16 m (53 ft), with a range of 8-23 m (25-75 ft) (Figure 7-2). No large woody debris was observed in the mapped portion of the reach. Upstream of the mapped portion of the reach, the valley narrows and the glacial bowl begins to steepen into a small gorge. Larger substrate was more common and the stream gradient increased, and most of the habitat was largely riffle or cascade. Merced Falls separates the Lost Valley from the Little Yosemite Valley, and the section of stream between the two valleys that contained the falls was ensconced in bedrock walls. The stream channel was narrow (<10m) for most of this section and was largely high/low gradient riffle separated by several smaller cascades.

7.2 Fish Study

Data collected during 2006 sampling in the lower and upper segments of the Merced River was compiled and evaluated for this Interim Report. As discussed in Section 5.2.2.1, the interim-stage data evaluation focused primarily on fish species composition, abundance and distribution, with seasonal comparisons conducted where applicable. The initial stages of community assemblage analyses and fish habitat associations are also included in this interim report. As discussed in Section 5.2.2.3, the lower river segment was sampled during summer and fall 2006, whereas the upper river segment was sampled during fall 2006. Reach designations remain consistent between all Merced Alliance study components and are repeated in Table 7-2 below (repeated from Section 5.2.1.2).

Table 7-2. Merced River reach designations

Reach Name	Reach Abbreviation	River Mile Range
Lower River		
Confluence Reach	CON	RM 0.0–8.1
Encroached Reach	ENC	RM 8.1–26.6
Gravel Mining 2 Reach	GM2	RM 26.6–32.3
Gravel Mining 1 Reach	GM1	RM 32.3–44.7
Dredger Tailings Reach	DTR	RM 44.7–51.3
Merced Falls Reach	MF	RM 51.3–54.3
Foothill Reservoirs Reach	MCL	RM 54.3–79.9
Upper River		
Upper Foothills Reach 3	UF3	RM 79.9–91.3
Upper Foothills Reach 2	UF2	RM 91.3–100.6
Upper Foothills Reach 1	UF1	RM 100.6–105.6
Lower Batholith Reach	LB	RM 105.6–118.7
Yosemite Valley Reach	YV	RM 118.7–126
Glaciated Batholith Reach	GB	RM 126 to headwaters

7.2.1 Fish Species Composition, Abundance, and Distribution

Twenty seven fish species were detected throughout the Merced River during summer and fall 2006 (Table 7-3). Of these, 24 were resident species common to the region. Over 56% of fish species observed were introduced (15 of 27 species). Two State Species of Special Concern were documented (hardhead and Kern Brook lamprey) and two Federal Species of Concern were observed including *O. mykiss* (steelhead/rainbow trout) and Chinook salmon. Common and scientific names for all fish species detected are presented in Appendix H, Table H-1.

As the series of foothill dams (i.e., Crocker-Huffman, Merced Falls, Mc Swain, and New Exchequer [see Figure 3-1]) currently block fish migration between the lower and upper segments of the Merced River, anadromous fish were only observed in the lower segment, primarily downstream of the Snelling Diversion (Crocker-Huffman Dam). Fish survey results are presented separately for each river segment.

Table 7-3. Native, introduced, anadromous, and residential fish abundance and species richness during summer and fall 2006.

Occupancy	Residency	Abundance[1]	Species Richness
Lower River (Summer and Fall 2006)			
Anadromous[2]	Native	64	2
	Introduced	1	1
Resident	Native	1,035	9
	Introduced	1,448	14
Lower River Total		**2,548**	**26**
Upper River (Fall 2006)			
Anadromous	Native	--	--
	Introduced	--	--
Resident	Native	1,093	5
	Introduced	290	6
Upper River Total		**1,383**	**11**
Combined Lower & Upper River (Summer and Fall 2006)			
Merced River Total		**3,931**	**27[a]**

[1] Fish that were not identified to species level during snorkel sampling are not included.
[2] All *O. mykiss* were included with resident species because origin could not be determined.
[a] Total species observed (27) was composed of the following: summer and fall 2006 (22); summer 2006 only (2); and fall 2006 only (3) (Table 7-4).

7.2.1.1 Lower River

In the lower river segment, 2,548 individual fish from 26 species were observed during the summer and fall 2006 surveys. A small number of anadromous species ($n_{and\ sp}$=3) and individuals ($n_{and\ ind}$=65) were present, including both native (i.e., Chinook salmon and Pacific lamprey) and introduced (i.e., striped bass) species (Table 7-3). Of these, Chinook salmon and striped bass were observed below Crocker-Huffman Dam, while Pacific lamprey was present below the dam and in the reach just upstream of the dam (in the Merced Falls Reach). It is assumed that the partially removed fish ladder at Crocker-Huffman provided limited passage for the lamprey observed above the dam. The *O. mykiss* observed upstream of Crocker-Huffman Dam were considered resident and not anadromous since the diversion is the upstream of migration points for most species. Resident species made up the majority of fish species composition and the majority of individuals ($n_{res\ ind}$ = 2,483) observed in the lower river segment during 2006. Of the resident fish, slightly less than 40% (9 of 23) were native species (42% as abundance [1,035 of 2,483]) (Table 7-2).

Both species richness and total observed abundance were greater in the lower Merced River during summer (24 species, n_{Sum}=1,990) as compared with fall 2006 (21 species, n_{Fall}=559). As shown in Figure 7-4, Sacramento sucker was the most frequently observed native fish species in both summer and fall 2006, at approximately 34% of the total sample size. During summer 2006, other native, non-anadromous species including prickly sculpin, hardhead, Sacramento pikeminnow, California roach, and riffle sculpin were each observed at less than 5% of total sample size. In fall 2006, observed abundance of Sacramento pikeminnow had increased to approximately 7% of total sample size and no hardhead were observed. Prickly sculpin, California roach, and riffle sculpin remained at less than 5% of total sample size. Within the set of introduced species, mosquitofish and spotted bass were the most abundant in the lower river during both fall and summer 2006 surveys. Bluegill sunfish and largemouth bass were less than 5% of total sample size in the summer, but were observed at higher abundance during fall; 11% and 14%, respectively.

Estimated Linear Abundance. The total number of each fish species observed during summer and fall 2006 was normalized to produce an estimate of linear abundance, expressed as the number of fish per 100 meters. The linear abundance values are summarized by reach in Figure 7-6. As evidenced by the wide range of values and the large number of statistical outliers shown in the box plot for each reach, estimated linear fish abundance in the lower river segment exhibited high variability. This was particularly evident in the Confluence, Gravel Mining 1, and Dredger Tailings reaches where estimated linear abundance ranged across three orders of magnitude. Overall in the lower river during summer 2006, intra-reach variability outweighed the variability between the reaches (p=0.23 Kruskal-Wallis nonparametric ranking test alternative to ANOVA) obscuring any potential reach-scale trend. During fall 2006, variability of estimated linear abundance within reaches was also high (p=0.15), although slightly less so than that observed during the summertime sampling effort.

Species Richness, Diversity, and Percent Composition. Despite the high variability in estimated linear abundance, a closer look at reach-specific richness and diversity metrics along with percent composition in Figures 7-7 through 7-9 suggests that the lower river reaches may have behaved as somewhat distinct units during summer and fall 2006. As shown in Figure 7-7a, summertime calculated index values in the Confluence and Dredger Tailings reaches were fairly similar to one another, exhibiting medium-range species richness (11 and 9, respectively) and low diversity (3.2 and 1.9, respectively). However, as seen by the percent composition data (Figure 7-7b), the dominant fish species observed in each reach was different. In the Confluence Reach mosquitofish comprised almost 70% of total species present while in the Dredger Tailings Reach, Sacramento sucker made up roughly 85% of total species. The divergence in richness and diversity indices for these two reaches is characteristic of an uneven distribution of individuals across the representative fish species. This is supported by the percent composition data (Figure 7-7b), which shows the predominance of one species and low representation of several other species.

The Encroached, Gravel Mining 2, and Gravel Mining 1 reaches exhibited higher species richness (13 to 17) during the summer sampling event, but also showed medium to low diversity (3.2 to 7.7). Again, this indicates an uneven distribution of individuals across the species present, an observation which is supported by the percent composition data (Figure 7-7b). The dominant species (or set of species) in each of these reaches differed as well, with spotted, smallmouth, and largemouth bass at relatively large numbers in the Encroached Reach, bluegill sunfish in the Gravel Mining 2 Reach, and mosquitofish in the Gravel Mining 1 Reach.

The Merced Falls Reach had the lowest species richness (5) in the lower river segment, as well as fairly low species diversity (4) (Figure 7-7a). Close correspondence between the two index values indicates a more even distribution of individuals across each species, a condition that was not observed elsewhere in the lower river segment. While all other lower river reaches exhibited multiple fish species at less than 2% of total species composition, in the Merced Falls Reach no species was present at less than 6% of total sample size (Figure 7-7b) during summer 2006.

Shifts in Sacramento sucker and mosquitofish had the largest influence on species composition in the lower segment between summer and fall 2006. As shown in Figure 7-8, fall 2006 sampling in the lower river presented several similarities as well as some differences, as compared with summer 2006. During both seasonal sampling events, Sacramento sucker, common carp, and mosquitofish were widely distributed in the lower reach whereas sunfish and bass species were abundant in only the downstream reaches (Confluence, Encroached, and Gravel Mining 2) (Figure 7-7 and 7-8). Additionally, a high abundance of Sacramento sucker was observed within the upstream reaches (Gravel Mining 1, Dredger Tailings, and Merced Falls) whereas bass and common carp had higher abundances within the downstream reaches (Confluence, Encroached, and Gravel Mining 2).

Overall, the number of species observed during fall 2006 was lower than that of summer 2006 (Figures 7-8a). While prickly sculpin was evenly distributed during summer 2006 sampling, this species was only observed in three reaches (Confluence, Dredger Tailings, and Merced Falls) in fall 2006 (Figure 7-8b). The Confluence, Encroached, and Gravel Mining 2 Reaches behaved similarly to one another, exhibiting roughly equal richness (9 to 11) and diversity (5 to 6) values, as well as percent composition of species present (i.e., they were mainly bluegill sunfish, largemouth bass, and spotted bass). The Gravel Mining 1 Reach exhibited much lower species richness in fall 2006, down from 15 to 4, but a similar diversity (2.4). While mosquito fish and Sacramento sucker were still the predominant species in this reach during fall 2006, previously low representation of prickly sculpin, spotted bass, California roach, largemouth bass, common carp, goldfish, redear sunfish, bluegill sunfish, brown bullhead bigscale logperch, and white catfish had decreased to zero in fall 2006. Prickly sculpin and Pacific lamprey were numerically dominant within the Merced Falls reach in fall 2006 compared to Sacramento sucker in summer 2006. While one Chinook salmon was observed during summer in the Dredger Tailings Reach, none were observed during fall 2006.

7.2.1.2 Upper River

In the upper river segment, 1,383 individual fish across 11 species were observed during the fall 2006 surveys (Table 7-3). Fish community composition in the upper river segment included only resident species, since the foothill dams currently limit anadromous fish to the lower Merced River. Similar to the lower river, the number of introduced species observed (6 or 55%) was greater than native species (5 or 45%). However, unlike in the lower river where relative values of species richness and abundance were roughly the same for native vs. introduced species, the abundance of native fish species (n_{nat} = 1,093) in the upper river was significantly greater than that of introduced fish species (n_{intro} = 290) (Table 7-3). As in the lower river, Sacramento sucker made up approximately 30% of total abundance, however two to three other native species, including *O. mykiss*, hardhead, and Sacramento pikeminnow, also comprised a large fraction of the total observed abundance in the upper river segment (Figure 7-5). The introduced smallmouth bass were seen at relatively high numbers, while largemouth bass were less than 5% of total sample size. Brown trout, an introduced species, was also less than 5% of total sample size, and was the only fish species observed exclusively in the upper Merced River.

Estimated Linear Abundance. Linear abundance estimates (number of fish per 100 m) for the upper segment are presented by reach in Figure 7-6. As shown by the wide range of values and large number of statistical outliers in the box plot for each reach, estimated linear fish abundance values in the upper river also exhibited high variability. This was particularly evident in the Upper Foothills 3 Reach where estimated linear abundance ranged across four orders of magnitude. However, overall in the upper river during fall 2006, intra-reach variability was only slightly greater than variability between the reaches (p=0.07 Kruskal-Wallis nonparametric ranking test alternative to ANOVA), suggesting that in terms of estimated linear abundance, the reaches may have behaved somewhat independently.

Species Richness, Diversity, and Percent Composition. During fall 2006, calculated indices and measured species composition in the upper river segment exhibited a pattern distinct from that of the lower river segment. As shown in Figure 7-9a, species richness was highest (11) in the Upper Foothills 3 Reach and decreased with distance upstream. The lowest value observed in any reach during 2006 was a species richness of 3 in the Yosemite Valley Reach. Species diversity decreased in much the same way (i.e., from downstream to upstream). Throughout reaches in the upper segment, species diversity corresponded roughly to species richness, indicating a more equal distribution of individuals across the species present in each reach. Percent composition data (Figure 7-9b) support this finding and also indicate that Sacramento Sucker and *O. mykiss* became generally more abundant from the downstream end of the upper river near Lake McClure to Yosemite Valley. Smallmouth bass, hardhead, and Sacramento pikeminnow were relatively more abundant in the downstream reaches (Upper Foothills 3, Upper Foothills 2, and Upper Foothills 1); hardhead had notably high relative abundance at the Upper Foothills 1 Reach. Brown trout were observed only in Upper Foothills 1, Lower Batholith, and Yosemite Valley reaches and were the numerically dominant species in the Yosemite Valley Reach (57% of total composition). Spotted bass and riffle sculpin were observed in selected reaches in lower relative abundances. Largemouth bass, common carp, and brown bullhead were only observed in the Upper Foothills 3 Reach.

7.2.2 Fish Community Assemblages

Fish species observed during 2006 are presented in Table 7-4, organized by an expanded version of the San Joaquin River Drainage (SJRD) community assemblage model originally defined in Brown et al. (2003) (see Table 5-11 for assemblage definitions). The species in Table 7-4 are also associated with more broad water temperature assemblages (Moyle 2002), with species' presence is indicated by reach and sampling season. Additionally, Figures 7-10 and 7-11 show estimated fish species linear abundance within each SJRD community assemblage for both summer and fall 2006.

As indicated in Table 7-4, fish species composition in the Merced River followed general water temperature assemblages. Warm water species, also referred to as the deep-bodied fish assemblage by Moyle (2002), include bass, sunfish, and catfish. Warm water species were observed in the lower segment of the Merced River with some species also observed in the lower reaches of the upper river segment (e.g., bass, brown bullhead, California roach, and carp) (Table 7-4). Cold water species, also referred to as the rainbow trout assemblage by Moyle (2002), include brown trout and rainbow trout *(O. mykiss)*. Cold water species were observed in upper segment reaches with *O. mykiss* also observed in the upper reaches of the lower river segment. Transitional zone fish species, referred to by Moyle (2002) as the pikeminnow-hardhead-sucker assemblage, are more adaptive to the variable water temperature between the warm water and cold water zones and include minnows (Sacramento pikeminnow and hardhead), sculpin (prickly and riffle), and suckers. Transitional zone species were observed throughout the sampled areas of the Merced River with some fishes more evenly distributed (e.g., Sacramento sucker and smallmouth bass) compared to others (e.g., hardhead and Sacramento pikeminnow).

As shown in Figures 7-10 and 7-11, fish communities observed in the Merced River during 2006 also generally supported the SJRD community assemblage model (Brown *et al.* 2003). The lower river segment was composed primarily of Valley Floor Community and Foothill Community assemblages from RM 0 to 32.3 (i.e., Confluence, Encroached and Gravel Mining 2 reaches), and Foothill Community and Trout Community assemblages from RM 32.3 to 54.3 (i.e., Gravel Mining 1, Dredger Tailings, and Merced Falls reaches). The upper river segment also generally supported the Brown *et al.* (2003) assemblage model with Foothill Community fishes in the lower reaches from RM 79.9 to 105.6 (i.e., Upper Foothills 3, 2, 1) and Trout Community fishes from RM 105.6 to 126 (i.e., Lower Batholith and Yosemite Valley reaches). One Trout community species (*O. mykiss*) extended across all upper segment reaches. Interestingly, the Valley Floor Community was also represented in the upper segment, just above Lake McClure in the Upper Foothills 3 Reach. The Foothill and Broad Geographic Range communities were distributed throughout both segments of the Merced River from Confluence Reach to the Upper Foothills 1 Reach with one species (Sacramento sucker) extending into the Lower Batholith and Yosemite Valley reaches.

Table 7-4. Fish community assemblages and species presence by season and reach during summer and fall 2006.

			Lower River						Upper River				
Species Name	**Community Assemblage**	**Water Temp Assem.**	Confluence	Encroached	Gravel Mining 2	Gravel Mining 1	Dredger Tailings	Merced Falls	Upper Foothills 3	Upper Foothills 2	Upper Foothills 1	Lower Batholith	Yosemite Valley
O. mykiss[1]	Trout	Cold					● ◎	●	◎	◎	◎	◎	◎
Brown trout,	Trout	Cold									◎	◎	◎
Trout species[2]	Trout	Cold										◎	
Sacramento sucker	Foothill	Transitional		● ◎	● ◎	● ◎	● ◎	● ◎	◎	◎	◎	◎	◎
Spotted bass	Foothill	Transitional	● ◎	● ◎	● ◎	●	◎		◎	◎			
Riffle sculpin	Foothill	Transitional	◎	● ◎	●		●	● ◎		◎			
California roach	Foothill	Warm				●	◎						
Hardhead	Foothill	Transitional	●				●		◎	◎	◎	◎	
Sacramento pikeminnow	Foothill	Transitional		●	◎	● ◎	● ◎		◎		◎		
Pikeminnow/ hardhead[2]	Foothill	Transitional							◎		◎		
Bluegill sunfish	Lower Large Trib	Warm	● ◎	● ◎	● ◎	●							
Redear sunfish	Lower Large Trib	Warm	●	● ◎	●	●							
Largemouth bass	Lower Large Trib	Warm	● ◎	● ◎	● ◎	●			◎				
White catfish	Lower Large Trib	Warm			◎	●							
Channel catfish	Lower Large Trib	Warm	◎	● ◎									
Green sunfish	SJ Main #2	Warm		● ◎	●								
Black crappie	SJ Main #2	Warm	● ◎	●	●								
Goldfish	SJ Main #2	Warm		●	● ◎	●							

Species Name	Community Assemblage	Water Temp Assem.	Lower River						Upper River				
			Confluence	Encroached	Gravel Mining 2	Gravel Mining 1	Dredger Tailings	Merced Falls	Upper Foothills 3	Upper Foothills 2	Upper Foothills 1	Lower Batholith	Yosemite Valley
Common carp	SJ Main #2	Warm	● ◎	● ◎	● ◎	●	● ◎		◎				
Hitch	SJ Main #2	Transitional					◎						
Brown bullhead	SJ Main #2	Warm				●			◎				
Bigscale logperch	SJ Main #2	Warm	● ◎	● ◎		●							
Kern Brook lamprey	SJ Main #2	Transitional	◎										
Mosquitofish	SJ Main #2	Warm	● ◎	● ◎	● ◎	● ◎	◎						
Smallmouth bass	Broad Geo Range	Transitional	●	●					◎	◎	◎		
Prickly sculpin	Broad Geo Range	Transitional	● ◎	●	●	●	● ◎	● ◎					
Striped bass	Anadromous	Anadromous		●									
Pacific lamprey	Anadromous	Anadromous			●	● ◎	●	● ◎					
Chinook salmon	Anadromous	Anadromous					●						
Sculpin species[2]	None	Transitional							◎				
Unidentified[2]	-	-					◎						

● = Present during summer 2006. ◎ = Present during fall 2006.

[1] *O. Mykiss* observed below Crocker Hoffman dam has the potential to be anadromous.

[2] Unable to identify specific species during snorkel survey.

The following sections summarize observed differences between summer 2006 (Figure 7-10) and fall 2006 (Figure 7-11) community assemblages within each river segment. While overall patterns supported the SJRD community assemblage model (Brown *et al.* 2003), in some cases species dominance or extent within each community assemblage changed with season.

7.2.2.1 Lower River

While linear densities were generally higher within all community assemblages during summer 2006, the assemblages themselves were typically similar between lower river reaches during summer and fall 2006 sample efforts. Fishes of the Foothill, Broad Geographic Range, and all three Valley Floor Community groups were broadly, but sometimes sparsely distributed (Table 7-4 and Figures 7-10 and 7-11). In contrast, Trout and Anadromous Communities were more distinct and were observed primarily/exclusively in the upstream reaches of the lower river segment.

In the lower river segment, the Trout Community was represented only by *O. mykiss,* which extended below the foothill reservoirs to the Dredger Tailings and Merced Falls reaches in summer 2006 and to the Dredger Tailings Reach in fall 2006. The Foothill Community was comprised of introduced spotted bass and native Sacramento sucker at consistently high linear densities during both summer and fall 2006 surveys. During the summer 2006 survey, the presence of spotted bass and hardhead in the Confluence Reach pulled the extent of the Foothill Community downstream to the confluence with the San Joaquin River. In the fall, it was spotted bass and prickly sculpin stretching the Foothill Community towards the confluence, while no hardhead were observed as members of this community.

There was no apparent difference between distribution of the two Valley Floor Communities (e.g., Lower Large Tributary and San Joaquin Mainstem #2) during summer and fall, although higher linear abundance of species in both communities were observed further upstream during the summer survey i.e., as far as RM 42 during summer 2006, compared with RM 26 during fall 2006. The dominant species in each community stayed roughly the same between seasons. In the Lower Large Tributary Community, two introduced species, largemouth bass and bluegill sunfish, had the highest linear abundance during summer and fall 2006. Redear sunfish was also observed at relatively high abundance during summer 2006, but significantly lower abundance and across a lesser extent during fall 2006. The San Joaquin Mainstem #2 Community contained relatively high linear abundance of several species during summer 2006, and extended only as far as Gravel Mining 1 (RM 45) in the lower river segment. In the fall, the distribution of this community generally extended up to Crocker-Huffman Dam and contained predominantly mosquitofish and common carp. In the case of common carp, the San Joaquin Mainstem #2 Community extended above the foothill reservoirs into the Upper Foothills 3 Reach (Figure 7-11).

The Andromous Community was present in both summer (above Encroached Reach) and fall 2006 (above Gravel Mining 2 Reach). The Broad Geographic Range Community, containing one introduced species (smallmouth bass) and one native species (prickly sculpin), did not extend all the way to the confluence with the San Joaquin during the summer 2006 survey. Due to the presence of prickly sculpin throughout mid- to upper reach of the lower segment, this community did extend to the foothill reservoirs. A particularly high linear abundance of smallmouth bass were observed in Confluence and Encroached reaches during summer 2006. In fall 2006, the Broad Geographic Range Community was represented only by low densities of prickly sculpin near the confluence and in the vicinity of the Crocker-Huffman Dam in the Dredger Tailings and Merced Falls reaches.

7.2.2.2 Upper River

Community assemblages in reaches of the upper segment of the Merced River were also distinguishable from one another (Table 7-4 and Figure 7-11). Trout Community species were observed in all upper segment reaches, although the native *O. mykiss* showed a much wider distribution than introduced brown trout. The Foothill Community had the highest species richness and broadest distribution between all upper segment reaches, with the exception of the Yosemite Valley Reach. The Yosemite Valley Reach contained both the Trout and Foothill communities, however only brown trout, *O. mykiss*, and Sacramento Sucker were the main species represented.

Three Valley Floor Community species, including largemouth bass, brown bullhead, and common carp, were also observed in the lowermost reach of the upper river segment (Upper Foothills 3 Reach, just upstream of Lake McClure) (Figure 7-11). The Broad Geographic Range Community was observed in the upper segment (Table 7-4 and Figure 7-11) due to the presence of smallmouth bass at relatively high estimated linear abundance in the lower three reaches of the upper segment (Upper Foothills 3 and Upper Foothills 2).

7.2.3 Habitat Use by Fish Species

Reflecting their varied life history requirements, fish distribution varied by habitat type. Eleven different habitat types were sampled between the upper and lower segments of the Merced River during summer and fall 2006, which included the macro habitat types identified in fall 2005, as well as backwater and stream margin habitat (Table 5-9). Within the lower river segment, the highest abundance of fish was observed in backwater areas, along stream margins, and in pool habitat (Figures 7-12 and 7-13). Under relatively higher flow conditions in fall 2006, floodplain habitat was also being used by fishes (Figure 7-13). Glide, pocket water, and high gradient riffle habitats did not occur at sufficient frequency (or at all) in the lower segment of the Merced River (Section 7.1.2) and so were not sampled, Within the upper river segment, the highest abundance of fish was observed in stream margin, pool, and glide habitat (Figure 7-14). Backwater and floodplain habitats did not occur at sufficient frequency (or at all) in the upper river segment (Section 7.1.3) and so were not sampled during fall 2006. While fish abundance within each habitat type was standardized to fish/100 m, the habitat area sampled was not standardized (to total sample area) for the interim analysis.

Species using each habitat also varied with habitat type. Valley Floor Community fishes (e.g., bass, sunfish, and mosquitofish) were observed primarily in backwater and margin habitats in the lower segment of the Merced River and in mid-channel pool, glide, and run habitats in the upper segment (Figure 7-12 and 7-13). Foothill Community species (e.g., hardhead and Sacramento pikeminnow) were observed in wide variety of habitats in both the lower and upper segments of the Merced River; however, within the upper segment, the highest abundances were observed in margin and glide habitat (Figure 7-14). Trout Community fishes were observed in low numbers in the lower segment along the stream margin, and in run and low gradient riffle habitat, whereas they were observed in all but the margin habitats in the upper segment and was the dominant species in the plunge pool habitat.

7.3 BMI Study

7.3.1 Aquatic Bioassessment

7.3.1.1 BMI

Aquatic bioassessment sampling was conducted in Fall 2006 at 18 sites in the lower river segment and 20 sites in the upper river segment (Table 5-12, Figure 5-1). Multihabitat composite (MHC) samples were collected at all of these sites; targeted riffle composite (TRC) samples were collected at 6 sites in the lower river and 19 sites in the upper river (Table 7-5).

Table 7-5. Aquatic bioassessment samples collected during fall 2006.

Monitoring Site	Samples Collected[1]	Monitoring Site	Samples Collected[1]
Lower River		Upper River	
CON-B1	MHC	UF3-B1	MHC & TRC
CON-B2	MHC	UF3-B2	MHC & TRC
ENC-B1	MHC	UF3-B3	MHC & TRC
ENC-B2	MHC	UF3-B4	MHC & TRC
ENC-B3	MHC	UF2-B1	MHC
ENC-B4	MHC	UF2-B2	MHC & TRC
ENC-B5	MHC	UF2-B3	MHC & TRC
GM2-B1	MHC	UF2-B4	MHC & TRC
GM2-B2	MHC	UF1-B1	MHC & TRC
GM2-B3	MHC & TRC	UF1-B2	MHC & TRC
GM1-B1	MHC & TRC	UF1-B3	MHC & TRC
GM1-B2	MHC	LB-B1	MHC & TRC
GM1-B3	MHC & TRC	LB-B2	MHC & TRC
DTR-B1	MHC & TRC	LB-B3	MHC & TRC
DTR-B2	MHC	LB-B4	MHC & TRC
DTR-B3	MHC & TRC	LB-B5	MHC & TRC
DTR-B4	MHC & TRC	YV-B1	MHC & TRC
MF-B1	MHC	YV-B2	MHC & TRC
		YV-B3	MHC & TRC
		GB-B1	MHC & TRC

[1] MHC = Multihabitat Composite; TRC = Targeted Riffle Composite.

A complete taxonomic list of sampled BMIs is presented in Appendix I-1. Metric values for individual monitoring sites are presented in Appendix I-2,. From the 63 composite samples collected, 30,476 BMIs were subsampled comprising 140 distinct taxa, including 64 EPT taxa and 15 Coleoptera taxa (Table 7-6). Several other metrics including Shannon Diversity, % Collector-Gatherer (CG) plus Collector-Filterer (CF) Individuals, % Non-Gastropoda Scrapers, % Tolerant Taxa and metrics associated with abundance and biovolume are summarized in Table 7-6 as cumulative totals by sample type and as median values (and range) across all monitoring sites. The summary metrics indicate that BMI assemblages collected from MHC samples had higher cumulative total richness and diversity when compared to TRC samples. The percentage of CG and CF individuals (cumulative total) was similar between the two sample groups while TRC samples had a higher percentage of Non-Gastropoda Scrapers. There were higher percentages of tolerant taxa in MHC samples when compared to TRC samples, when considering either the project cumulative totals or the median values across all monitoring sites. Both BMI abundance and biovolume were higher in TRC samples when compared to MHC samples, as displayed by median values for all monitoring sites in Table 7-6.

The wide range of metric values documented across monitoring sites is discussed in Section 8.3 (BMI Survey Data Evaluation). A more thorough evaluation of the observed variation, including relationships with measured habitat variables, will be carried out following completion of the second year of sample collection and processing.

Table 7-6. Metric summaries for BMI assemblages sampled during fall 2006.

Metrics[1]	Cumulative Totals			Median for all Monitoring Sites (Range)	
	Project	MHC	TRC	MHC (n=38)	TRC (n=25)
Taxonomic Richness	140	137	95	33 (19 – 45)	31 (9 – 38)
EPT Richness[2]	64	63	51	16 (4 – 28)	19 (1 – 26)
Coleoptera Richness[2]	15	15	9	2 (0 – 5)	3 (0 – 6)
Shannon Diversity	3.4	3.5	3.0	2.5 (1.3 – 3.1)	2.4 (1.4 – 2.9)
% CG+CF Individuals[2]	69	69	70	70 (39 – 95)	68 (45 – 98)
% Non-Gastropoda Scrapers[2]	18	16	21	15 (0 – 46)	20 (1 – 48)
% Tolerant Taxa[2]	17	18	14	16 (4.9 – 35)	8 (0 – 22)
BMI Abundance (#/m^2)	--	--	--	1,470 (410 – 7,450)	2,020 (67 - 13,500)
BMI Biovolume (ml/m^2)	--	--	--	2.9 (0.5 – 14)	5.4 (<0.1 – 59)

[1] Metrics based on level one standard taxonomic effort (CAMLnet, January 2003 revision).
[2] Metrics used for generating composite metric scores.
[3] MHC biovolume sample size: n=37.
[4] TRC biovolume sample size: n=24.

7.3.1.2 *Habitat Assessment*

As described in Section 5.2.3.3, a physical habitat assessment was conducted at each monitoring site, in which ten habitat parameters were ranked on a scale of 0 to 20 and totaled for the site (total possible score of 200). As shown in Table 7-7, habitat scores ranged from 76 to 190 (median=156), where scores of 0 to 50 are considered "poor;" scores of greater than 50 to 100 are considered "marginal;" scores greater than 100 to 150 are considered "suboptimal"; and scores of greater than 150 to 200 are considered "optimal" (Barbour et al. 1999). With the exception of site CON-B1 (which ranked marginal), all monitoring sites ranked in either the suboptimal or optimal range during Fall 2006 (Table 7-7).

Table 7-7. Physical habitat quality scores for BMI samples collected during fall 2006.

Monitoring Site	Physical Habitat Quality Score[1]	Monitoring Site	Physical Habitat Quality Score[1]
Lower River		Upper River	
CON-B1	76	UF3-B1	119
CON-B2	133	UF3-B2	178
ENC-B1	122	UF3-B3	187
ENC-B2	134	UF3-B4	162
ENC-B3	145	UF2-B1	131
ENC-B4	131	UF2-B2	160
ENC-B5	144	UF2-B3	165
GM2-B1	145	UF2-B4	158
GM2-B2	152	UF1-B1	168
GM2-B3	161	UF1-B2	154
GM1-B1	157	UF1-B3	169
GM1-B2	148	LB-B1	157
GM1-B3	160	LB-B2	169
DTR-B1	184	LB-B3	156
DTR-B2	153	LB-B4	185
DTR-B3	176	LB-B5	190
DTR-B4	178	YV-B1	154
MF-B1	164	YV-B2	146
		YV-B3	169
		GB-B1	179

[1] Scoring criteria are presented in Appendix I-3; individual scores by criteria and site are presented in Appendix I-2.

Results of water quality measurements are shown by monitoring site in Table 7-8.

Table 7-8. Water quality measurements taken once per reach during aquatic bioassessment sampling during fall 2006.

Monitoring Site	Temperature (°C)	Conductivity (µS/cm)	pH	Dissolved Oxygen (mg/L)	Dissolved Oxygen %
Lower River					
CON-B1	19.9	71.4	7.7	8.9	98.7
CON-B2	19.2	75.5	7.4	7.9	86.7

Monitoring Site	Temperature (°C)	Conductivity (µS/cm)	pH	Dissolved Oxygen (mg/L)	Dissolved Oxygen %
ENC-B1	18.4	59.3	7.5	8.5	89.8
ENC-B2	17.2	43.7	7.7	7.9	80.3
ENC-B3	16.7	48.0	7.5	8.5	87.7
ENC-B4	18.4	37.2	7.9	8.6	92.0
ENC-B5	18.7	31.3	7.6	10.3	110.6
GM2-B1	16.4	29.2	7.7	7.9	81.0
GM2-B2	18.2	33.4	7.5	8.9	93.9
GM2-B3	15.7	28.3	7.5	8.7	88.6
GM1-B1	17.9	30.6	7.5	11.5	121.8
GM1-B2	14.2	27.1	7.7	8.7	85.1
GM1-B3	15.4	28.6	7.7	8.8	87.5
DTR-B1	14.8	28.2	7.3	9.4	93.0
DTR-B2	13.4	24.7	7.7	8.7	84.0
DTR-B3	15.4	24.9	7.7	10.0	99.3
DTR-B4	14.2	24.1	7.6	9.9	95.8
MF-B1	15.4	24.3	7.7	9.6	96.1
Upper River					
UF3-B1	18.3	67.1	7.8	8.5	90.3
UF3-B2	17.2	61.8	7.9	7.9	84.0
UF3-B3	16.9	61.8	8.0	8.8	89.4
UF3-B4	17.9	62.9	8.0	7.0	68.0
UF2-B1	18.2	58.7	7.8	8.8	94.0
UF2-B2	14.2	57.6	6.4	9.0	88.0
UF2-B3	14.6	25.3	7.2	8.6	85.6
UF2-B4	15.7	55.7	7.5	8.8	80.3
UF1-B1	16.8	46.0	7.5	9.3	95.6
UF1-B2	14.0	39.7	7.3	8.7	86.5
UF1-B3	14.8	40.3	7.8	8.9	88.7
LB-B1	12.0	29.6	8.0	9.4	86.9
LB-B2	10.5	27.0	7.5	10.0	90.3
LB-B3	12.1	27.0	7.1	8.5	80.0
LB-B4	11.6	29.2	*	9.0	80.9
LB-B5	10.8	28.3	*	8.9	80.7
YV-B1	11.2	25.5	7.7	8.9	80.8
YV-B2	10.5	23.6	7.3	8.8	78.5
YV-B3	7.7	19.9	7.5	11.2	94.0
GB-B1	8.0	20.2	8.0	10.4	88.00

Additional physical habitat data collected with MHC and TRC samples are summarized by monitoring site in Table 7-9 and Table 7-10. Transect-scale data for all sites are summarized in Appendix I-3. As shown by the wide range of measured transect values, intra-site variation was pronounced for the MHC samples. As expected, this variability is greater than that of TRC samples, with the disparity inherent to differences in sample design. MHC collections were made at 11 transects every 50 m along the reach and more often than not, the transects were located in distinct habitat units. In contrast, TRC samples were collected from 8 quadrats, which often occurred within the same riffle unit and were in a homogeneous physical habitat.

Table 7-9. Site-scale physical habitat data for MHC samples collected during fall 2006.

Reported as median (range) for 11 transects.

Monitoring Site	Habitat Type[1]	Wetted Width (m)	Canopy Cover (%)	Depth (ft)	Velocity (ft/s)	Embedd-edness (%)	Substrate[1]
Lower River							
CON-B1	Run	25 (20-30)	15 (0 – 80)	3 (2 – 4)	1 (0 – 2)	90 (80 – 100)	Fines
CON-B2	Run/ Pool	38 (34 – 42)	0 (0 – 75)	1.9 (0.5 – 4.8)	1.1 (0.5 – 2)	80 (0 – 100)	Fines
ENC-B1	Run/ Pool	24 (18 – 32)	5 (0 – 100)	2 (1 – 6)	1 (0 – 2)	50 (0 – 75)	Fines/Boulder
ENC-B2	Pool/ Run	32 (26 – 34)	45 (0 – 100)	2 (2 – 4)	0 (0 – 2)	70 (20 – 100)	Fines
ENC-B3	Run/ Pool	31 (23 – 40)	35 (0 – 100)	2 (0-5)	1 (0 -2)	20 (0 – 100)	Fines/FOM
ENC-B4	Pool/ Run	26 (23 – 30)	15 (0 – 60)	2 (1 – 10)	0 (0 – 5)	100 (100)	Fines/FOM
ENC-B5	Run/ Pool	31 (21 – 46)	0 (0 – 15)	2 (1 – 4)	2 (1-4)	25 (15 – 100)	Fines/Gravel
GM2-B1	Pool/ Run	94 (83 –	8 (0 – 70)	3 (2 – 37)	0 (0)	100 (50 – 100)	Fines
GM2-B2	Run	24 (20 – 60)	5 (0 – 10)	2 (1 – 3)	2 (1 – 4)	25 (10 – 80)	Gravel/Fines
GM2-B3	Run/ Riffle	32 (13 – 50)	15 (0 – 80)	2 (1 -3)	1 (0 – 3)	50 (0 – 100)	Fines/Gravel
GM1-B1	Run/ Pool	40 (18 – 50)	0 (0 -8)	3 (1 – 3)	2 (1 – 6)	10 (0 – 60)	Fines/Gravel
GM1-B2	Pool/ Run	125 (65 –	25 (0 – 60)	3 (2 – 4)	0 (0 – 1)	50 (50 – 100)	Fines/Gravel
GM1-B3	Run/ Riffle	25 (21 – 56)	5 (0 – 80)	3 (1 – 3)	2 (0 – 4)	20 (0 – 50)	Gravel/Cobble
DTR-B1	Pool/ Run	24 (22 – 64)	15 (0 – 100)	2 (1 – 4)	3 (1 – 7)	20 (0 – 75)	Gravel/Fines
DTR-B2	Pool/ Run	66 (60 – 84)	50 (0 – 95)	2 (1 – 4)	1 (1)	70 (15 – 90)	Fines/Gravel

Monitoring Site	Habitat Type[1]	Wetted Width (m)	Canopy Cover (%)	Depth (ft)	Velocity (ft/s)	Embedd-edness (%)	Substrate[1]
DTR-B3	Run/ Pool	45 (33 – 80)	30 (10 – 90)	2 (1 – 4)	2 (1 – 4)	25 (15 – 90)	Gravel/Cobble
DTR-B4	Run/ Riffle	60 (42 – 70)	35 (0 -90)	1 (0 -3)	2 (0 – 4)	10 (0 – 80)	Cobble/Fines
MF-B1	Pool/ Run	48 (36 – 60)	30 (0 – 90)	3 (2 – 4)	1 (0 – 2)	50 (0 – 100)	Fines/Boulder
Upper River							
UF3-B1	Pool/ Run	22 (14 – 38)	0 (0 – 10)	2 (1 – 4)	2 (1 – 2)	50 (0 – 100)	Fines/ Cobble
UF3-B2	Run/ Riffle	18 (14 – 26)	10 (0 – 30)	1 (0 – 4)	1 (0 – 5)	5 (0 – 40)	Cobble/ Boulder
UF3-B3	Run/ Riffle	15 (12 – 26)	10 (5 – 50)	1 (0 – 3)	1 (0 – 4)	20 (0 – 100)	Cobble/ Boulder
UF3-B4	Riffle/ Run	40 (16 – 40)	0 (0 – 15)	2 (1 – 3)	1 (0 – 3)	35 (0 – 70)	Gravel/ Cobble
UF2-B1	Pool/ Run	27 (22 – 35)	20 (0 – 40)	1 (0 – 3)	0 (0-1)	33 (0- 80)	Boulder/Cobb le
UF2-B2	Run/ Riffle	25 (14 -30)	0 (0 – 35)	1 (0 – 4)	1 (0 – 3)	0 (0 – 50)	Boulder/Cobb le
UF2-B3	Riffle/ Run	20 (16 – 24)	5 (0 – 30)	2 (0 – 4)	1 (0 – 3)	5 (0 – 100)	Boulder/Cobb le
UF2-B4	Pool/ Run	16 (14 -25)	0 (0 – 50)	2 (0 – 3)	1 (0 – 2)	25 (0 – 50)	Cobble/ Boulder
UF1-B1	Riffle/ Run	26 (21 – 49)	10 (0 – 20)	1 (1 – 4)	1 (0 – 3)	15 (0 – 45)	Boulder/Cobb le
UF1-B2	Riffle/ Pool	25 (20 – 28)	10 (5 – 75)	1 (0 – 4)	0 (0 – 2)	50 (20 – 65)	Boulder/Cobb le
UF1-B3	Riffle/ Run	26 (20 – 30)	5 (0 – 30)	1 (1 – 3)	1 (0 – 3)	5 (0 – 15)	Boulder/Cobb le
LB-B1	Run/ Riffle	19 (10 – 50)	30 (0 – 55)	2 (0 – 4)	1 (0 – 3)	0 (0 – 15)	Boulder/Cobb le
LB-B2	Cas-cade	18 (16 – 20)	20 (5 – 90)	1 (0 – 3)	1 (0 – 3)	30 (0 – 100)	Cobble/ Fines
LB-B3	Run/ Pool	14 (14 – 22)	50 (30 – 65)	1 (0 -3)	0 (0 – 1)	60 (10 – 80)	Fines/ Gravel
LB-B4	Run/ Riffle	16 (16 – 47)	10 (5 – 35)	2 (0 – 3)	0 (0 – 5)	0 (0 – 40)	Boulder/Cobb le
LB-B5	Run/ Glide	17 (10 – 20)	25 (0 – 70)	1 (0 – 3)	0 (0 – 3)	23 (0 – 50)	Boulder/Cobb le
YV-B1	Riffle/ Run	16 (12 – 22)	55 (10 –	1 (0 – 3)	0 (0 – 2)	45 (20 – 100)	Gravel/ Fines

Monitoring Site	Habitat Type[1]	Wetted Width (m)	Canopy Cover (%)	Depth (ft)	Velocity (ft/s)	Embedd-edness (%)	Substrate[1]
YV-B2	Pool/ Run	20 (12 – 36)	50 (30 –	1 (0 – 3)	0 (0 – 2)	40 (10 – 85)	Gravel/ Fines
YV-B3	Riffle/ Pool	17 (16 – 20)	50 (30 – 90)	1 (0 – 5)	0 (0 – 4)	35 (10 – 60)	Cobble/ Gravel
GB-B1	Riffle	18 (12 – 30)	50 (20 – 90)	1 (0 – 2)	1 (0 – 3)	38 (10 – 50)	Boulder/ Cobble

1 Listed as Dominant/Subdominant.
2 Reported as median (range) for 11 transects.

Table 7-10. Site-scale physical habitat data for TRC samples collected during fall 2006.
Reported as median (range)[1] for 8 quadrats.

Monitoring Site	Canopy Cover (%)[1]	Depth (ft)[1]	Velocity (ft/s)[1]	Embedd-edness (%)[1]	Substrate[2]
Lower River					
GM2-B3	12	0.9	1.9	50	Gravel/Cobble
GM1-B1	3 (0 – 5)	0.5 (0.2 – 0.8)	2.8 (1.8 – 3.3)	0 (0 – 5.0)	Gravel/Cobble
GM1-B3	5	0.6	2.2	10	Cobble/Gravel
DTR-B1	0	1.0	6.5	5	Gravel/Cobble
DTR-B3	80	1.3	3.7	15	Gravel/Cobble
DTR-B4	43	1.2	2.6	20	Gravel/Cobble
Upper River					
UF3-B1	5	0.8 (0.5 – 1.0)	2.1 (2.0 – 2.2)	60	Gravel/Cobble
UF3-B2	3 (0 – 10)	0.8 (0.4 – 1.0)	1.7 (1.0 – 2.3)	5 (0.0 – 5.0)	Cobble/Boulder
UF3-B3	25	0.8	3.1	10	Gravel/Cobble
UF3-B4	5 (5 – 20)	1.0 (0.8 – 1.3)	1.4 (1.3 – 2.2)	40 (25 – 50)	Gravel/Cobble
UF2-B2	0 (0 – 60)	0.5 (0.3 – 1.7)	0.9 (0.3 – 2.5)	3 (0 – 40)	Boulder/Cobble
UF2-B3	5 (0 – 25)	0.5 (0.2 – .7)	0.9 (.4 – 3.2)	0 (0 – 40)	Boulder/Cobble
UF2-B4	8 (0 – 45)	0.8 (0.0 – 1.2)	1.6 (0.5 – 3.7)	0	Boulder/Cobble

Monitoring Site	Canopy Cover (%)[1]	Depth (ft)[1]	Velocity (ft/s)[1]	Embedd-edness (%)[1]	Substrate[2]
UF1-B1	3 (0 – 10)	0.7 (0.2 – 1.8)	0.9 (0.6 – 1.7)	0 (0 – 50)	Boulder/Cobble
UF1-B2	25	0.7	1.3	45	Cobble/Boulder
UF1-B3	18 (5 – 30)	0.9 (0.5 – 1.4)	2.3 (0.3 – 3.3)	0.0	Boulder/Cobble
LB-B1	43 (10 – 60)	1.4 (0.5 – 1.7)	1.4 (0.9 – 2.2)	0.0	Boulder/Cobble
LB-B2	45 (5 – 60)	0.8 (0.5 – 2.0	1.3 (0.8 – 1.9)	38 (15 – 50)	Cobble/Gravel
LB-B3	43 (30 – 55)	0.7 (0.6 – 1.1)	1.7 (1.4 – 1.9)	10 (10 – 15)	Gravel/Fines
LB-B4	8 (5 – 20)	0.8 (0.3 – 1.9)	3.6 (0.6 – 4.3)	0 (0 – 30)	Boulder/Cobble
LB-B5	25 (25 – 40)	0.6(0.3 – 1)	4.3 (0.8 – 4.4)	20 (5 – 25)	Boulder/Cobble
YV-B1	73 (60 – 80)	1.1 (0.8 – 1.2)	1.1 (0.8 – 1.2)	70 (60 – 80)	Fines/Gravel
YV-B2	55	0.6	1.3	20	Gravel/Cobble
YV-B3	22 (10-25)	1.2 (0.5 – 1.3)	1.0 (0.7 – 2.2)	33	Cobble/Boulder
GB-B1	50 (40 – 85)	0.5 (.5 – 1.4)	1.7 (.2 – 2.6)	22 (10 – 50)	Cobble/Boulder

1 Range reported when three or more riffles were sampled.

2 Listed as Dominant/Subdominant.

7.3.2 Exotics Survey

Passive habitat traps (Figure 5-7) targeting the Chinese mitten crab, were deployed at five sites (Table 5-12, Figure 5-1) in the lower river segment and monitored biweekly from July through October 2006. In addition, bioassessment samples were inspected for the Asiatic clam and the New Zealand mud snail. No Chinese mitten crabs were captured in the passive habitat traps, nor were any New Zealand mud snails observed in the bioassessment samples. However, the Asiatic clam was present in samples collected from 12 monitoring sites located in the lower river segment, beginning at the confluence with the San Joaquin River (CON-B1, RM=1.0) and continuing upstream to site GM1-B3 (RM=44.5).

7.4 Avian Study

One-hundred and twenty seven avian species were detected in both the upper and lower Merced River corridor across all seasons during 2006. Of these, three were introduced species common to the region; European starling, rock pigeon, and house sparrow. Over half of avian species observed were songbirds (83 of 127 species, or 65%). Several state species of special concern were recorded, including Cooper's hawk, sharp-shinned hawk, osprey, common yellow throat, tricolored blackbird, yellow warbler, and double-crested cormorant. Common and scientific names for all avian species detected are presented in Appendix J, Table J-1.

7.4.1 Breeding Season

Overall, a total of 4,748 individuals and 109 avian species (including birds flying over and detections >50 meters) were detected in the upper and lower Merced River corridor during the 2006 breeding season. The number of individual birds, species richness and species diversity for each point is presented in Appendix J, Table J-3). In general, points located along the lower segment of the Merced River exhibited a higher number of individuals, species richness and species diversity than sites located along the upper segment. As shown in Figure 7-15a, monitoring sites in the Confluence and Encroached reaches (RM 0 to 8.1 and 8.1 to 26.6, respectively) showed a high species richness, with greater than seven species on average per point. In contrast, sites along the upper Merced River exhibited less than five species on average per point (Figure 7-15b). Species richness demonstrated a statistically significant linear trend (r^2=0.83, $p<0.0001$) of decreasing species richness with distance upstream from the confluence with the San Joaquin River.

Avian community composition also differed between the upper and lower segments of the Merced River (Appendix J, Table J-4). There were 80 total species detected along the lower river corridor, 45 of which were unique to lower river sites. Along the upper river, 64 total species were detected, with 29 species unique to the upper river sites. Thirty five species were common to both the upper and lower river corridor.

The majority of bird detections during the 2006 breeding season point counts were songbirds. The most common species detected was the tree swallow, followed by European starling, an introduced species common throughout California. The native songbirds bushtit and house wren were also frequently observed during the 2006 breeding season. Nine raptor species were detected, including the white-tailed kite, which is proposed for listing under the Federal Endangered Species Act (ESA) and Swainson's hawk which is listed as threatened under the California ESA. Breeding behavior was evident for Cooper's hawk and red-shouldered hawk (Figure 7-16 and Appendix J, Table J-5). A single Cooper's hawk nest was found at site GM1-A2 and one Red-shouldered Hawk was observed carrying nesting material at site DTR-A2. The majority of raptor detections occurred in the lower river.

7.4.2 Fall Migration

During the 2006 fall migration, a total of 1,762 birds and 93 species were observed along the upper and lower Merced River. The average number of detections per visit and overall species richness values for each site is presented in Figure 7-17a. As was the case for the breeding season results, monitoring sites in the lower river corridor had, on average, higher abundance and bird species richness than sites in the upper river corridor (see Appendix J, Table J-6 for detections by species and by monitoring site). The high number of individuals observed at site DTR-A2 was due in part to large flocks of cedar waxwing. Summed across all sites, the native ruby-crowned kinglet was the most abundant species detected during fall area searches. Other more common migrants include cedar waxwing, American robin and yellow-rumped warbler.

7.4.3 Winter Season

Winter area search surveys will take place three times during the winter of 2006/2007. Only results of the first survey are presented in this report, since the field season is not yet complete. During December 2006, area searches were conducted at five sites in the lower river corridor. A total of 458 birds and 44 species were detected. As shown in Figure 7-17b, species richness was similar across all sites in December 2006. Measured abundance varied only slightly across sites, with the exception of site CON-A1 (George J. Hatfield State Park) which exhibited 30-40% less bird detections than other sampled locations. The number of detections for each species at each site is presented in Appendix J-7. Summed across all sites, ruby-crowned kinglet and golden-crowned sparrow, both native to the region, were the most abundant species during the first round of winter surveys.

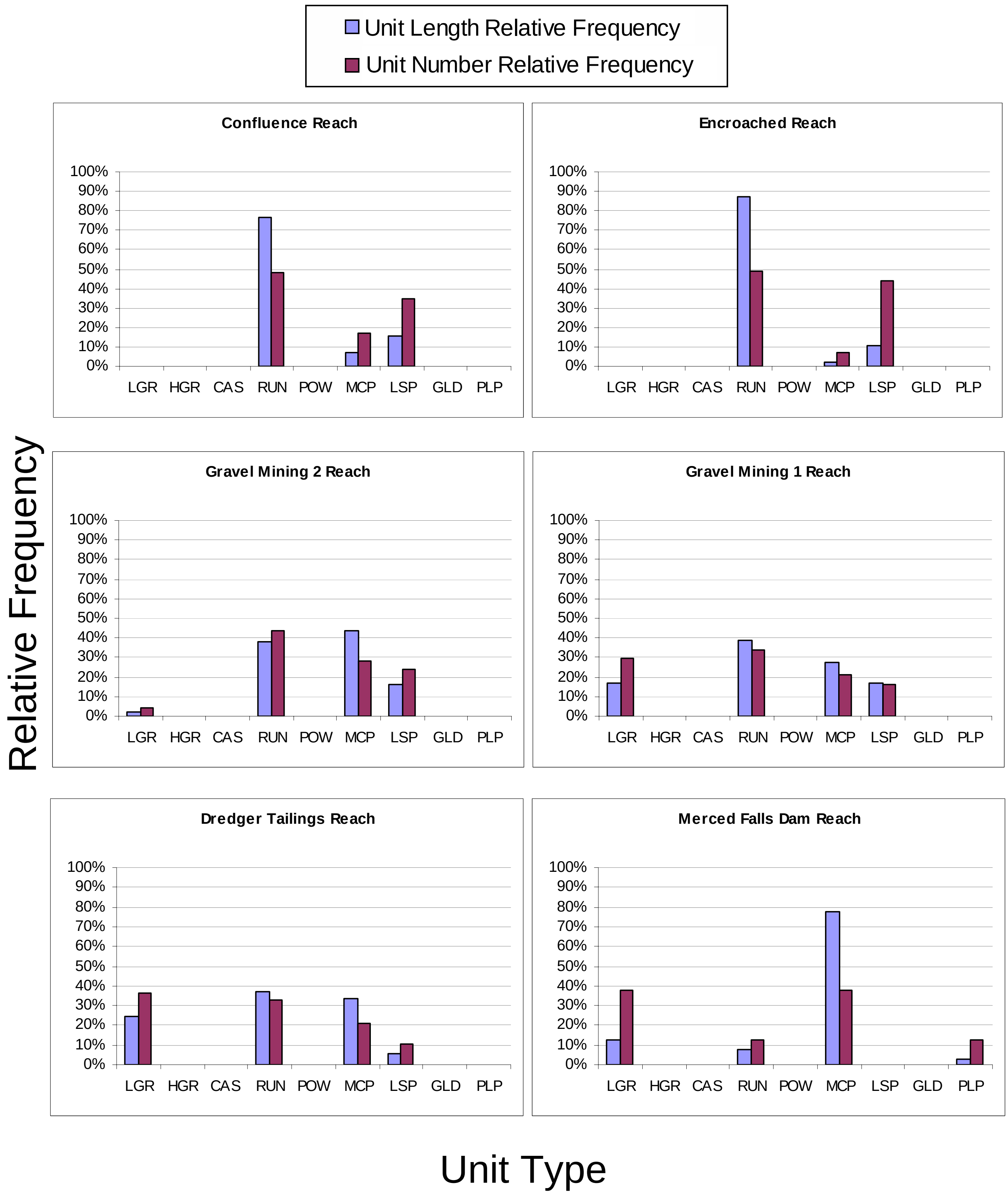


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Figure 7-1a. Relative frequency of habitat unit types by reach under low flow conditions for the lower Merced River. Graphs are based on aerial videography dated from October 3-5, 2005. Details on the methodology can be found in Section 5.2.1.

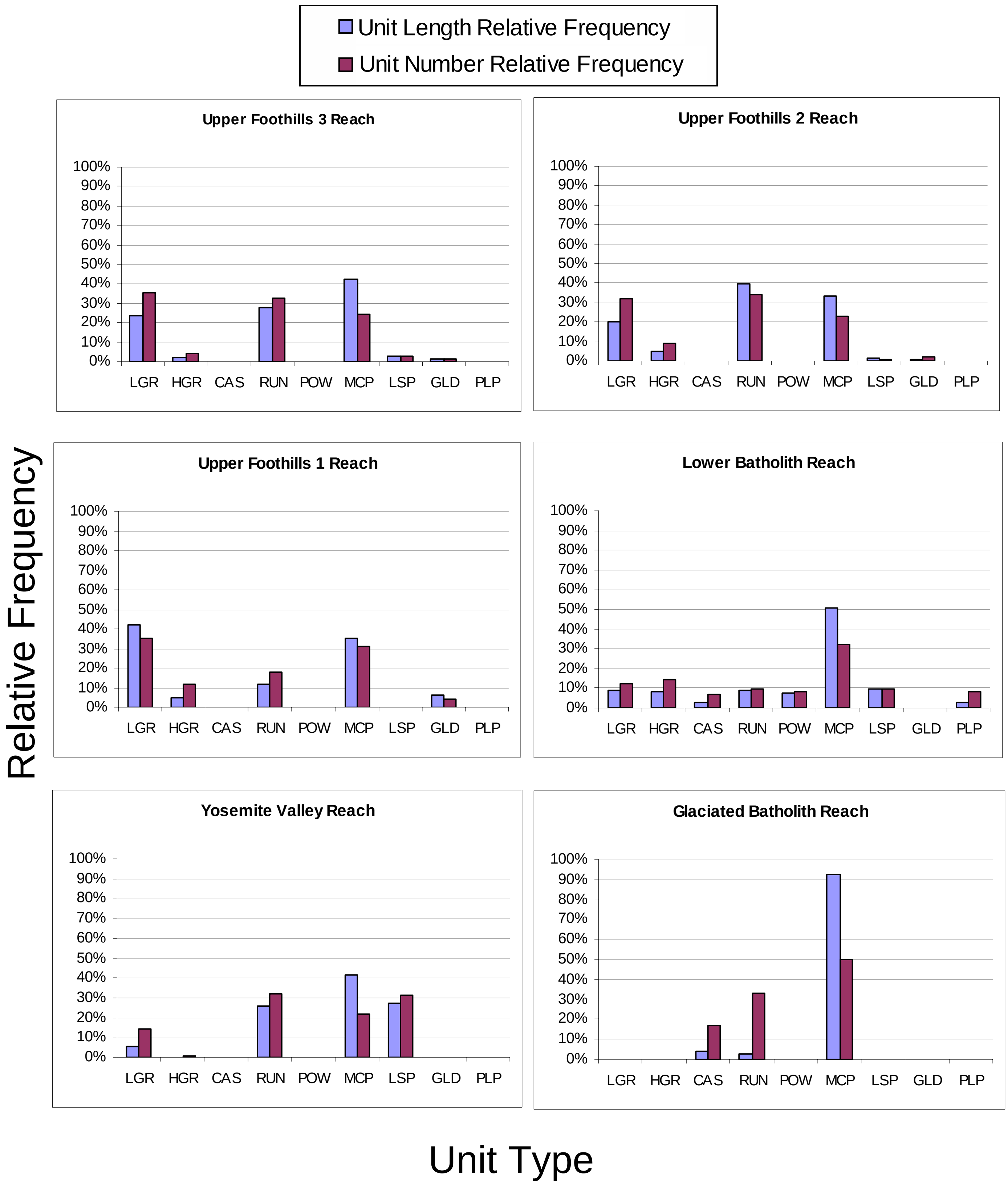

Figure 7-1b. Relative frequency of habitat unit types by reach under low flow conditions for the upper Merced River. Data for the Upper Foothills reaches are based on aerial videography from November 15, 2005. Discrete portions of the Lower Batholith, Yosemite Valley, and Glaciated Batholith reaches were mapped using on-the-ground techniques from November 15-22, 2005.

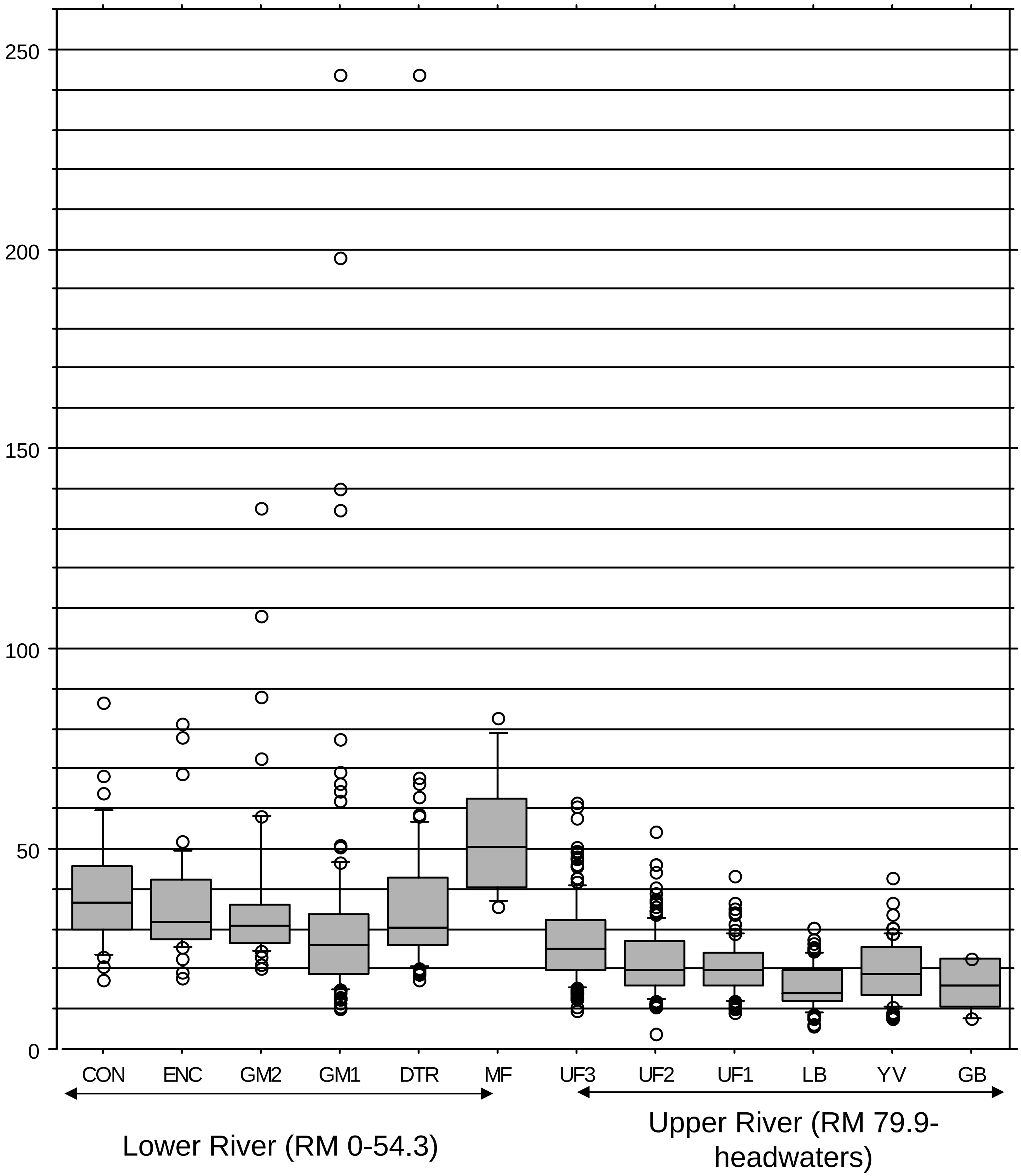

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Figure 7-2. Median stream widths by reach for lower and upper Merced River. Median, 25th and 75th percentiles are shown by boxes, and whiskers indicate 10th and 90th percentiles. Filled circles indicate data outside the 10th and/or 90th percentile.

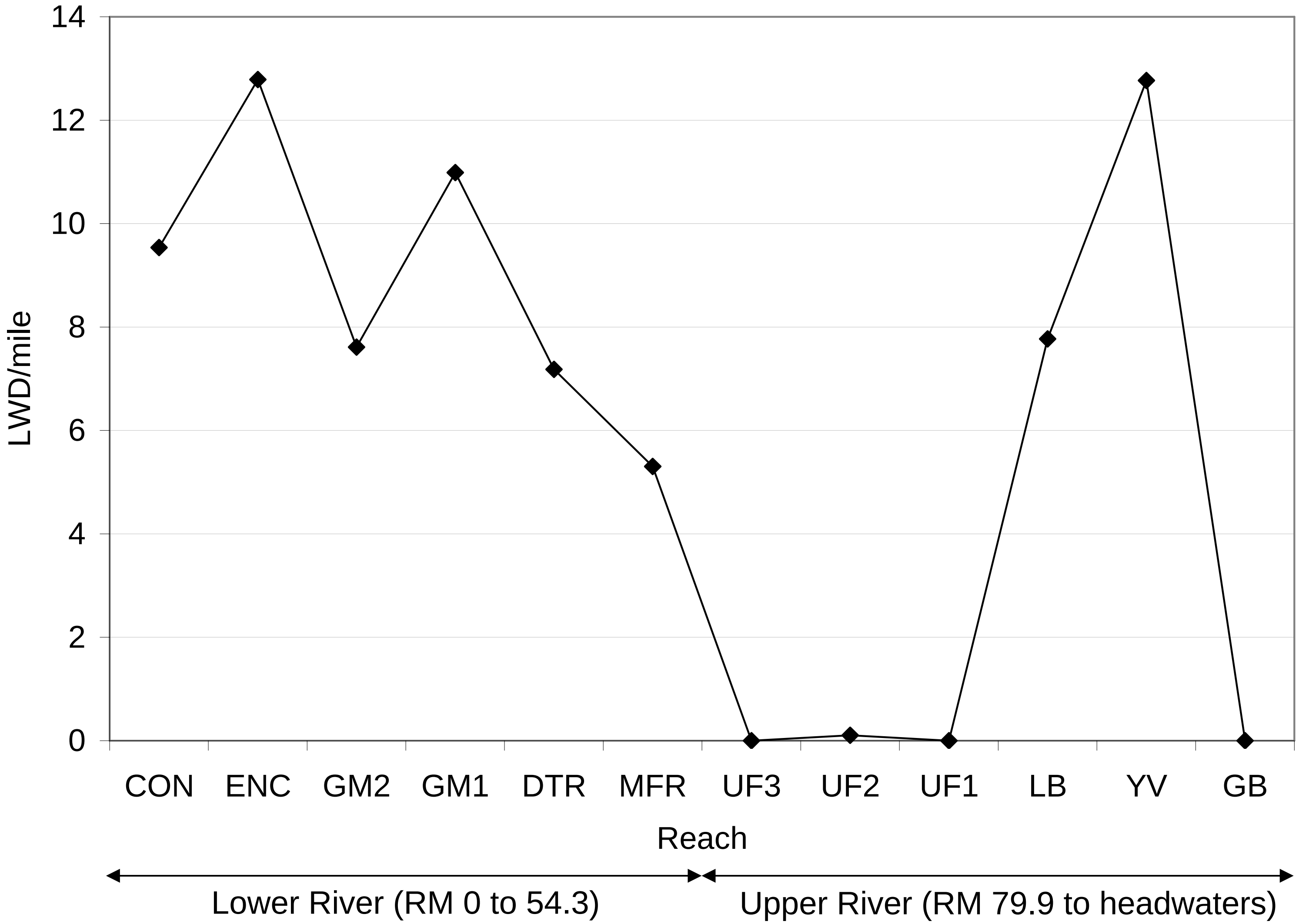

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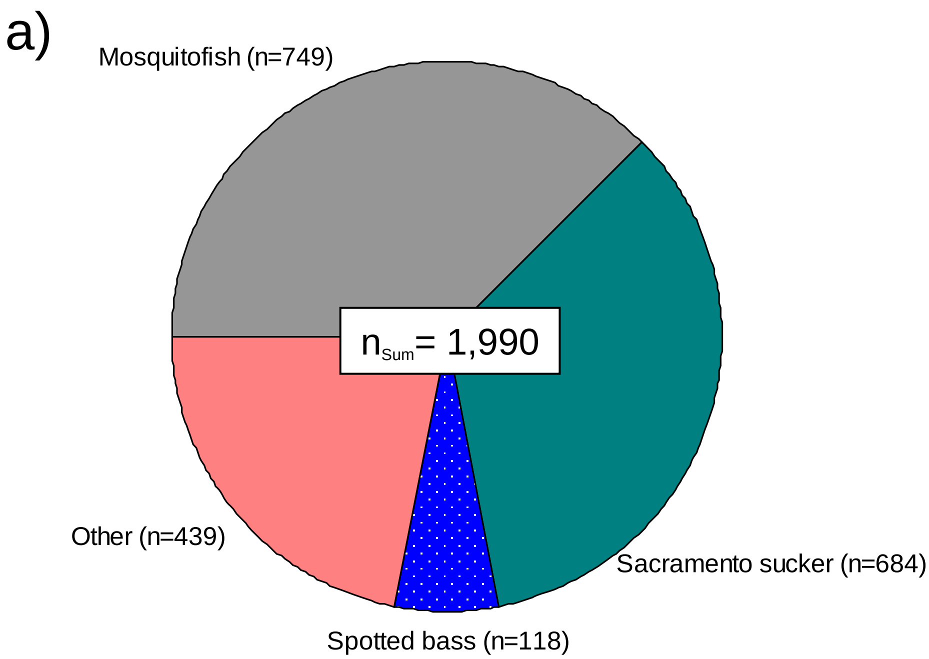
Figure 7-3. Mapped large woody debris density (LWD/mile) in the lower and upper Merced River under low flow conditions, fall 2005. Discrete portions of the Lower Batholith (LB), Yosemite Valley (YV) and Glaciated Batholith (GB) reaches were mapped, so density estimates do not encompass the full reach extent.



Lower River "Other"	Sum	Fall
Bluegill sunfish	70	-
Pacific lamprey	60	3
Common carp	47	19
Largemouth bass	46	-
Prickly sculpin	46	7
Smallmouth bass	43	-
Hardhead	31	-
Sacramento pikeminnow	16	-
California roach	15	1
Bigscale logperch	14	5
Redear sunfish	11	1
Riffle sculpin	10	5
O. mykiss	7	3
Green sunfish	7	1
Goldfish	6	1
Black crappie	3	1
Brown bullhead	2	-
Channel catfish	2	5
Striped bass	1	-
White catfish	1	1
Chinook salmon	1	-
Hitch	-	3
Kern Brook lamprey	-	1
Unknown	-	1

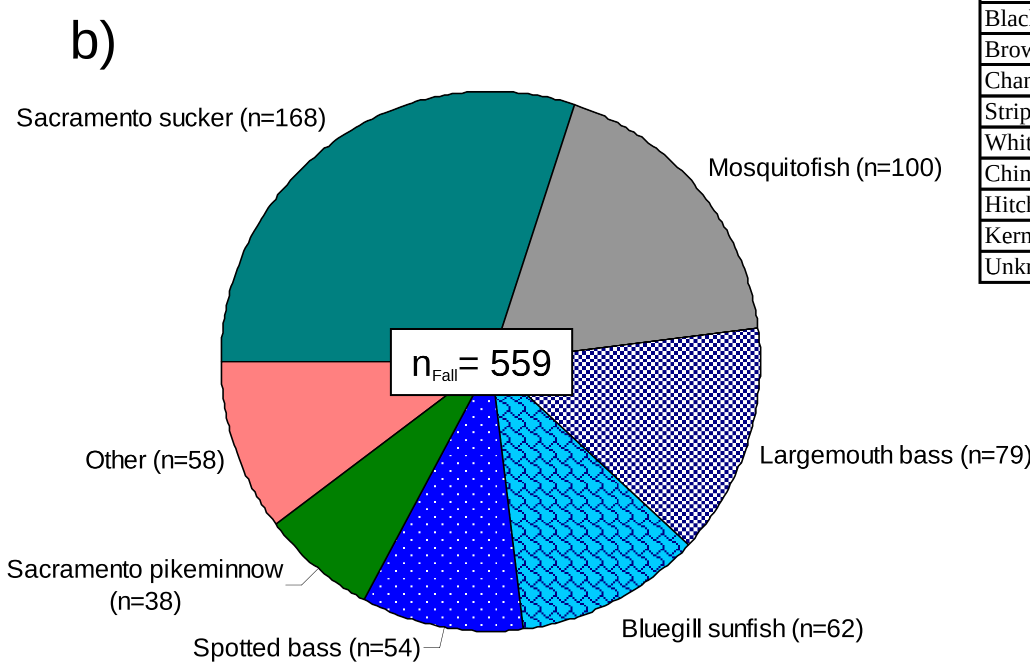
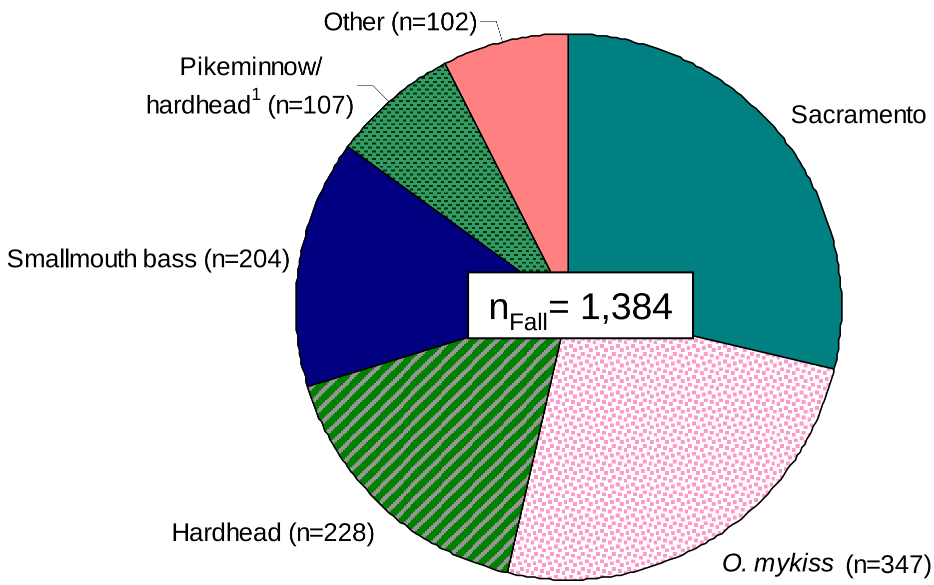


Figure 7-4. Fish species composition in the lower Merced River in a) summer 2006 and b) fall 2006. Number of individuals observed for each species is given in parentheses, and total seasonal sample size is shown in the center of the pie chart. One individual fish was not identifiable during the fall snorkel survey.



Upper River "Other"	Fall
Brown trout	29
Largemouth bass	28
Common carp	25
Sacramento pikeminnow	10
Sculpin species	4
Spotted bass	3
Trout species	1
Riffle sculpin	1
Brown bullhead	1

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Figure 7-5. Fish species composition in the upper Merced River during fall 2006. Number of individuals observed for each species is given in parentheses, and total seasonal sample size is shown in the center of the pie chart. [1]Unable to be differentiated during snorkel surveys.

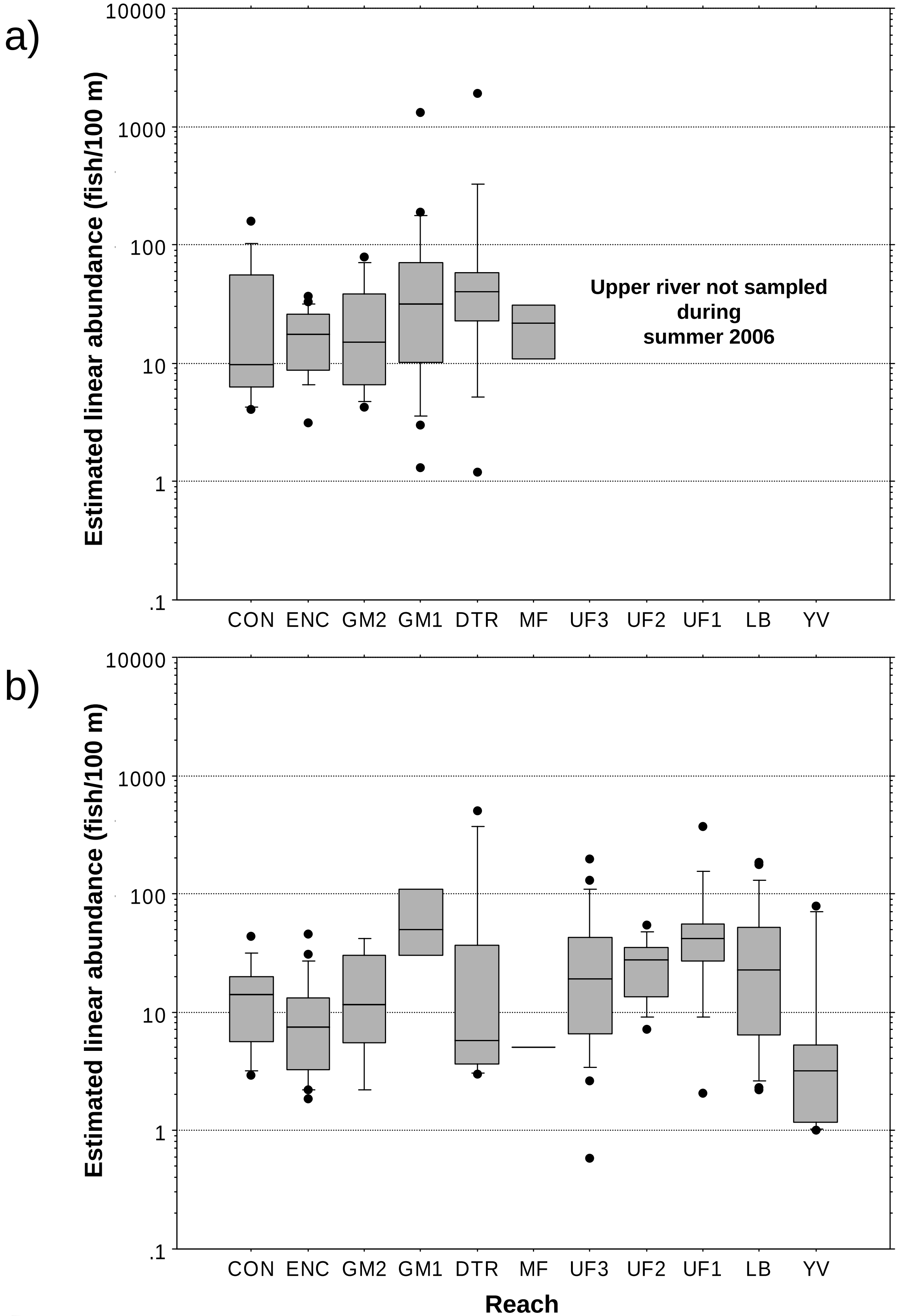

Figure 7-6. Estimated linear abundance for fish species observed during a) summer 2006 and b) fall 2006. Median, 25th and 75th percentiles are shown by boxes, and whiskers indicate 10th and 90th percentiles. Filled circles indicate data outside the 10th and/or 90th percentile.

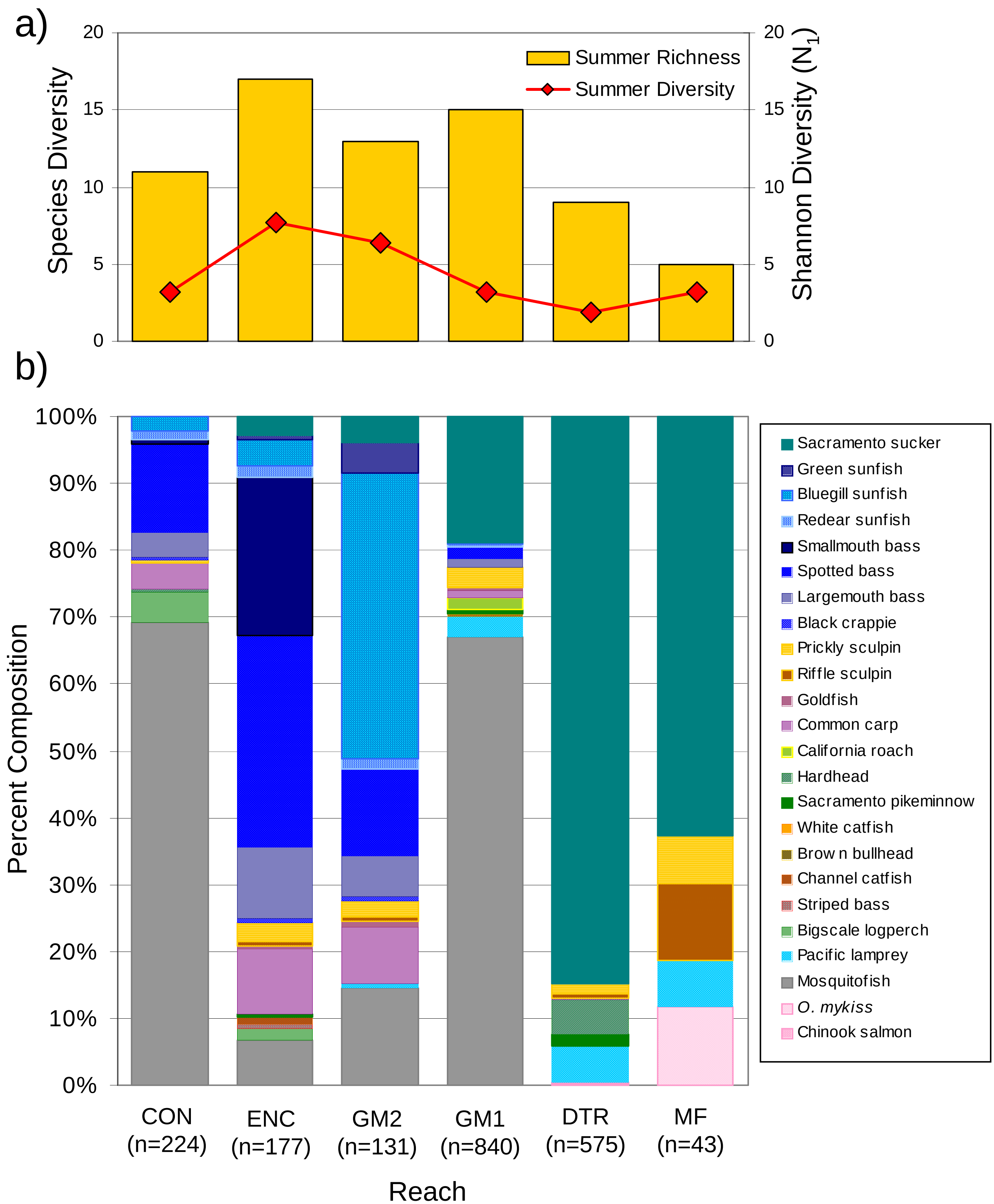

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Figure 7-7. a) Species richness and diversity and b) percent composition by reach in the lower Merced River during summer 2006. Reach definitions are given in Table 7-2.

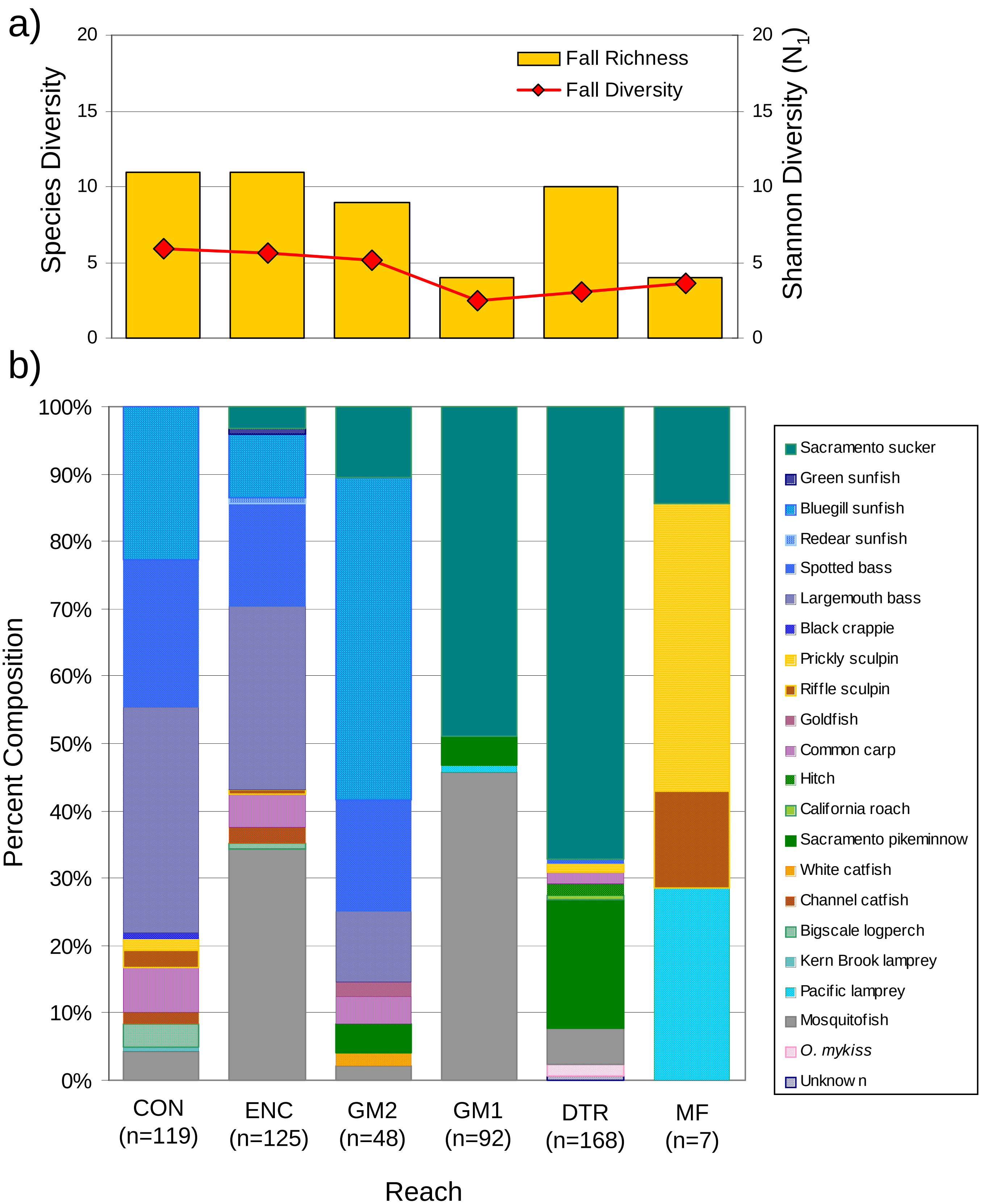

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Figure 7-8. a) Species richness and diversity and b) percent composition by reach in the lower Merced River during fall 2006. Reach definitions are given in Table 7-2.

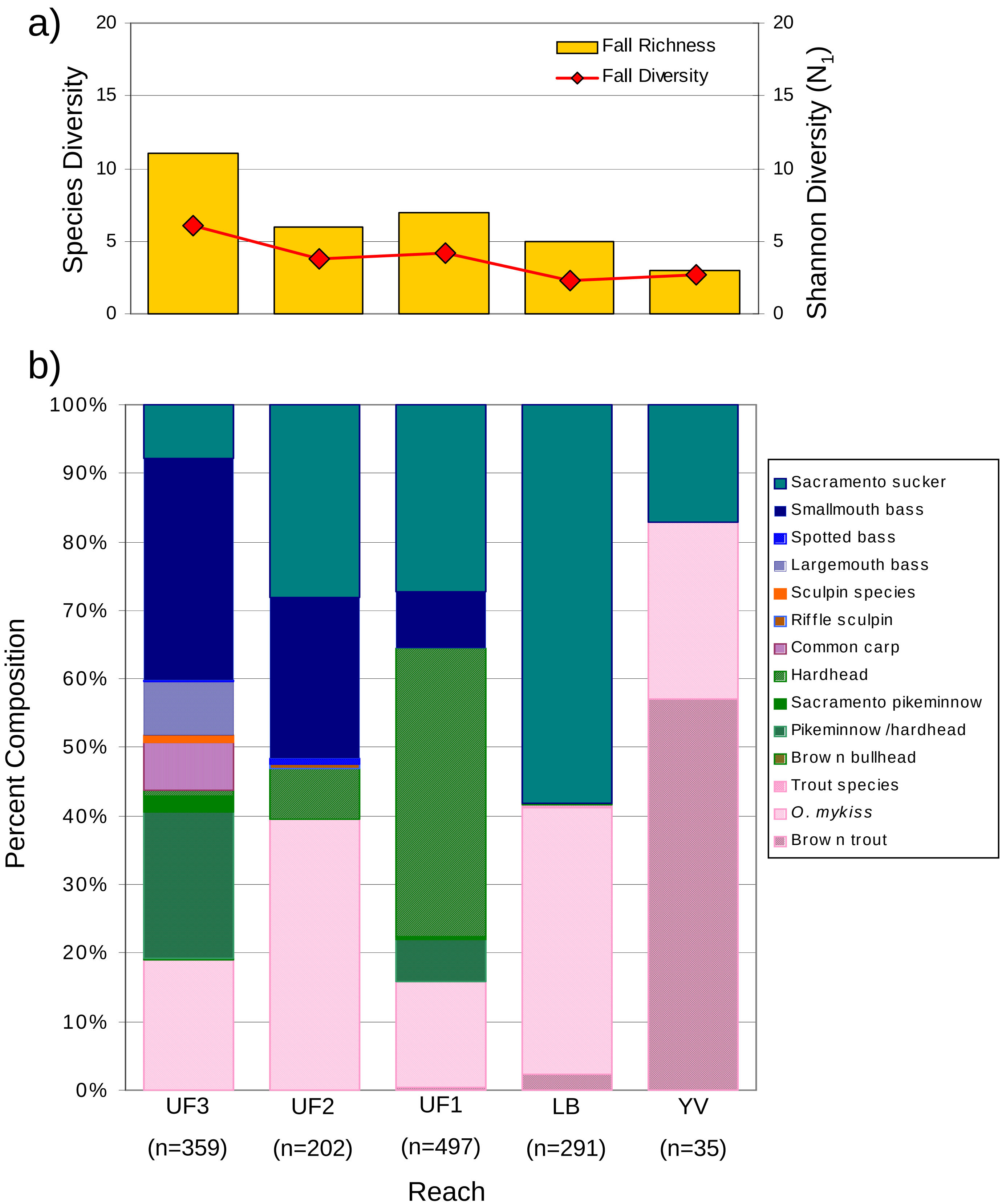

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Figure 7-9. a) Species richness and diversity and b) percent composition by reach in the upper Merced River during fall 2006. Reach definitions are given in Table 7-2.

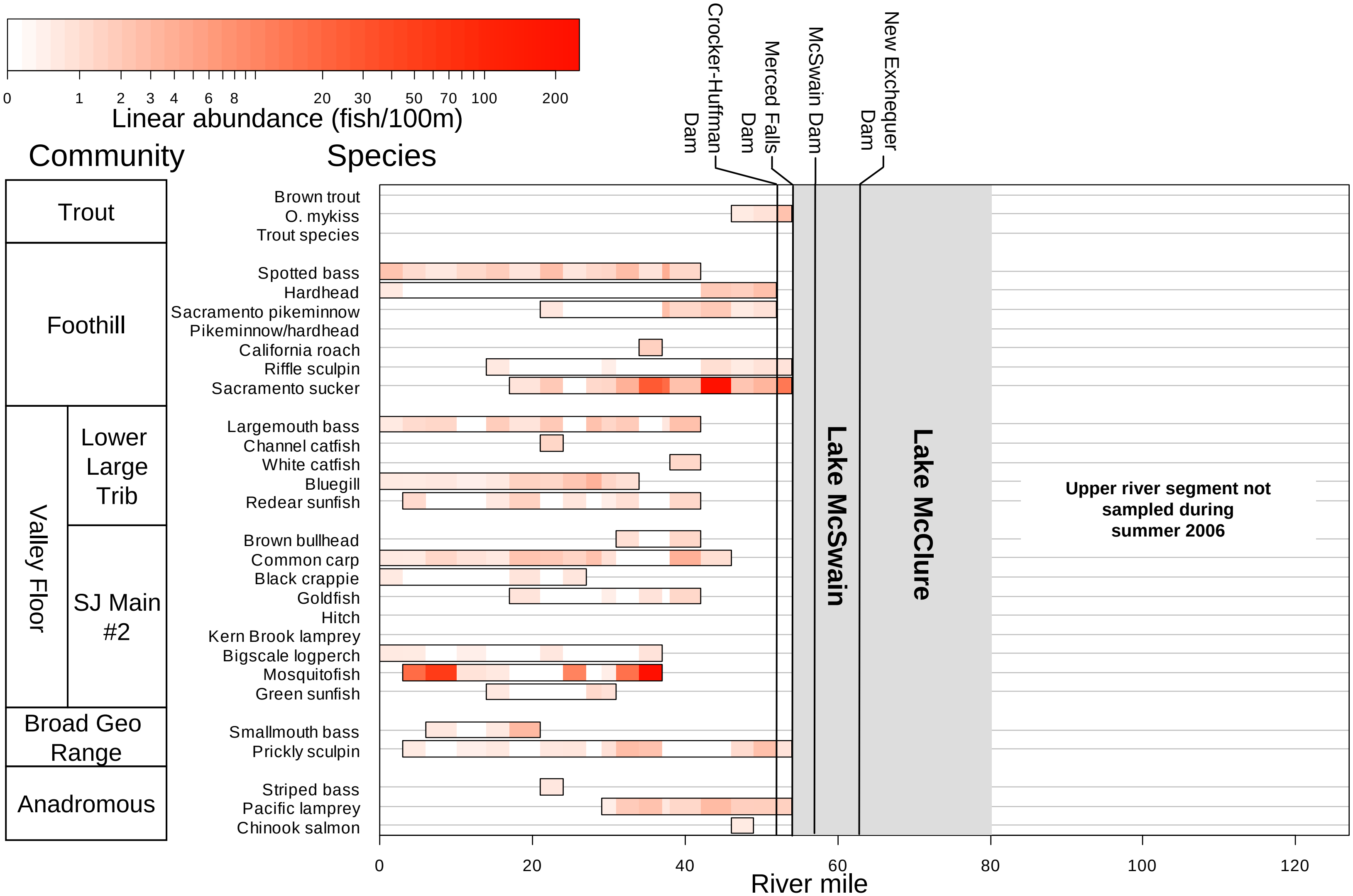

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Figure 7-10. Fish linear abundance from summer 2006 snorkel and electrofishing surveys. See Table 5-11 for fish community descriptions. Only the lower river was sampled during the summer surveys. The foothill reservoirs, Lake McSwain and Lake McClure, were not sampled as part of the Merced Alliance biological assessment.

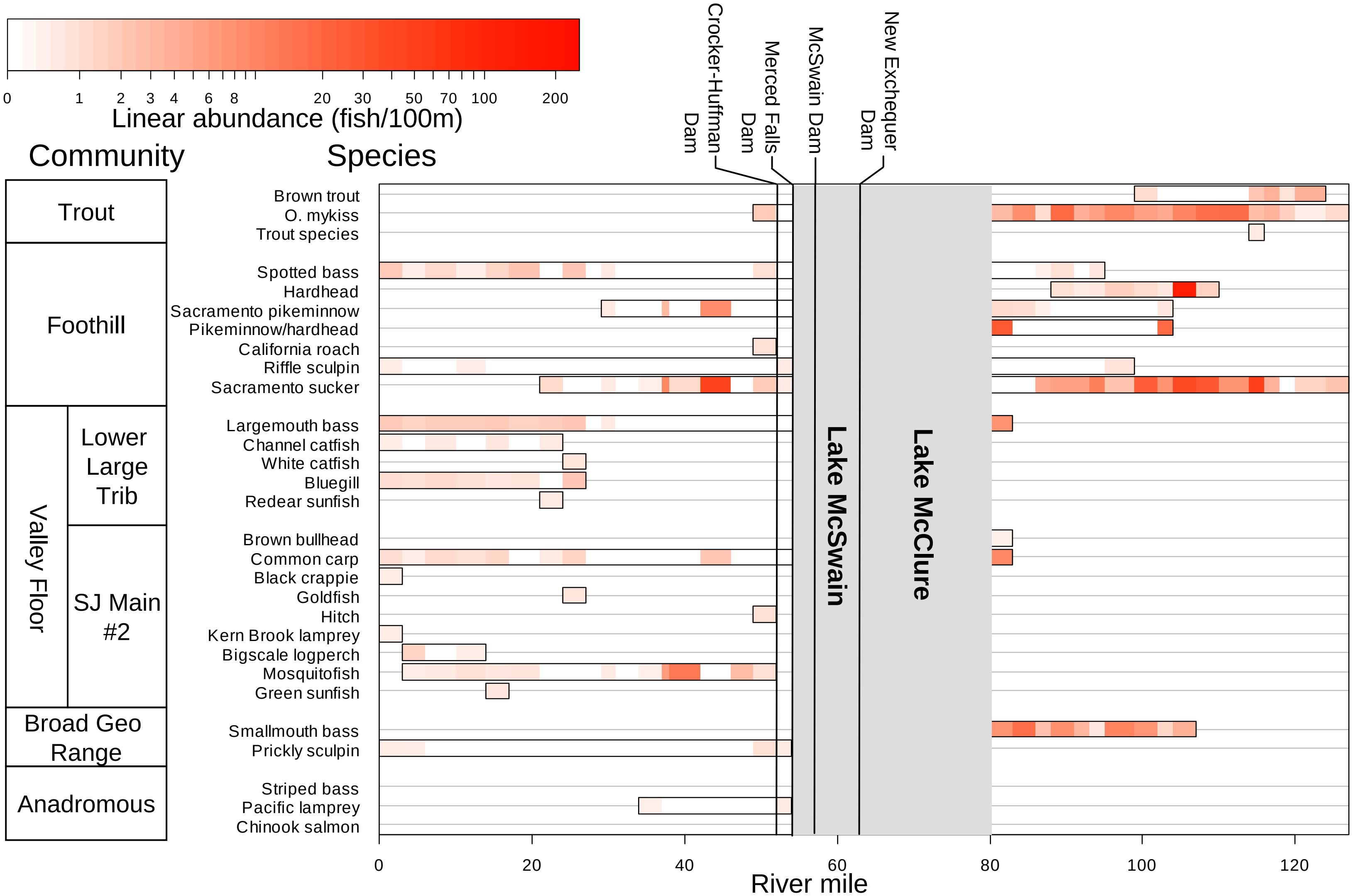

Figure 7-11. Fish linear abundance from fall 2006 snorkel and electrofishing surveys. See Table 5-11 for fish community descriptions. The foothill reservoirs, Lake McSwain and Lake McClure, were not sampled as part of the Merced Alliance biological assessment.

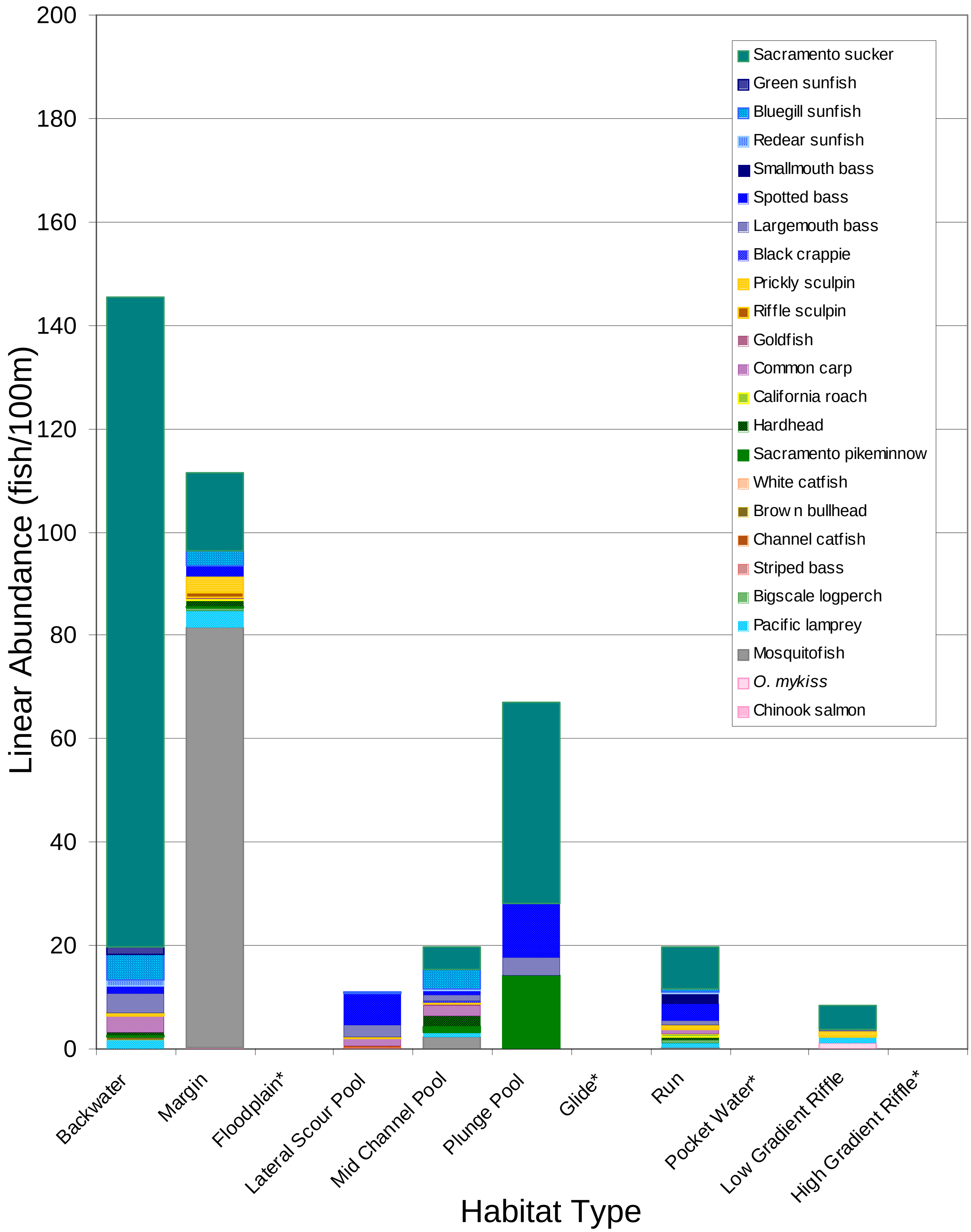

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Figure 7-12. Fish distribution by habitat in the lower Merced River during summer 2006. Habitats marked with a * were not sampled during this survey. A description of each habitat type is given in Table 5-3.

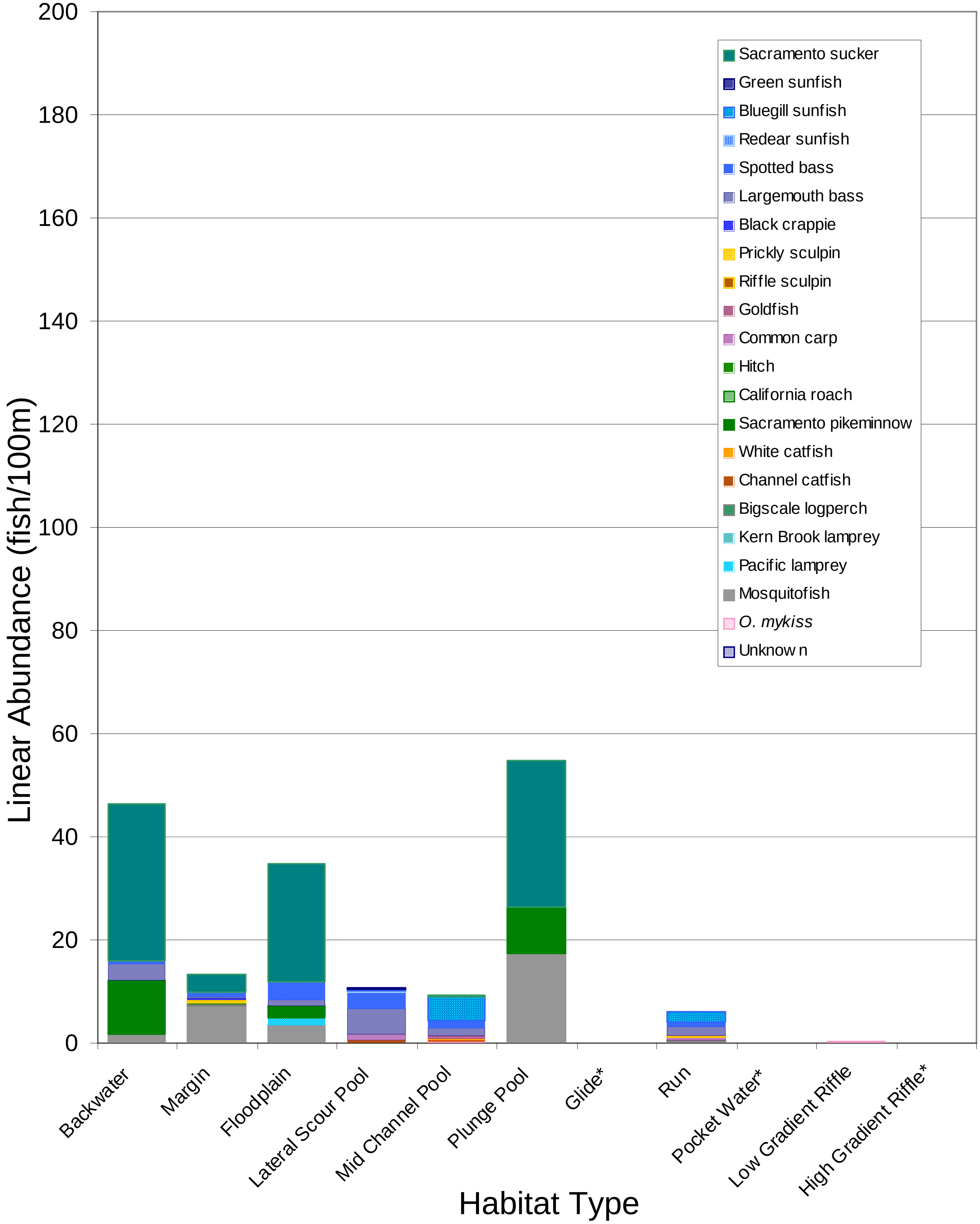

Figure 7-13. Fish distribution by habitat in the lower Merced River during fall 2006. Habitats marked with a * were not sampled during this survey. A description of each habitat type is given in Table 5-3.

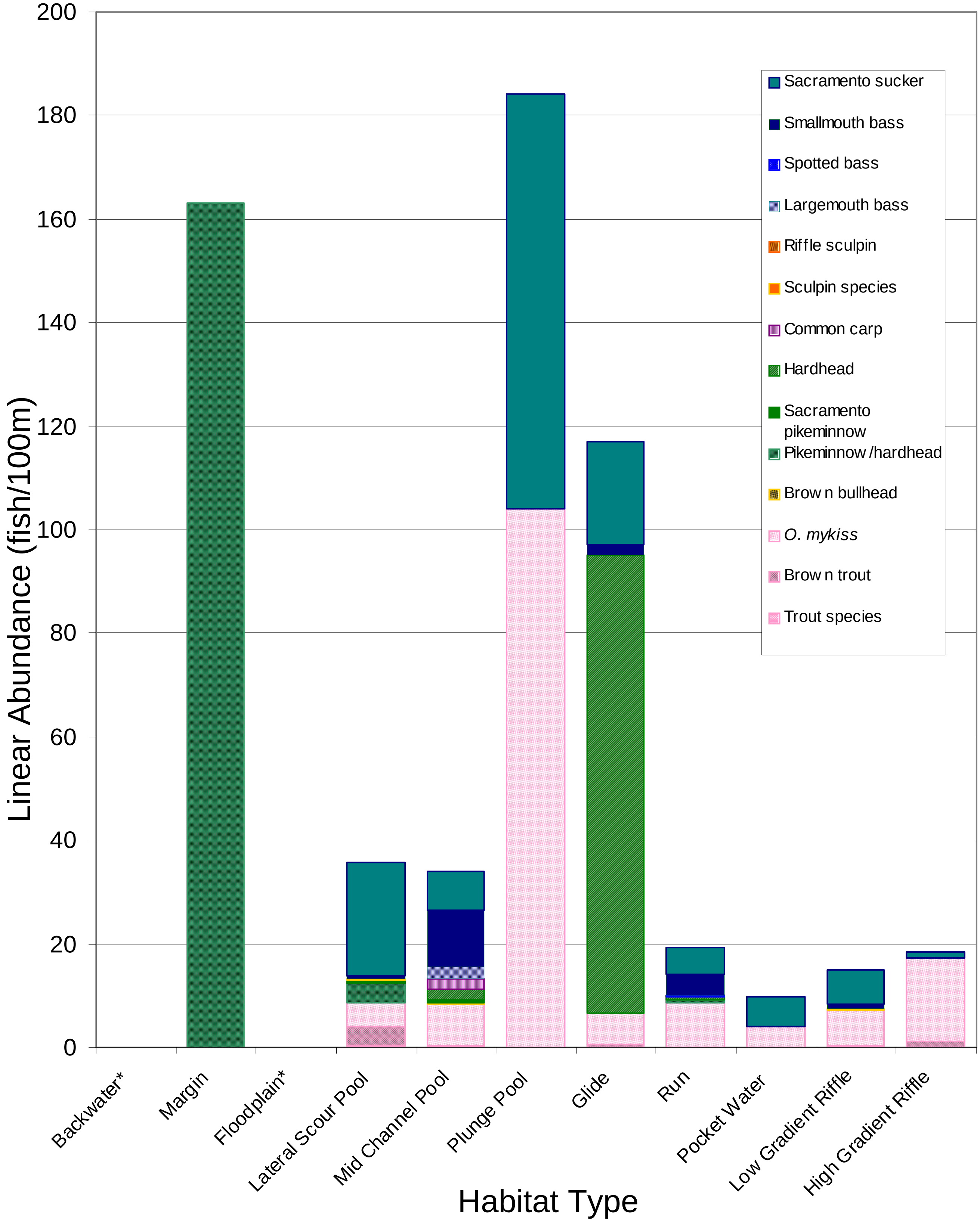

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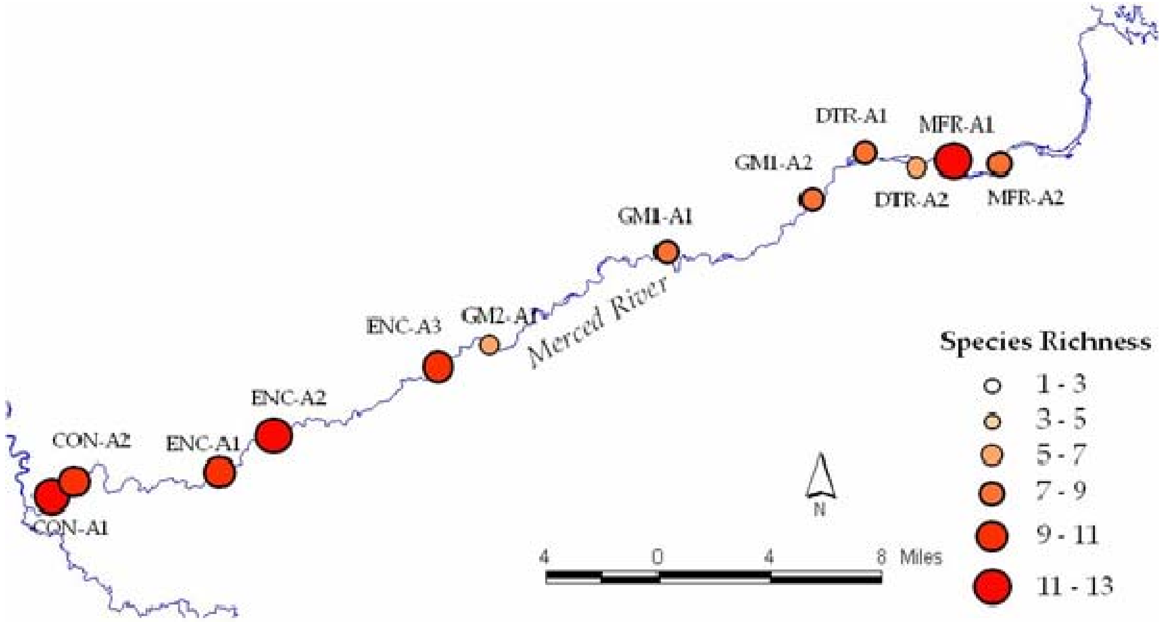
Figure 7-14. Fish distribution by habitat in the upper Merced River during fall 2006. Habitats marked with a * were not sampled during this survey. A description of each habitat type is given in Table 5-3.

a)



b)

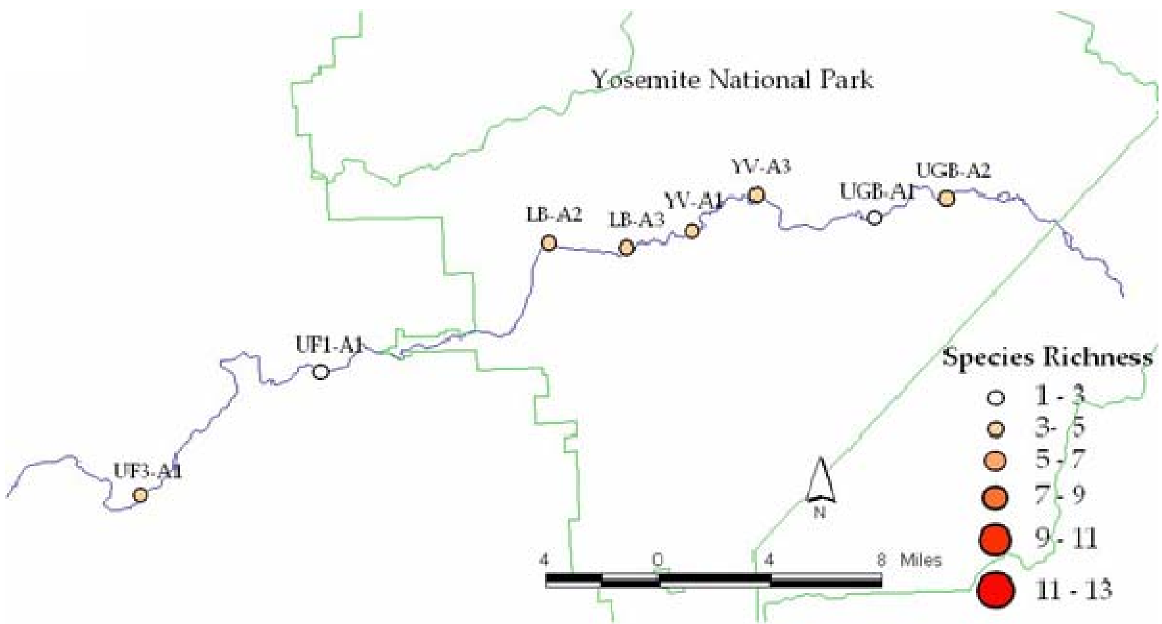


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Figure 7-15. Species richness from point count surveys at avian monitoring sites in a) the lower, and b) upper Merced River during the 2006 breeding season.

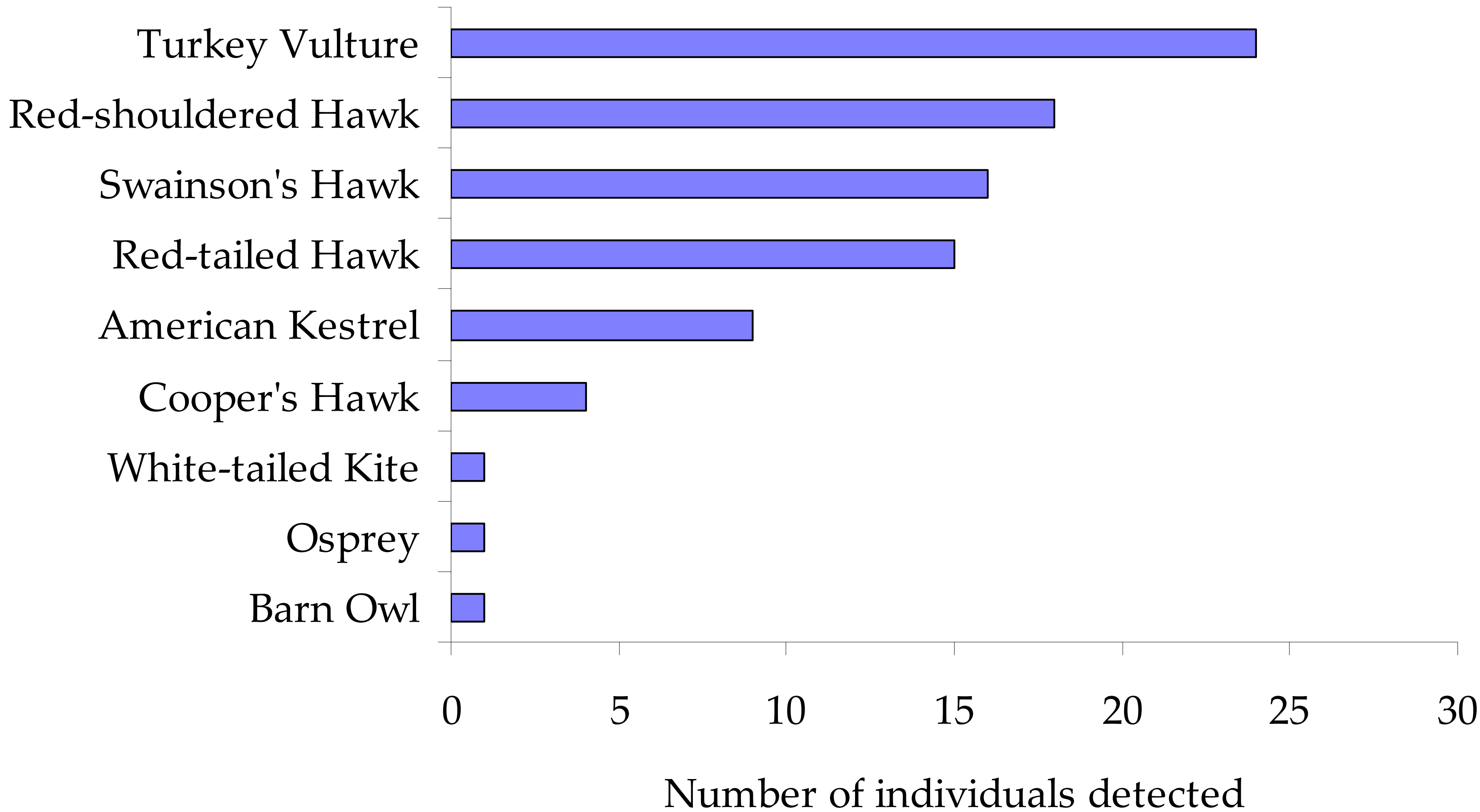

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Figure 7-16. Number of individuals of raptor species detected during 2006 breeding season point counts.

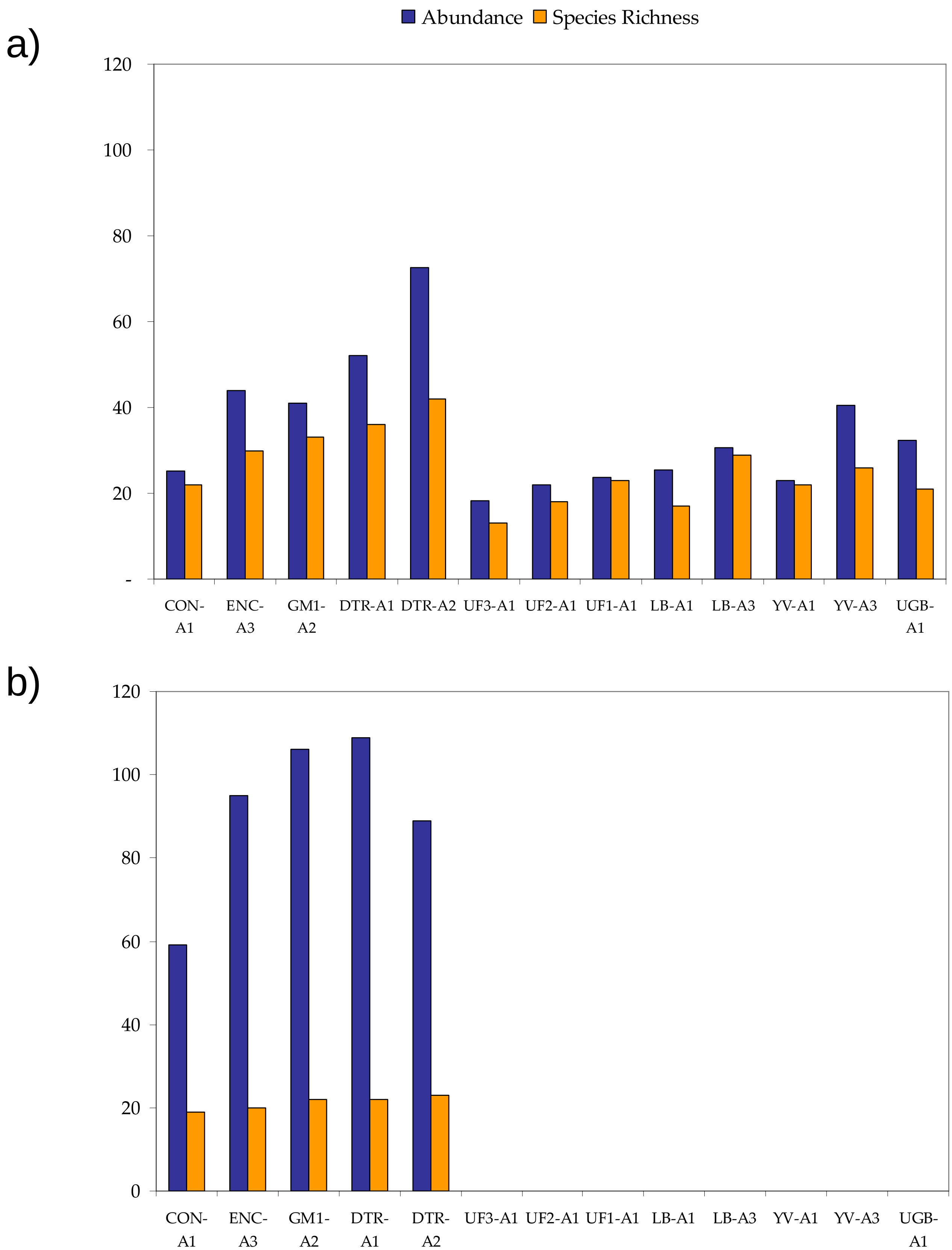

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Figure 7-17. Species richness from area search surveys at Merced River avian monitoring sites during a) fall 2006 and b) winter 2006.

8 DATA EVALUATION

8.1 Coarse-scale Aquatic Habitat Mapping

Results of the coarse-scale aquatic habitat mapping effort were used along with several other factors to support monitoring site selection for the fish and BMI surveys. As described in sections 5.2.2.3 and 5.2.3.3, monitoring sites were selected to represent the range of coarse-scale aquatic habitat types identified during mapping efforts, to be accessible, to take advantage of existing data (where possible), and to maintain coincident fish and BMI sites (where possible). As described in Section 5.2.3.3, BMI sites were comprised of 500-m reaches which encompassed a variety of coarse- and finer scale aquatic habitat types to produce a multi-habitat composite sample. Wherever possible, reach-wide targeted riffle samples were also collected at a BMI monitoring site. While fish monitoring sites also included multiple sample locations and often several habitat types within a site, habitat associations were considered as part of the fish study objectives (Section 5.2.2.1) and therefore data were reported for individual habitat units. The remainder of the habitat mapping evaluation focuses on individual aquatic habitat units sampled during the fish surveys, although as shown in Figure 5-1, fish and BMI sites were often coincident so the overall evaluation of fish monitoring site selection is generally applicable to the BMI sites. For the interim report, evaluation of the sampled aquatic habitat types includes preliminary analysis of the frequency of occurrence of each habitat type by reach, while Section 7.1 describes frequency of occurrence as well as frequency by length for each reach. The preliminary analysis occurred prior to reclassification of some sampled fish habitat as floodplain habitat, causing the two data sets to differ slightly. Further analysis of sampled habitat types, including frequency by length and inclusion of floodplain habitat, will be considered following collection of 2007 and 2008 habitat data.

With the exception of cascades (see Table 5-3 for definition), all types of coarse-scale habitat mapped in the Merced River during fall 2005 were represented within the fish monitoring sites and were sampled during summer and fall 2006 (Table G-1, Appendix G). While cascade habitat was present as multiple short units in the mapped portions of the Lower Batholith and Glaciated Batholith reaches (Figure 7-1b), the characteristic high gradient (> 4%) provides limited fish habitat, and made it difficult and unsafe to sample cascades using available standard methods. As shown in Figure 7-1a,b, runs were the predominant habitat type (by length) in most reaches, followed by low gradient riffles and mid-channel pools. Accordingly, these three habitat types were sampled with the highest relative frequency within the selected fish monitoring sites (Table G-1, Appendix G). In general however, the main mapped habitat types were under-sampled when considered on the basis of relative frequency of occurrence by length within each reach. This was due to the inclusion of backwater and margin habitat types, two additional categories of aquatic habitat which were classified in the Merced River during 2006 summer and fall surveys but not included in the 2005 mapping effort.

While the scale of the remote helicopter videography method did not allow for inclusion of backwater habitat features, they were identified as commonly utilized fish habitat during the 2006 lower river surveys and, accordingly, these features were sampled in the Confluence, Encroached, Gravel Mining 2, Gravel Mining 1, and Dredger Tailings reaches (Figure 7-1a,b**)**. Margin habitat, defined as the area along the stream bank exhibiting relatively slower velocity, lesser water depth and unique cover attributes as compared with main channel habitat, was originally included in fish survey data sheets as a further descriptor, or sub-classification of the larger coarse-scale unit. However, during 2006 fish surveys in the lower Merced River, fish were frequently observed along the river margins and several margin samples comprised 100% of a given coarse-scale habitat unit i.e., run or low-gradient riffle. During 2007 and 2008 field surveys, margin habitat will be further classified according to its association with a main channel coarse-scale habitat feature. Where possible, margin habitat sampled during the 2006 surveys will be retro-actively associated with mapped coarse-scale habitat types and presented along with the full data summary in the final report.

8.2 Fish Study

8.2.1 Evaluation of New Fish Data

Patterns in fish species richness, diversity, and composition were discernable during summer and fall 2006, at both the segment and reach scale. Seasonal differences in these parameters were also noted in some cases. In general, the species richness and diversity patterns found at the reach-scale (Figures 7-7 through 7-9) reflect which community assemblages are present in each of the reaches and the richness of those community assemblage groups. For example, the Trout Community, which was observed in both the upper reaches of both the upper and lower river segments, contains relatively low community species richness. Correspondingly, reaches where the numerically dominant fish assemblage was the Trout Community also had lower species richness. In contrast, reaches containing the Valley Floor Community assemblage (with high community species richness) also had higher species richness.

The presence of the foothill reservoirs appears to have extended the Valley Floor Community into the upper segment of the Merced River. Within the upper segment, species richness was highest in the reach just upstream of Lake McClure, or the Upper Foothills 3 Reach (Figure 7-9). The observed condition is likely a result of species migrating upstream from Lake McClure, including the non-native species smallmouth, largemouth, and spotted bass, as well as common carp, which are currently (or were historically) stocked for sport fishing.

While fish hypotheses (Section 5.2.2.2)will be more fully addressed following the second year of data collection, initial results indicate that relatively high flows observed during 2006 in the Merced River may have extended the downstream limit of Foothill Community fishes (e.g., Sacramento pikeminnow, tule perch, Sacramento sucker, hardhead, riffle sculpin) as compared with that observed during earlier surveys conducted by Brown et al. (2003) following an extended 6-year drought (fish hypothesis #6). However, the high flow conditions did not appear to simultaneously limit the upstream limit of the Large Lower Tributary Community (e.g., largemouth bass, bluegill, redear sunfish, white catfish, channel catfish), and thus the two communities overlapped throughout the lower river segment.

Differences between high flow and low flow years were not expected to affect the longitudinal distribution of Broad Geographical Range species (fish hypothesis #7). Indeed, prickly sculpin and smallmouth bass distribution in the lower Merced River during a relatively high flow year (2006) was similar to that of earlier surveys during a relatively low flow year (Brown 2000). Initial results do indicate some seasonal differences within the Broad Geographical Range Community species in the lower river segment (Figures 7-10 and 7-11).

8.2.2 Comparisons to Historical Fish Data

Comparisons to historical fish data will be done in the final report once all surveys are completed.

8.3 BMI Study

8.3.1 Evaluation of New BMI Data

8.3.1.1 Aquatic Bioassessment

Pair-wise Wilcoxon tests were applied to the first year data to evaluate the apparent differences in BMI abundance, biovolume and EPT richness between the two types of samples collected (MHC and TRC) (Table 7-6). Note that while there were 25 TRC samples collected, 22 MHC/TRC site pairs were used for the analyses. Three samples were excluded from the abundance and biovolume analyses, including site UF3-B1 which had very low abundance and a non-reportable biovolume signal ($<0.1 ml/m^2$). The relatively poor condition of BMI samples at two other sites eliminated the possibility of biovolumne measurements, because the measurement technique itself would have further compromised the sample integrity. Results of the Wilcoxon tests indicated significantly lower MHC abundance (number/m^2) and biovolume (ml/m^2) when compared to TRC abundance and biovolume ($p<0.05$, $n=22$). On the other hand, as noted in the results, MHC samples tended toward higher richness and diversity when compared to TRC samples. The higher richness documented for MHC samples was tested for significance by applying the Wilcoxon test to the EPT richness metric determined for MHC and TRC samples. EPT richness was used to represent richness instead of Taxonomic Richness because the former is highly correlated with Taxonomic Richness and it has a higher signal-to-noise ratio than Taxonomic Richness (Rehn et al. *in review*). Results of the Wilcoxon test indicated significantly higher MHC EPT richness when compared to TRC EPT richness ($p<0.05$; n=25).

Composite metric scores are plotted in Figure 8-1 for both multihabitat composite (MHC) and targeted riffle composite (TRC) samples. Two overall patterns are apparent from Figure 8-1 regarding the distribution of composite metric scores as a function of monitoring site location. First, in contrast to the results of the pair-wise Wilcoxin comparisons between MHC and TRC summary data, there does not appear to be a consistent difference between MHC and TRC composite metric scores either across or within monitoring sites. However, there is a distinct grouping of composite metric scores for sites upstream and downstream of the foothill reservoirs, Lake McSwain and Lake McClure (hereafter referred to as foothill reservoirs).

An exception to this pattern is site UF3-B1, which behaves more like a site downstream of the foothill reservoirs despite its physical location immediately upstream. The MHC sample collected from site UF3-B1 exhibited taxonomic composition more consistent with sites downstream of the reservoir, including relatively high chironomid abundance, low EPT richness, and lack of stoneflies (Appendix I-2). The TRC sample collected from site UF3-B1 was highly unusual because of its low abundance (67/m^2); for reference, the median abundance for TRC samples was 2,020/m^2 (Table 7-6). In addition, the overall composite metric scores for both the MHC and TRC samples collected from this site were well below all other sites in the upper river and the physical habitat assessment score was one of the lowest recorded throughout the watershed (Table 7-7).

While site UF3-B1 is located upstream of the foothill reservoirs, its close proximity to Lake McClure could affect the BMI community at this site. As reservoir levels fluctuate throughout the year, the nature of aquatic habitat at sites proximal to the reservoirs may be altered. If, during the summer, the inflow into the reservoir was less than the amount released, the reservoir level would have declined. Aquatic habitat closest to the tributary-reservoir interface, such as site UF3-B1, may have been altered from lentic to lotic in a relatively short timeframe. The interval between this transition and the time at which the sample was taken may not have been sufficient for colonization of the site by BMIs adapted to lotic conditions.

Another possibility is that the presence of the reservoir system interferes with the upstream aerial migration and colonization of adult insects (also known as positive rheotaxis). Under this scenario, recently emerged adult insects migrate upstream before depositing eggs in order to counteract downstream drift of the organism in its larval stage. While this may occur at sites such as UF3-B1 that are just upstream of the reservoir, the upstream flight of insects below the dam may be impeded. The overall result would be a net decline in BMI abundance at sites just upstream of the reservoir. BMI colonization cycles are unknown for many taxa, however, and net effects of downstream drift and upstream movements have been inconsistently reported in the literature as summarized by Allan (1995).

Figure 8-2 shows an ordination plot of relative monitoring site similarity as a function of taxonomic composition, with ecological subregion added as a grouping variable. As was the case with the composite metric scores, monitoring sites were clustered by watershed position, with two distinct groupings occurring upstream and downstream of the foothill reservoirs. Sites within the three lower river ecological subregions formed one group while sites within the three upper river ecological subregions formed another group. Further, more subtle partitioning of sites is evident within the upper river site groups: Upper Foothills Metamorphic subregion (4), Lower Batholith subregion (5) and Upper Batholith subregion (6). The monitoring site within the Upper Foothills Metamorphic subregion (4) that lies between the two major ordination groupings is likely site UF3-B1, which has a taxonomic composition more closely related to the lower river sites.

While a consistent difference between the MHC and TRC was not evident in the composite metric scores, differences in specific attributes that comprise BMI assemblages are apparent from the comparison of summary data (Table 7-3) for the two types of samples. Preliminary results also indicate a clear partitioning of sites by watershed position for biological metrics and taxonomic composition. Variation in taxonomic composition and metric values will be further examined for relationships with site scale habitat variables and larger landscape scale variables after the second year of data collections. The results support the potential application of a different suite of metrics for characterizing BMI assemblages downstream of the reservoir.

8.3.1.2 Exotics Surveys

Chinese mitten crab (*Eriocheir sinensis*). Chinese mitten crabs have been found in the San Joaquin-Sacramento Delta eastern San Joaquin County (Escalon-Bellota Weir on the Calaveras River and Little Johns Creek near Farmington), and south to the San Luis National Wildlife Refuge near Gustine (CDFG 1998b). In the last decade, there have been several unconfirmed reports of the Chinese mitten crab from the lower Stanislaus and Merced Rivers, but no official collections have been documented from this area; in addition, no crabs were reported from these areas during 2007 (Heib, pers. comm. 2007).

During the first year of the study, the surveys conducted for the Chinese mitten crab did not indicate the presence of these organisms. Passive habitat traps were deployed at five sites near the San Joaquin River Surveys (Figure 5-1) and monitored biweekly during the summer and fall (when developing crabs are most likely to be visible). In addition, during aquatic bioassessment sampling, no Chinese mitten crab carapaces were observed along the river banks.

Since the crabs were initially collected in the San Francisco Bay in 1992, rapid, population-wide fluctuations in their abundance have been documented (Bergendorf 2003, Rudnick et.al. 2005, Hanson and Sytsma 2005). Their abundance increased dramatically in 1998-1999 and during this timeframe their distribution was documented as far south as the San Luis National Wildlife Refuge in the San Joaquin River. Yet, extensive surveys conducted in the San Joaquin River Basin (Brown and May 2001) in the year 2000 did not reveal the presence of the Chinese mitten crab. This apparent absence may have been attributable to high variation in annual population size.

Recent studies (Rudnick et.al. 2005; Hanson and Systma 2005) indicate that variation in environmental parameters, particularly flow and salinity, play a strong role in governing the crab's population dynamics. The 2006 water year was exceptionally high, with spring and summer flows exceeding 4000 cfs, which may have sustained the decline in Chinese mitten crab population.

Surveys of the Chinese mitten crab will be repeated at the same sites in the lower Merced watershed during the summer and fall of 2007. If possible, several passive habitat traps will be deployed in areas with recently documented crab populations. The additional traps will aid in ruling out population cycling as a reason for their absence and also corroborate the efficacy of the traps.

Asiatic Clam *(Corbicula fluminea* [family Corbiculidae]). The Asiatic clam is native to southern and eastern Asia. The clam was first documented in California in 1938 and is now present in rivers and streams throughout the state. The species is most abundant in well-oxygenated, clear waters but is found both in lotic and lentic habitats. Clay and fine to coarse grained sand are preferred substrates, although these clams may be found in lower numbers on most any substrate (USGS 2001).

Previous studies have documented the presence of the Asiatic clam in tributary rivers to the San Joaquin River, including the Merced. The clam is thought to affect ecosystem processes by limiting suspended algal biomass within tributaries, thereby reducing export of suspended algae into mainstem rivers (Brown and May, 2004).

The Asiatic clam (*Corbicula fluminea*) was present in samples collected from 12 of the sites located in the lower river segment from the confluence site upstream to site GM1-B3 at an elevation of 255 feet. Fingernail clams (Family Sphaeriidae) were found at several sites between 150 feet and 320 feet elevation in the lower river segment. Clams were scarce in benthic samples from the upper watershed where four sphaeriid clams (*Pisidium*) were documented. Although a quantified estimate of Asiatic clam abundance on the Merced is beyond the scope of this study, the data from the BMI collections and field observations indicate that dams may represent a barrier to upstream dispersal of this organism.

New Zealand Mud Snail (*Potamopyrgus antipodarum* [family Hydrobiidae]). The New Zealand mudsnail is a an invasive species with a high reproductive potential that inhabits many habitat types including silt, sand, gravel, cobbles, and vegetation. Populations of the New Zealand mud snail have been documented on several rivers in Northern California, including the Napa and Calaveras Rivers; yet the New Zealand mud snail has not been documented on the Merced River (Post, pers. comm. 2006). Aquatic bioassessment collections taken from upper and lower river segments were inspected for New Zealand mud snails during laboratory processing. No mud or spring snails of the family Hydrobiidae were found in the benthic samples.

8.3.2 Comparisons to Historical BMI Data

Comparisons to historical BMI data will be done in the final report once all surveys are completed.

8.4 Avian Study

8.4.1 Evaluation of New Avian Data

While the longitudinal trend in 2006 breeding season species richness is significant (r^2=0.83, p<0.0001), with the lower river sites exhibiting increased species richness as compared with upper river sites (Avian Figures 3,4), the effect of riparian patch size and configuration has not yet been included in the analysis. The riparian corridor is relatively wider at the lower river monitoring sites as compared with a more narrow or non-existent riparian corridor along the upper river. Since riparian habitat harbors the most diverse bird communities in the arid and semi-arid regions of the western United States (Knopf et al. 1988, Dobkin 1994, Saab et al. 1995) greater bird diversity is not unexpected in areas containing sizeable patches of riparian habitat. Indeed, forest patch size and configuration as well as other landscape scale habitat features are known to influence avian abundance and distribution (Askins 1995, Robinson et al. 1995, Howell et al. 2000). The effect of landscape scale habitat features on bird distribution and abundance will be explored for the final report, following 2007 data collection.

Regarding the difference between avian community composition in the upper and lower river corridor, some of the species listed as unique to either the upper or lower river may be present in both segments but were just not detected in the first year of the study (e.g., Hutton's vireo may be present in the lower river in very low abundance). Many of the species unique to the lower river corridor were birds associated with open water habitat or wetlands (e.g., black-crowned night heron, common moorhen, double-crested cormorant, Forster's tern, great blue heron, great egret, green heron, osprey, pied-billed grebe, and wood duck). These waterbird species contributed to the higher species diversity found in the lower river.

8.4.2 Comparisons to Historical Avian Data

Comparisons to historical avian data will be included in the final report once all avian surveys are completed.

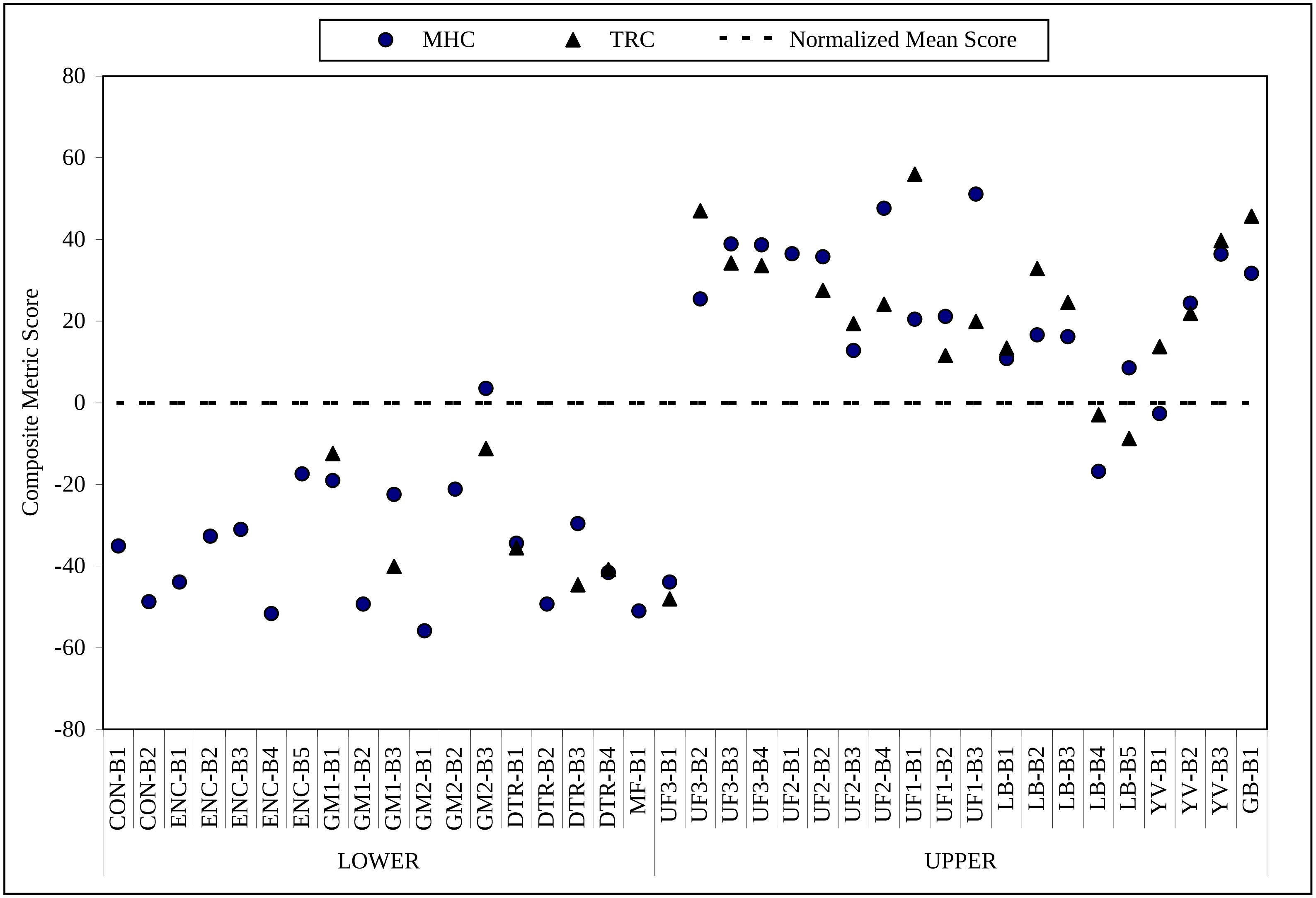

Figure 8-1. Composite metric scores for the lower and upper Merced River BMI sampling during late summer/early fall 2006. Scores are normalized to a grand mean of zero, represented by the dashed, horizontal line**.** Both sample types are included in the figure: multihabitat composite (MHC) where n_{MHC}=38 and targeted riffle composite (TRC) where n_{TRC}=25.

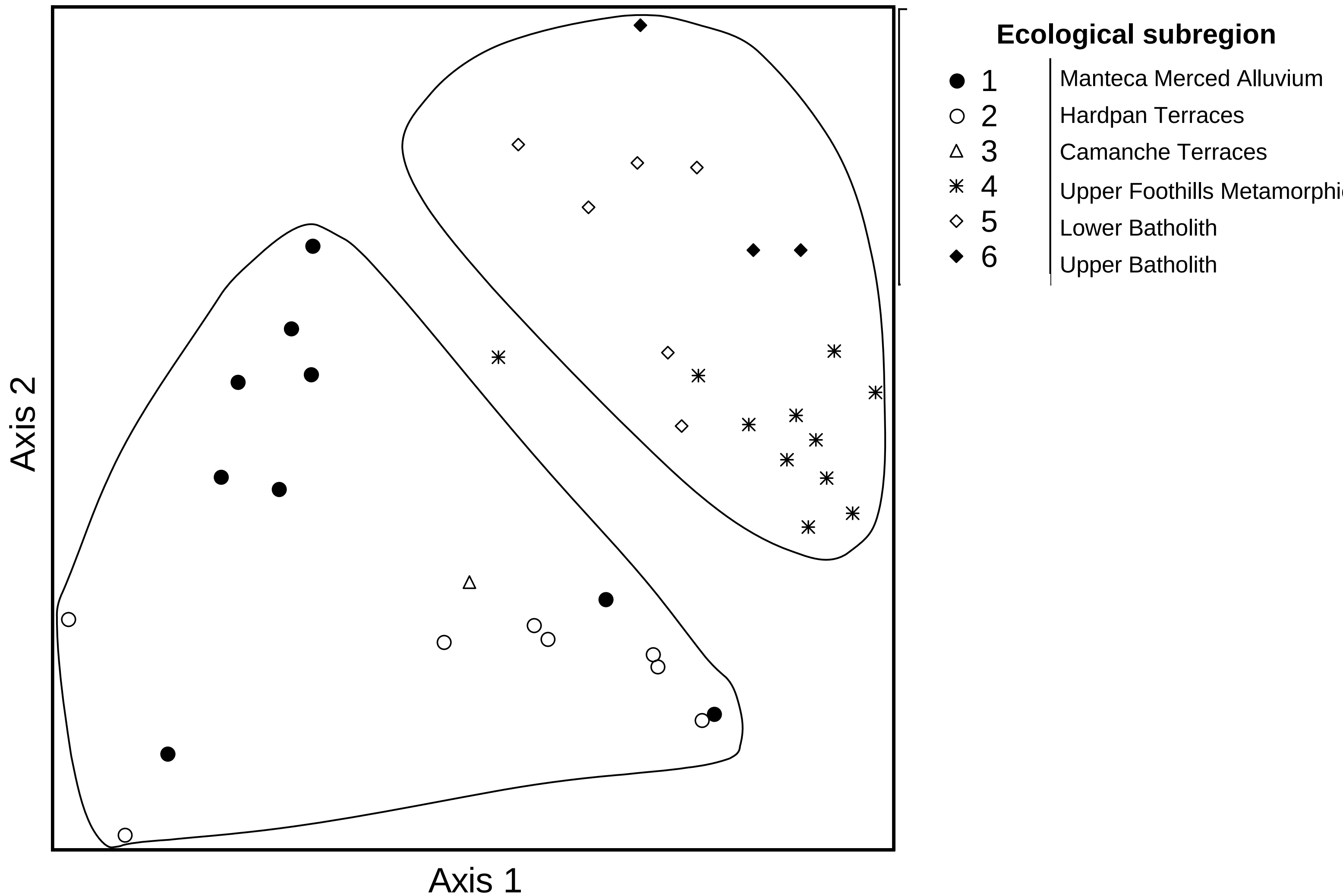

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Figure 8-2. Ordination plot showing relative site similarity as a function of BMI taxonomic composition, with ecological subregion included as a grouping variable. Boundaries for the ecological subregions are illustrated in Figure 5-5 and presented in the legend above from downstream to upstream.

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