
TABLE OF CONTENTS

	Page
7.5 Fish and Aquatics Resources Affected Environment.....	7.5-1
7.5.1 Information Sources	7.5-2
7.5.2 Project Overview	7.5-4
7.5.3 Aquatic Species.....	7.5-5
7.5.4 Resource Management Objectives.....	7.5-6
7.5.5 Riverine Physical Environment.....	7.5-7
7.5.5.1 Hydrology.....	7.5-7
7.5.5.2 Channel Geomorphology and Sediment Transport and Supply	7.5-8
7.5.5.3 Riparian Vegetation	7.5-9
7.5.5.4 Water Temperature and Dissolved Oxygen	7.5-10
7.5.6 Instream Flow Habitat Modeling	7.5-12
7.5.7 Riverine Aquatic Community	7.5-15
7.5.7.1 Algae.....	7.5-15
7.5.7.2 Benthic Macroinvertebrates	7.5-15
7.5.7.3 Aquatic Mollusks	7.5-17
7.5.7.4 Productivity and Habitat/Species Diversity.....	7.5-17
7.5.8 Riverine Fish.....	7.5-18
7.5.8.1 Distribution and Diversity	7.5-19
7.5.8.2 Fish Passage Barriers.....	7.5-20
7.5.8.3 Growth and Condition	7.5-21
7.5.8.4 Emergence/Spawning Timing	7.5-22
7.5.8.5 Abundance (Standing Crop)	7.5-23
7.5.8.6 Fish Stocking	7.5-26
7.5.8.7 Bypass Reach Habitat	7.5-26
7.5.8.8 Peaking Reach Habitat	7.5-28
7.5.9 Foothill Yellow-Legged Frogs	7.5-29
7.5.9.1 Habitat	7.5-29
7.5.9.2 Distribution and Abundance.....	7.5-30
7.5.9.3 Breeding Timing.....	7.5-31
7.5.9.4 Habitat Suitability Criteria.....	7.5-31
7.5.9.5 Habitat versus Flow	7.5-31
7.5.10 Reservoirs and Diversion Pools.....	7.5-32
7.5.10.1 Large Reservoirs.....	7.5-33
7.5.10.2 Medium Reservoirs	7.5-35

- 7.5.10.3 Small Diversion Pools 7.5-38
- 7.5.10.4 Fish Passage Barriers at Reservoir and Small Stream
Diversion Pool Inlets 7.5-39
- 7.5.11 Fish Entrainment 7.5-39
 - 7.5.11.1 Large Reservoirs..... 7.5-40
 - 7.5.11.2 Medium Reservoirs 7.5-40
 - 7.5.11.3 Small Diversions 7.5-41
- 7.5.12 Special-Status Species..... 7.5-41
 - 7.5.12.1 Special-status Aquatic Mollusks..... 7.5-41
 - 7.5.12.2 Hardhead 7.5-42
 - 7.5.12.3 Foothill Yellow-legged Frogs..... 7.5-42
 - 7.5.12.4 California Red-legged Frogs 7.5-42
 - 7.5.12.5 Western Pond Turtle 7.5-43

List of Tables

- Table 7.5-1. Summary of Management Objectives that Apply to Aquatic Resources.
- Table 7.5-2a. Middle Fork American River below Middle Fork Interbay Water Temperature Profiles (July–August) and the Corresponding River Mile at which the Water Temperature Reaches 17°C and 20°C.
- Table 7.5.2b. Rubicon River Water Temperature Profiles (July–August) and the Corresponding River Mile at which the Water Temperature Reaches 17°C and 20°C.
- Table 7.5-3. Depth and Velocity Guilds for the Aquatic Species for Use in the Spatial Niche Analysis.
- Table 7.5-4. Species and Life Stage Periodicities.
- Table 7.5-5. Summary of Fish Species Observed during the 2007–2009 Fish Population Sampling.
- Table 7.5-6. Rainbow Trout Observed Emergence Dates Above the Small Stream Diversion Pools.
- Table 7.5-7. Hardhead and Sacramento Pikeminnow Observations from Quantitative and Qualitative Fish Sampling.
- Table 7.5-8. Rainbow Trout Spawning Weighted Usable Area under Spring Minimum Flows With and Without Accretion.
- Table 7.5-9. Fish Stranding and Trapping / Isolation Observed in the Middle Fork American River Peaking Reach.
- Table 7.5-10. Reservoir Gill Netting Catch and Catch per Unit Effort (CPUE).
- Table 7.5-11a. Historical Fish Stocking Records at Hell Hole Reservoir.
- Table 7.5-11b. Historical Fish Stocking Records at French Meadows Reservoir.
- Table 7.5-12. Middle Fork Project Facilities Inlet/Outlet Characteristics.
- Table 7.5-13. Turbine Characteristics and Associated Estimated Mortality at MFP Facilities.

List of Figures

- Figure 7.5-1a. Water Temperature Measured at Four Locations in the Middle Fork American River between French Meadows Reservoir and Middle Fork Interbay (River Mile 46.6, 44.6, 39.4, and 36.1) in 2006, 2007, and 2008.
- Figure 7.5-1b. Water Temperature Measured at Three Locations in the Middle Fork American River between Middle Fork Interbay and Ralston Afterbay (River Mile 35.5, 29.4, and 26.0) in 2006, 2007, and 2008.
- Figure 7.5-1c. Water Temperature Measured at Three Locations in the Middle Fork American River between Ralston Afterbay and the Confluence with the North Fork American River (River Mile 23.1, 14.3, and 0.1) and One Location in the North Fork American River below the Confluence (River Mile 20.8) in 2006, 2007, and 2008.
- Figure 7.5-1d. Water Temperature Measured at Four Locations in the Rubicon River between Hell Hole Reservoir and Ralston Afterbay (River Mile 28.8, 22.5, 14.3, and 0.7) in 2006, 2007, and 2008.
- Figure 7.5-1e. Water Temperature Measured in Duncan Creek at Two Locations Below the Duncan Creek Diversion (River Mile 0.1 and 8.41) and One Location Above the Duncan Creek Diversion (River Mile 8.8) in 2006, 2007, and 2008.
- Figure 7.5-1f. Water Temperature Measured in North Fork Long Canyon Creek at One Location Below the North Fork Long Canyon Diversion (River Mile 3.1) and One Location Above the North Fork Long Canyon Diversion (River Mile 3.2) in 2006, 2007, and 2008.
- Figure 7.5-1g. Water Temperature Measured in South Fork Long Canyon Creek at Two Locations Below the South Fork Long Canyon Diversion (River Mile 0.1 and 3.2) and One Location Above the South Fork Long Canyon Diversion (River Mile 3.4) in 2006, 2007, and 2008.
- Figure 7.5-1h. Water Temperature Measured in Long Canyon Creek at Three Locations (River Mile 0.1, 6.8, and 11.1) in 2006, 2007, and 2008.
- Figure 7.5-2. Fish Distribution in the Middle Fork American River, Rubicon River, Long Canyon Creek, North Fork Long Canyon Creek, South Fork Long Canyon Creek, Duncan Creek, and Little Duncan Creek.
- Figure 7.5-3. 2008 Length Frequency Histograms of Rainbow Trout and Brown Trout Captured During Electrofishing at Small Streams (Top), Electrofishing and Snorkeling at Large River Sites (Middle), and Snorkeling at Sites in the Peaking Reach (Bottom).
- Figure 7.5-4. 2007 Age and Growth Rates of Rainbow Trout at all Study Sites (Top), Middle Fork American River and Rubicon River Sites (Middle), and Small Stream Sites (Bottom).

- Figure 7.5-5. The Cumulative Number of Years that Diverting was Occurring (1975–2007) at Duncan Creek (top), North Fork Long Canyon Creek (middle), and South Fork Long Canyon Creek (bottom).
- Figure 7.5-6a. The 2007 Density and Biomass of Trout in the Study Streams.
- Figure 7.5-6b. The 2008 Density and Biomass of Trout in the Study Streams.
- Figure 7.5-7a. The 2007 Density and Biomass of Trout Upstream and Downstream of Small Stream Diversions.
- Figure 7.5-7b. The 2008 Density and Biomass of Trout Upstream and Downstream of Small Stream Diversions.
- Figure 7.5-7c. The 2009 Density and Biomass of Trout Upstream and Downstream of Small Stream Diversions.
- Figure 7.5-8a. 2007 Comparison of Trout Density and Biomass Between Study Sites and Potential Comparison Sites.
- Figure 7.5-8b. 2008 Comparison of Trout Density and Biomass Between Study Sites and Potential Comparison Sites.
- Figure 7.5-9a. Hell Hole Reservoir Water Surface Elevation in Relation to the Hell Hole Boat Ramp Operational Range and Minimum Pool Elevations by the Forecasted Water Year Type.
- Figure 7.5-9b. French Meadows Reservoir Water Surface Elevation in Relation to the French Meadows Boat Ramp Operational Range and Minimum Pool Elevations by the Forecasted Water Year Type.
- Figure 7.5-10a. French Meadows Reservoir Water Temperature and Dissolved Oxygen Profiles at Site FM1 for all Years (2005–2008) and Sampling Months (June - October).
- Figure 7.5-10b. Hell Hole Reservoir Water Temperature and Dissolved Oxygen Profiles at Site HH1 for all Years (2005–2008) and Sampling Months (June–October).
- Figure 7.5-10c. Ralston Afterbay Water Temperature and Dissolved Oxygen Profiles at Site RA1 for all Years (2005–2008) and Sampling Months (June–October).
- Figure 7.5-11. Gill Netting Catch per Unit Effort (CPUE) (Fish per Hour) in Hell Hole Reservoir, French Meadows Reservoir, Middle Fork Interbay, and Ralston Afterbay.

List of Maps

- Map 7.5-1. Middle Fork Project Aquatic Study Sites.
- Map 7.5-2. Water Temperature Monitoring and Meteorological Station Locations.
- Map 7.5-3a. Average Water Temperatures in Study Streams in August 2007 Unimpaired Flow – Model Data.
- Map 7.5-3b. Measured August 2007 Average Water Temperature in Study Streams (Temperature Values Linearly Interpolated between Monitoring Locations).
- Map 7.5-4. 2007–2008 Fish Population Study Sites.
- Map 7.5-5. Fish Passage Barrier Locations and Frequency.
- Map 7.5-6a. Gray Eagle Bar – American Bar Stranding Study Area.
- Map 7.5-6b. Fords Bar Stranding Study Area.
- Map 7.5-7. Foothill Yellow-Legged Frog Study Site Locations.
- Map 7.5-8. Foothill Yellow-Legged Frog Habitat Suitability.
- Map 7.5-9. Foothill Yellow-Legged Frog Distribution and Abundance.
- Map 7.5-10a. French Meadows Reservoir Water Temperature and Dissolved Oxygen Profile Sampling Locations (2005–2008).
- Map 7.5-10b. Hell Hole Reservoir Water Temperature and Dissolved Oxygen Profile Sampling Locations (2005–2008).
- Map 7.5-10c. Ralston Afterbay Water Temperature and Dissolved Oxygen Profile Sampling Locations (2005–2008).
- Map 7.5-11. Western Pond Turtle Incidental Sightings in the Middle Fork American River Watershed.

List of Appendices

- Appendix B1. Monthly Impaired and Unimpaired Flow by Water Year Type and Water Year at Gaging Stations and Modeled Hydrologic Nodes under Impaired and Unimpaired Conditions.
- Appendix B2. Habitat Area versus Flow Relationships and Effective Habitat Analyses.

7.5 FISH AND AQUATICS RESOURCES AFFECTED ENVIRONMENT

This section describes the fish and aquatic resources in the vicinity of the Middle Fork American River Project (MFP or Project), including United States Department of Agriculture-Forest Service (USDA-FS) Sensitive Species and California Species of Concern.

Hydrology, water quality, geomorphology, and riparian resource information pertinent to the discussion of fish and aquatic resources are summarized in this section. Detailed information on hydrology (Section 7.3 – Water Use Affected Environment), water quality (Section 7.4 – Water Quality Affected Environment), geomorphology (Section 7.7 – Geomorphology Resources Affected Environment), and riparian resources (Section 7.8 – Riparian Resources Affected Environment) can be found in each of their respective sections.

Description of the fish and aquatic resources affected environment is organized based on the following categories:

- Information Sources
- Project Overview
- Aquatic Species
- Resource Management Objectives
- Riverine Physical Environment
 - Hydrology
 - Channel Geomorphology and Sediment /Transport and Supply
 - Riparian Vegetation
 - Water Temperature and Dissolved Oxygen
- Instream Flow Habitat Modeling
- Riverine Aquatic Community
 - Algae
 - Benthic Macroinvertebrates
 - Aquatic Mollusks
 - Productivity and Habitat/Species Diversity
- Riverine Fish
 - Distribution and Diversity
 - Fish Passage Barriers
 - Growth and Condition
 - Emergence/Spawning Timing
 - Abundance (Standing Crop)
 - Fish Stocking
 - Bypass Reach Habitat
 - Peaking Reach Habitat

- Foothill Yellow-legged Frogs
 - Habitat
 - Distribution and Abundance
 - Breeding Timing
 - Habitat Suitability Criteria
 - Habitat Versus Flow
- Reservoirs and Diversion Pools
 - Large Reservoirs
 - Medium Reservoirs
 - Small Diversion Pools
 - Fish Passage Barriers at Reservoir and Small Stream Diversion Pool Inlets
- Fish Entrainment
 - Large Reservoirs
 - Medium Reservoirs
 - Small Diversion
- Special-status Species
 - Special-status Aquatic Mollusks
 - Hardhead
 - Foothill Yellow-legged Frogs
 - California Red-legged Frogs
 - Western Pond Turtle

7.5.1 Information Sources

Information on aquatic resources are based on a review of existing literature, extensive agency and stakeholder consultation, and studies conducted as part of the MFP relicensing process. A summary of agency and stakeholder consultation is provided in Section 14.0 – Consultation Documentation. Early information gathering studies were conducted in consultation with the resource agencies in 2005 and 2006 to describe the physical environment in the MFP (PCWA 2007). In addition, 12 aquatic technical studies were developed in consultation with agencies and other interested relicensing participants and approved by the Federal Energy Regulatory Commission (FERC or Commission). These studies were developed to evaluate fish and aquatic resources in the vicinity of the MFP (PCWA 2007).

The key information used and collected for the aquatic resource studies is summarized below.

- Characterization of the physical environment, including river geomorphology, riparian habitat, instream aquatic habitat, and river and reservoir water temperatures (2005 and 2006 Physical Habitat Characterization Reports in Supporting Document [SD] G in the Pre-Application Document [PAD] [PCWA 2007]).

- Quantification and evaluation of aquatic habitat as a function of flow. Identification of time periods, flow conditions, and life stages when habitat may be a limiting factor for fish, benthic macroinvertebrates (BMI), special-status amphibian, and riparian populations in the MFP (AQ 1 – Instream Flow Technical Study Report [TSR] [PCWA 2011a; SD B]).
- Documentation of fish species composition, distribution, and abundance; and characterization of fish growth, condition factor, and population age structure in the bypass and peaking reaches and reservoirs (AQ 2 – Fish Population TSR [PCWA 2011b; SD B]).
- Documentation of the BMI community in the bypass and peaking reaches and comparison with communities in adjacent comparison stream reaches (AQ 3 – Macroinvertebrate and Aquatic Mollusk TSR [PCWA 2011c; SD B]).
- Determination of the presence or absence of three special-status mollusk species and identification of potentially suitable habitat for these species along bypass, peaking, and comparison river reaches (AQ 3 – Aquatic Mollusk TSR [PCWA 2011d; SD B]).
- Characterization of the relationship between flow and water temperature in the bypass and peaking reaches and the large reservoirs using models supported by existing water temperature data (AQ 4 – Water Temperature TSR [PCWA 2011e; SD B]).
- Analysis of salmonid growth and water temperature relationships and quantification of the amount and quality of habitat for salmonids in the Rubicon River and the peaking reach (AQ 5 – Biogenetics TSR [PCWA 2011f; SD B]).
- Documentation of the location, nature, and characteristics of fish barriers in the bypass and peaking reaches (including numerous confluences of non-Project tributaries), and inlets to Project reservoirs and diversion pools. Identification of Project facilities and operations that may affect fish passage (AQ 6 – Fish Passage TSR [PCWA 2011g; SD B]).
- Indirect and direct evaluation of potential fish mortality or translocations associated with flow diversion, intake structures, or powerhouse facilities (AQ 7 – Entrainment TSR [PCWA 2011h; SD B]).
- Characterization of reservoir water surface elevation management and its relationship to availability of fish habitat in Project reservoirs (AQ 8 – Reservoir Fish Habitat TSR [PCWA 2011i; SD B]).
- Description of stream channel and sediment transport characteristics in streams associated with the MFP. Characterization of large woody debris capture in MFP reservoirs and diversion pools (PCWA 2007 and AQ 9 – Geomorphology TSR [2008] [PCWA 2011j; SD B]).

- Characterization of riparian resources along bypass and peaking reaches and Project reservoirs. Evaluation of relationships between riparian resource and hydrologic regimes in bypass and peaking reaches (PCWA 2007; and AQ 10 – Riparian Resources TSR [PCWA 2011k; SD B]).
- Characterization of physical, chemical, and bacterial water quality conditions in the MFP, including bypass and peaking reaches, and Project reservoirs and diversion pools (AQ 11 – Water Quality TSR [PCWA 2011l; SD B]).
- Identification of foothill yellow-legged frog (FYLF) habitat and distribution/abundance of populations in the bypass, peaking, and comparison reaches. Documentation of the timing and length of the breeding season. Characterization of habitat availability and suitability (water stage, velocity, and temperature) in relation to various flow regimes. Documentation of western pond turtle (WPT) habitat (AQ 12 – Special-status Amphibians and Aquatic Reptiles TSR [AQ 12 – TSR] [PCWA 2011m; SD B]).
- Documentation of the potential distribution and abundance of California red-legged frog (CRLF) populations and habitat (AQ 12 – Supplemental TSR [PCWA 2011n; SD B]).
- The Sacramento River Basin and San Joaquin River Basin Water Quality Control Plan (Basin Plan) (CVRWQCB, Fourth Edition revised February 2007). This document specified water quality objectives of allowable limits or levels of water quality constituents by the State Water Resources Control Board (State Water Board) for the waters in the Upper American River Watershed.

7.5.2 Project Overview

A description of the Middle Fork American River Watershed (Watershed) and water use is provided in Section 7.1 and Section 7.3, respectively.

Eight river reaches, four reservoirs, and three small diversion pools (Figure 3-1 and Map 7.5-1) are associated with the MFP. Seven of the eight river reaches are designated bypass reaches and the other is designated as a peaking reach. The bypass reaches are downstream of diversions or reservoirs where water is diverted from the reaches during some or all of the year. The peaking reach is downstream of Oxbow Powerhouse where flows typically fluctuate intra- and inter-daily to meet power demands and support whitewater recreation. The bypass and peaking reaches and reservoirs are listed below according to size:

- Bypass Reaches
 - Small Streams
 - Duncan Creek
 - North Fork Long Canyon Creek
 - South Fork Long Canyon Creek
 - Long Canyon Creek

- Large Rivers
 - Middle Fork American River below French Meadows Reservoir
 - Middle Fork American River below Middle Fork Interbay
 - Rubicon River below Hell Hole Reservoir
- Peaking Reach
 - Middle Fork American/North Fork American River below Oxbow Powerhouse
- Reservoirs and Diversion Pools
 - Large Reservoirs
 - French Meadows Reservoir
 - Hell Hole Reservoir
 - Medium Reservoirs
 - Middle Fork Interbay
 - Ralston Afterbay
 - Small Diversion Pools
 - Duncan Creek
 - North Fork Long Canyon Creek
 - South Fork Long Canyon Creek

The field studies (2005 through 2010) conducted to characterize aquatic resources and their habitats in the vicinity of the MFP were focused at 12 major study sites on the bypass and peaking reaches. These study sites are shown as “Instream Flow” Study Sites on Map 7.5-1. Additional study sites were evaluated for specific Technical Study Plans (TSP), including study sites on unimpaired comparison rivers (North Fork American and North Fork of the Middle Fork American rivers) or upstream of MFP diversions and reservoirs. The bypass and peaking reaches were stratified into geomorphic river channel type and hydrological sub-reaches (i.e., reaches that have similar channel types and flow regimes). Study sites were located within each sub-reach (Map 7.5-1).

7.5.3 Aquatic Species

No anadromous, catadromous, or other migratory species are present in the vicinity of the MFP. Three native anadromous species (winter steelhead, Pacific lamprey, and Chinook salmon) historically migrated into the Watershed. Both steelhead and Chinook salmon reportedly ascended the Middle Fork American River past the Rubicon River confluence, and the Rubicon River as far as the Pilot Creek confluence (approximately 5 miles upstream of the Middle Fork American River confluence) (Yoshiyama, et al. 1996). Impassable dams on the lower American River, including Nimbus and Folsom dams completed in 1955 and 1956, respectively, by the United States Bureau of Reclamation (USBR) prevent anadromous fish passage into the bypass and peaking reaches.

There are four sensitive aquatic species in the vicinity of the MFP including:

- Foothill yellow-legged frog (FYLF) (*Rana boylei*) – FSS, CSC
- Hardhead (*Mylopharodon conocephalus*) – FSS
- California red-legged frog (CRLF) (*Rana aurora draytonii*) – FT, CSC
- Western pond turtle (WPT) (*Actinemys marmorata*) – FSS, CSC

where: FT = Federal Threatened Species, FSS = USDA Forest Service Sensitive Species, CSC = California Department of Fish and Game Species of Special Concern.

FYLF, hardhead, and WPT are common to abundant in select reaches associated with the MFP. No individuals of CRLF are known to exist in the immediate vicinity of the MFP (Section 7.5-12).

Fish species present in the bypass and peaking reaches associated with the MFP are rainbow trout, brown trout, hardhead, Sacramento pikeminnow, Sacramento sucker, sculpin species, speckled dace, and California roach. Species present in the Project reservoirs are rainbow trout, brown trout, hardhead, Sacramento pikeminnow, Sacramento sucker, kokanee, tui chub, and lake trout.

7.5.4 Resource Management Objectives

For most streams in the vicinity of the MFP, resource management objectives focus on providing suitable habitat conditions to support coldwater fish populations (rainbow trout) and other aquatic species. Management objectives also focus on protecting sensitive warmwater fish and special-status amphibians, where appropriate.

Management plans that apply to aquatic resources in the vicinity of the MFP are listed below and are summarized in Table 7.5-1.

- California Wild Trout Program
- Eldorado National Forest Land and Resources Management Plan
- Tahoe National Forest Land and Resources Management Plan
- National Park Service – Nationwide Rivers Inventory
- United States Bureau of Reclamation (USBR) – American River Water Resources Investigation: Wild and Scenic River Eligibility Study and Preliminary Classification
- Water Quality Control Plan (Basin Plan) – Central Valley Region, the Sacramento River Basin and San Joaquin River Basin

The Rubicon River is a California Department of Fish and Game (CDFG)-Designated Wild Trout Stream managed to protect wild trout populations. <<http://www.dfg.ca.gov/fish/Resources/WildTrout/Waters/index.asp>>

The Rubicon River and the peaking reach (the Middle Fork American and North Fork American rivers downstream of Ralston Afterbay Dam) are candidates for Wild and Scenic River status. Although they are not formally designated as Wild and Scenic rivers, state and federal resource agencies are required to managed the rivers and the area within 0.25 mile of the rivers to protect outstandingly remarkable values that cause them to be considered eligible (Table 7.5-1). A detailed description of the Wild and Scenic River status is provided in Section 6.5, Wild and Scenic Rivers Act.

No essential fish habitat as defined under the Magnuson-Stevens Fishery Conservation and Management Act is present in the vicinity of the MFP.

7.5.5 Riverine Physical Environment

The riverine physical environment associated with the MFP is described below. The physical environment includes: (1) hydrology; (2) channel geomorphology and sediment transport and supply; (3) riparian vegetation; and (4) water temperature and dissolved oxygen.

7.5.5.1 Hydrology

A detailed description of MFP hydrology is included in Section 7.3 – Water Use Affected Environment. Overviews of FERC License minimum Instream flows, typical MFP operations in the bypass and peaking reaches, and accretion are discussed below.

Current FERC License Minimum Instream Flows

- The minimum instream flow requirements are in Table 3-14, Section 3.0 – No-Action Alternative. The existing minimum instream flows are typically based on a dry/wet water year type designation. In the hydrology period of record (1975–2007) about 12% of the years were dry and the remainder were wet (Table 7.3-2).
- The minimum instream flows are generally fixed minimums without a natural seasonal hydrograph shape.
- In the peaking reach, there is a ramping rate requirement that releases shall not cause vertical fluctuations greater than 3 feet per hour.

Typical MFP Operations in the Bypass and Peaking Reaches

BYPASS REACHES

In the large river bypass reaches (Middle Fork American River and Rubicon River) flows are altered year-round. Flows are typically reduced and more stable during the

winter/spring as water is diverted into storage or used for power generation (Figure 7.3-2). During the summer and fall seasons, flows in the bypass reaches are typically equal to or greater than natural unimpaired conditions as water is released from storage to meet minimum instream flow requirements mandated in the FERC License.

In the smaller stream bypass reaches (Duncan, North and South Fork Long Canyon, and Long Canyon creeks) flows typically are lower than natural flows during the winter-spring season (Figure 7.3-3) due to diversions. During the summer-fall season, the diversions are not operated because of low inflow and minimum instream flow requirements, and natural flows are present in the streams.

PEAKING REACH

In the peaking reach, flows can fluctuate substantially to meet daily power demands or to support whitewater recreation. Operations of the MFP (except in the wettest of water years and/or seasons of the year) can result in daily flow fluctuations in the peaking reach from about 75 cubic feet per second (cfs) (FERC License minimum flow requirement) to the capacity of the Oxbow Powerhouse (approximately 1,025 cfs) (Figures in Appendix B1). Winter-spring season flows are often similar to natural flows due to the large amount of accretion from the North Fork of the Middle Fork American River and the North Fork American River (see below). Summer-fall season flows are typically higher and more variable than unimpaired conditions due to releases to meet consumptive water and power demands and whitewater recreation.

Accretion

During the winter and spring seasons, flow accretion from the surrounding sub-watersheds occurs along the length of the bypass and peaking reaches. The accretions in the Middle Fork American River, the Rubicon River, Duncan Creek, and Long Canyon Creek bypass reaches and in the peaking reach are large enough to transition the altered flow regimes at the top of the reaches (immediately downstream of Project dams) into a flow regime further downstream that has a more natural seasonal flow pattern (higher winter-spring flows and lower summer-fall flows) (Figure 7.3-2 and Figures in Appendix B1). Accretion flow is relatively small during the summer-fall period in the bypass and peaking reaches and has a limited affect on the summer-fall flow pattern.

7.5.5.2 Channel Geomorphology and Sediment Transport and Supply

Details of the MFP geomorphology are included in Section 7.7 – Geomorphology Resources Affected Environment. Overviews of the river channels, fine sediment, gravel supply, and channel berms are discussed below.

River Channels

The MFP is located in an area characterized by steep (2 to 4%, with local slopes up to 10%), V-shaped canyons and rugged terrain. Only the upper portions of the Long

Canyon Creek (including North and South Fork Long Canyon creeks) and the Rubicon River (5.6 miles downstream of Hell Hole Dam) are found within wider, glacier-formed U-shaped valleys. The majority of the bypass streams are highly to moderately entrenched with no or limited adjacent floodplains. Longitudinal profiles of the MFP streams and rivers are shown in Figure 7.7-1.

The majority of the streams are mixed bedrock-alluvial channels with coarse substrates and with few alluvial sections that are adjustable. Some notable exceptions from the typical channels in the MFP are: (1) the Rubicon River below Hell Hole Dam for about 1.5 miles consists of subsurface flow through alluvium deposited from the historic Hell Hole Dam failure; (2) North and South Fork Long Canyon Creeks have more abundant smaller substrate (gravels, small cobbles) than the other channels; and (3) the peaking reach downstream of Ralston Afterbay is a low gradient (0.5%), alluvial channel with numerous alternating point bars and mid-channel bars (PCWA 2007).

Fine Sediment

Fine sediment abundance is very low throughout the MFP; pools have very little fine sediment storage (Table 7.7-7).

Fine sediment content for all of the gravel samples were within the established criteria to support high spawning success (Table 7.7-8).

Gravel Supply

All study streams contained suitably-sized spawning material (8-64 mm) for trout (AQ 9 – Geomorphology TSR [2008] [PCWA 2011j; SD B]). However, gravel is not overly abundant.

MFP reservoirs and diversion pools capture a portion of the natural gravel supply in the streams and rivers, thereby, reducing sediment supply in the bypass and peaking reaches (Table 7.7-11).

Channel Berms

Sediment/channel conditions in the bypass and peaking reaches are being maintained by the current flow regime and berm development, channelization, or aggradation/degradation is not occurring (Section 7.7 – Geomorphology Resources Affected Environment and Section 7.8 – Riparian Resources Affected Environment).

7.5.5.3 Riparian Vegetation

Details of the riparian resources are discussed in the Section 7.8 – Riparian Resources Affected Environment.

- Riparian vegetation was sparse and patchily distributed along the majority of the bypass reaches (Middle Fork American River from French Meadows Dam to Middle Fork Interbay, Rubicon River, Duncan Creek, South Fork Long Canyon

Creek, and Long Canyon Creek) due to the confined valley walls and bedrock/coarse substrate.

- Wide corridors of riparian vegetation were relatively uncommon except in the peaking reach and on the Rubicon River immediately downstream from Hell Hole Dam.

7.5.5.4 Water Temperature and Dissolved Oxygen

General water quality data in the bypass and peaking reaches, excluding temperature and dissolved oxygen, are available in AQ 11 – TSR (PCWA 2011i; SD B) and are discussed in detail in Section 7.4 –Water Quality Affected Environment.

Placer County Water Agency (PCWA) installed and continuously monitored water temperatures at 50 locations on streams and rivers associated with the MFP, as well as on comparison rivers and tributary streams from 2005 to 2010 (PCWA 2007 and PCWA 2011e; SD B). The locations of these monitoring stations and meteorological stations used to collect information to support the relicensing studies are shown on Map 7.5-2. The data were used to characterize and evaluate water temperature conditions in the reservoirs and streams associated with the MFP. The data were also used in the development of the stream and reservoir water temperature models (AQ 4 – TSR [PCWA 2011e; SD B]). Dissolved oxygen measurements were collected at 31 locations during the spring and fall of 2007 in the bypass and peaking reaches (AQ 11 – TSR [PCWA 2011i; SD B]).

Dissolved oxygen concentrations in the bypass and peaking reaches ranged between 7.1 and 11.7 during the spring and fall sampling events (AQ 11 – TSR [PCWA 2011i; SD B]). These measurements are consistent with the Basin Plan objective of 7.0 mg/L (CVRWQCB 2007).

Project operations have altered the water temperature regimes in the large bypass and peaking reaches, particularly during the summer and early fall. An example of modeled unimpaired average water temperature for August 2007 compared to existing water temperature (August 2007) illustrates the cooling effect of MFP operations on the bypass and peaking reaches in late summer (Map 7.5-3a and 7.5-3b).

The storage of cold water in French Meadows and Hell Hole reservoirs during the spring runoff period and its subsequent release from low-level outlets and powerhouses throughout the summer and fall have substantially reduced water temperatures of the Middle Fork American and Rubicon rivers by as much as 15°F (e.g., from the low 60–70s to the mid 40–50s) or more.

Under existing conditions, summer water temperatures in the large rivers are reset to cooler reservoir/powerhouse release temperatures (typically about 45–55°F) below French Meadows Reservoir, Hell Hole Reservoir, Middle Fork Interbay, and Ralston Afterbay. The cool water released at the top of the reaches is warmed by air temperature and solar radiation as it moves downstream. For example, the daily

average water temperature in the Rubicon River warms from approximately 45 to 72°F from the Hell Hole Reservoir release to Ralston Afterbay. The peaking reach has the least amount of warming during the summer along its length relative to the other reaches. The peaking reach has highest relative starting temperature (e.g., 55°F) and the largest amount of water; therefore, warming is relatively slow (the lower difference between air temperature and water temperature and the large thermal mass of the river reduces the rate of warming). The average temperature of the water flowing from the peaking reach into Folsom Reservoir during the summer is much cooler (e.g., 10°F) than it would have been under unimpaired conditions (Map 7.5-3a and 7.5-3b).

Stream temperatures in the smaller bypass reaches (Duncan Creek and Long Canyon creeks) during the summer and fall are unaffected by the MFP because water is generally not diverted during this time period.

A seasonal summary of the 2006–2008 empirical water temperature data at various locations along the length of each river reach (Middle Fork American River bypass and peaking reaches, Rubicon River, and small streams) is shown in Figures 7.5-1a–h (Map 7.5-2 for locations). Seasonally, the coldest temperatures are in the winter and the warmest in July and August. The temperature of the cool water releases from the reservoirs/powerhouses is relatively constant (very slight warming trend) from late spring through early fall.

In general, water temperature in the bypass and peaking reaches is ideal for coldwater species such as rainbow trout. Mean daily summer temperatures along the length of most of the reaches ranges between 7°C–20°C (45°F–68°F). The water temperatures are consistent with the Basin Plan beneficial uses for coldwater freshwater habitat (COLD) and habitat for reproduction and early development of fish (CVRWQCB 2007).

Two of the river reaches have summer coldwater/warmer water transition zones and corresponding transition zones of coldwater/warmer water species (cold water trout and warmer water FYLF and hardhead). Transition zones are found in the lower portion of the Rubicon River and the lower portion of the Middle Fork American River below Middle Fork Interbay. These transition zones result from natural warming of the water along the length of the river reaches and are consistent with the beneficial uses designated for these streams in the Basin Plan –CVRWQCB 2007).

Tables 7.5-2a and 7.5-2b show the River Mile where the July–August 17°C (FYLF lower optimum temperature, see below) transition and the 20°C (trout upper temperature [Hokanson et al. 1977]) transition occur in critical, dry, and below normal water year types. These are the water year types that are most sensitive to minimum instream flow temperature alterations due to lower accretion flows (AQ 4 – TSR [PCWA 2011e; SD B] for a discussion of modeling methods/documentation). The 17°C water temperature transition location was the approximate upstream location of the FYLF distribution in the lower portion of the Rubicon River and the lower portion of the Middle Fork American River below Middle Fork Interbay in 2007 (Section 7.5.9) and is identified by FYLF experts, Dr. Amy Lind, USDA-FS and Dr. Sarah Yarnell, Cardno ENTRIX, as the approximate FYLF lower optimum summer water temperature.

7.5.6 Instream Flow Habitat Modeling

Instream flow physical habitat modeling was conducted for each bypass and peaking reach (12 study individual study sites) in the MFP using a combination of 1D and/or 2D hydrodynamics and habitat models (AQ 1 – TSR [PCWA 2011a]) (Map 7.5-1). Instream flow modeling was used to develop wetted perimeter and habitat area versus flow relationships, create habitat time series analyses, and analyze effective habitat (in the peaking reach).

The following habitat analyses were completed for the bypass reaches:

Reach (site)	Method	Species/Life Stage	Season	
Bypass Reach 1D Study Sites (D6.3, NFLC1.9, SFLC2.3, LC9.0, MF44.7, MF36.2, MF26.2, R25.7, R20.9, R3.5)	Wetted Perimeter vs. Flow	Productivity (algae, benthos)	Winter, Spring, Summer/Fall	
	Standard WUA vs. Flow	Rainbow Trout		
		• Spawning (primary and depth sensitivity)		March–May
		• Adult		June–October
		• Juvenile		June–October
		• Fry		June–August
		Hardhead		
		• Adult		June–October
		• Juvenile		June–October
	Spatial Niche (Guild)	All	June–October	
	Time Series (1975–2000)	Rainbow Trout		
		• Spawning (primary and depth sensitivity)		March–May
		• Adult		June–October
		• Juvenile		June–October
		• Fry		June–August
Hardhead				
• Adult			June–October	
• Juvenile			June–October	
Bypass Reach 2D Study Sites (MF26.2, R3.5)	Standard WUA vs. Flow	FYLF		
		Breeding	mid-May to mid-June	
		Tadpole	June–October	

The following habitat analyses were completed for the peaking reach:

Reach (site)	Method	Species/Life Stage	Season	
Peaking Reach 2D Study Sites (MF14.1, MF4.8)	Wetted Bed Area vs. Flow	Productivity (algae, benthos)	Winter, Spring, Summer/Fall	
	Standard WUA vs. Flow	Rainbow Trout		
		• Spawning (primary and depth sensitivity)		March–May
		• Adult		June–October
		• Juvenile		June–October
		• Fry		June–August
		Hardhead		
		• Adult		June–October
		• Juvenile		June–October
		Food Production		Winter, Spring, Summer/Fall
		FYLF		
	• Breeding		mid-May to mid-June	
	• Tadpole		June–October	
	Spatial Niche (Guild)	All		June–October
	Effective Habitat vs. Flow Fluctuations	Rainbow Trout		
		• Spawning (primary and depth sensitivity)		March–May
		Food Production		Winter, Spring, Summer/Fall
FYLF				
• Breeding			mid-May to mid-June	
	• Tadpole		June–October	

Wetted perimeter versus flow relationships were developed at the 1D study sites and wetted bed area versus flow relationships were developed at the 2D study sites. Standard weighted usable area (WUA) versus flow relationships were developed at all of the study sites for the primary priority management species and life stages.

Priority management species and life stages were selected in collaboration with the Aquatic TWG (Tables 1-2; AQ 1 – TSR [PCWA 2011a; SD B]). The primary species and life stages selected for instream flow modeling included rainbow trout (juvenile rearing, adult rearing, and spawning), hardhead (juvenile and adult rearing), and FYLF (breeding and tadpoles). Univariate habitat suitability criteria (HSC) were developed for these species. Also, a guild (or spatial niche) approach was used to model habitat for all aquatic species (primary and secondary priority species/life stages). The

guild/spatial niche approach included the primary species/life stages listed above, as well as secondary species/life stages including juvenile and adult Sacramento pikeminnow, Sacramento sucker, California roach, sculpin species, speckled dace, fry of all the fish species, and macroinvertebrates/food production (Table 7.5-3 and Figure 1-5, AQ 1 – TSR [PCWA 2011a; SD B]). Brown trout was not identified as an important management species by the resource agencies and, therefore, was not evaluated separately as a target species. In the spatial niche analysis, rainbow trout was used as a surrogate for brown trout, as the two species have similar habitat preferences for most life stages.

A life stage periodicity chart (i.e., season of occurrence) for the aquatic species in the study area (Table 7.5-4) was developed from existing information (Meehan and Bjornn 1991; Behnke 1992, Moyle 2002), biologist observations, and study results (e.g., AQ 2 – TSR [PCWA 2011b; SD B], AQ 10 – TSR [PCWA 2011k; SD B], and AQ 12 – TSR [PCWA 2011m; SD B]). Biologically sensitive time periods for most fish species occur during spring spawning/incubation and summer/fall rearing (June–September). The exception is brown trout, which reportedly spawn in November and December (Moyle 2002).

All wetted perimeter and habitat area versus flow relationships (WUA and spatial niche) were modeled over a wide range of flows (low base flows up to approximately the 10% exceedance unimpaired flow).

The habitat versus flow relationships were combined with hydrology (impaired and unimpaired daily mean flows) over the 1975–2007 period of record to create habitat time series and habitat exceedance plots. The habitat time series were used to compare the amount of habitat during the different biologically sensitive time periods (reproduction and rearing) and identify potential habitat limiting factors/time periods. Habitat exceedance plots were created for each of five water year types (wet, above normal, below normal, dry, and critical/extreme critical).

At the 2D study sites in the peaking reach (MF4.8 and MF14.1), effective habitat versus flow fluctuation relationships were developed for rainbow trout spawning (primary HSC and depth sensitivity HSC), FYLF breeding and tadpole rearing, and benthic macroinvertebrate food production habitat to characterize habitat for low mobility or non-mobile species/lifestages in a fluctuating flow regime. The details of the effective habitat modeling methods are documented in AQ 1 – TSR (PCWA 2011a; SD B). The effective habitat tables/plots quantify the habitat that is continuously suitable over a specified time period such as a day or season can be used to understand the potential effects of Project-related flow fluctuations.

The aquatic species habitat modeling analyses were applicable either to the late spring spawning/breeding period or the summer/fall rearing period. Habitat suitability criteria were not developed for the winter or early spring period (cold water periods). Typically fish utilize comparatively low velocity water habitats during cold weather periods (Baltz et al. 1991; Vondracek et al. 1992). As a result, habitat modeling of winter habitat typically indicates that low flows provide suitable habitat. However, maintenance of

channel primary productivity and macroinvertebrate production capacity during the cold winter/early spring period may be an important consideration for maintaining the river ecological processes; therefore, wetted perimeter modeling was used to provide an index of potential winter/spring primary and benthic production capacity of the channel.

The wetted perimeter/bed versus flow, spatial niche, and effective food production habitat modeling results are provided in Section 7.5.7 – Riverine Aquatic Community. The modeling results for fish species and FYLF are found in the Section 7.5.8 – Riverine Fish and Section 7.5.9 – FYLFs, below.

7.5.7 Riverine Aquatic Community

To assess the condition of the general aquatic community, technical studies were completed to characterize: (1) algae; (2) benthic macroinvertebrates; (3) aquatic mollusks; and (4) productivity and habitat/species diversity. The key findings from these studies are summarized below.

7.5.7.1 Algae

PCWA collected algae samples to identify if *Didymosphenia geminata*, a nuisance algae species, was present in the study area and to document the abundance of algae. Algae samples were collected at each instream flow study site, at two comparison stream study sites (North Fork American River, South Fork Long Canyon Creek above the diversion), and at a study site at the top of the peaking reach (14 study sites total) (AQ 1 – TSR Appendix H, Table H-1 [PCWA 2011a; SD B]). Algae was assessed during late summer by using photographs and the field-based rapid periphyton survey protocol detailed in the Environmental Protection Agencies' Rapid Bioassessment Protocol For Use in Streams and Wadeable Rivers (Barbour et al. 1999).

Based on the summer algae abundance surveys, algae coverage was sparse at most of the instream flow sites (see photographs in AQ 1 – TSR Appendix H, Attachment A [PCWA 2011a]) but was relatively dense in the top of the peaking reach. Cumulative filamentous macroalgae and microalgae coverage ranged from a low of 10.7% at the Rubicon River near Ellicott Bridge (R20.9) to a high of 85.5% at Middle Fork American River below Ralston Afterbay (MF23.5) (AQ 1 – TSR Appendix H, Table H-2 [PCWA 2011a; SD B]).

Didymosphenia geminata was found throughout the MFP study area. The only streams/rivers where *Didymosphenia geminata* was not documented in samples collected as part of this study were North Fork Long Canyon Creek and the North Fork American River (AQ 1 – TSR Appendix H, Table H-1 [PCWA 2011a; SD B]).

7.5.7.2 Benthic Macroinvertebrates

The streams and rivers associated with the MFP support diverse communities of BMIs (AQ 3 – TSR [PCWA 2011c; SD B]). BMIs were sampled at 21 representative study sites, including unimpaired comparison rivers, using two survey methods: (1) Surface Water Ambient Monitoring Program (SWAMP) (Ode 2007) at 14 sites; or (2) California

Stream Bioassessment Procedure (CSBP) (CDFG 2003) at seven sites. The CSBP surveys were conducted at the seven sites to enable comparison with historical surveys. The macroinvertebrates in the bypass and peaking reaches were analyzed using two approaches: (1) a multi-metric index of biotic integrity (IBI) for streams and rivers influenced by hydropower projects developed by Rehn (2008); and (2) a comparison of specific metrics to compare with historic (2001–2006) BMI data at certain sites (AQ 3 – TSR [PCWA 2011c; SD B]).

Overall there was no observable difference in the IBI or the individual benthic macroinvertebrate metrics at the study sites related to MFP operations or facilities, except at the study sites in the top of the peaking reach immediately below Ralston Afterbay/Oxbow Powerhouse. The main findings from the study are summarized below.

- In combination, the hydropower IBI and individual metric scores indicated lower biological conditions at the top of the Middle Fork American River peaking reach immediately below Ralston Afterbay Dam (MF24.4) and immediately below Oxbow Powerhouse (MF23.6), compared to the adjacent sites on bypass rivers (Rubicon and Middle Fork American rivers) and comparison sites (North Fork American and North Fork of the Middle Fork American rivers). There were fewer intolerant EPT taxa, more high tolerance individuals, and lower taxa richness.
- In the peaking reach, excluding the two sites at the top of the reach, biological conditions (IBI and individual scores) were similar to those in non-peaking comparison sites (unimpaired comparison rivers and the Middle Fork American River and Rubicon River immediately upstream of Ralston Afterbay) (some variability occurred depending on the individual metric examined).
- Hydropower IBI scores were higher (indicating better biological conditions) at the higher elevation, colder water sampling sites in the MFP study area than at the lower elevation, warmer water sampling sites, suggesting that the hydropower IBI was correlated with elevation and water temperature.
- Hydropower IBI scores downstream of French Meadows and Hell Hole reservoirs were relatively high and within the range of those observed in unimpaired river reaches above hydropower reservoirs by Rehn (2008).
- The hydropower IBI scores for the sampling sites both above and below the diversions on South Fork Long Canyon and Duncan creeks were above the median hydropower IBI scores for streams located upstream of dams and diversions evaluated by Rehn (2008) (AQ 3 – TSR, Appendix D).
- Repeated annual sampling results from above and below Duncan Creek Diversion did not indicate a consistent difference in hydropower IBI scores.

7.5.7.3 Aquatic Mollusks

PCWA conducted a study at 26 locations in the MFP and comparison rivers to determine the presence, or lack thereof, of one special-status mussel species (California floater, *Anodonta californiensis*), and two special-status aquatic snail species (scalloped juga, *Juga (Calibasis) occata*; and Great Basin rams-horn snail, *Helisoma newberryi*) (AQ 3 – Aquatic Mollusk TSR, Table AQ 3-1 and Map AQ 3-1 [PCWA 2011d; SD B]). In addition, all aquatic mollusk species encountered were identified and their abundance and diversity by study site were reported.

No live specimens or shells of special-status mollusk species including California Floater, scalloped juga, and Great Basin rams-horn were found at any of the study sites.

Common aquatic mollusk species found in the study area included: (1) four bivalves—the freshwater mussel (*Margaritifera falcata*) and three peaclams (*Pisidium casertanum*, *Pisidium walkeri*, and an unidentified *Pisidium* species); and (2) five gastropods—*Ferrissia rivularis*, *Fossaria obrussa*, *Juga (Oreobasis) nigrina*, *Menetus opercularis*, and *Physella gyrina*. The peaclams and most of the aquatic gastropods identified in the study area are common native species that occur throughout most of North America. Other common invertebrates observed in the study area during the aquatic mollusk surveys included five native species of terrestrial gastropods and the signal crayfish (*Pacifastacus leniusculus*), which is not native to the Sierra Nevada drainages.

7.5.7.4 Productivity and Habitat/Species Diversity

The methods used to address productivity and habitat diversity for species include wetted perimeter, spatial niche habitat, and effective habitat (for fluctuating flows in the peaking reach).

Wetted Perimeter

Wetted perimeter and wetted bed versus flow relationships, useful for evaluating potential effects of flow regimes on productivity (algae and benthos), were relatively monotonic in their rate of increase in wetted perimeter with flow in the bypass and peaking reaches. The rate of increase in wetted perimeter with increased flow was greatest at the lowest flows and least at the highest flows. However, the relationships typically did not have distinct inflection points (distinct breaks) where an increase in flow exhibited an obvious change in the wetted perimeter relationship. Plots showing these relationships are available in Appendix B2 (also see AQ 1 - TSR, Appendix M [PCWA 2011a]).

Spatial Niche Habitat

Physical habitat (niche) utilization for different species and lifestages is summarized in Table 7.5-3. The spatial niche habitat versus flow relationships for each of the instream flow study sites are found in Appendix B2. In the small streams, shallow water habitat was the dominant niche over a wide range of flows, while moderately deep water niche habitat was dominant in the large rivers. The diversity of spatial niche habitat types was

least at low flow and generally greatest at intermediate flows. At low flow, shallow and/or slow velocity habitat was dominant at each of the study sites. As flows increased, deeper and faster water niches increased as a relative percentage of the total amount of habitat. At the highest flow, deep/fast water became the dominant habitat type. Generally, the diversity of habitat is positively related to the diversity of fish species and life stages in rivers. Several investigators have shown that species and life stage diversity is directly related to stream hydraulics and the spatial diversity and stability of habitat (e.g., Gorman and Karr 1978, Statzner and Higler 1986, Schlosser 1987, Bain et al., 1988, Allan 1995, Bowen et al 1998).

Effective Habitat (Fluctuating Flows in the Peaking Reach)

Flow fluctuations related to hydroelectric generation peaking have the potential to reduce overall productivity of rivers (Morgan et al. 1991; Cushman 1985; Gislason 1985; Moog 1993; Bain 2009) and to affect the diversity of aquatic species and/or abundance of juvenile life stages (especially shallow, slow water species and life stages) (Bain et al. 1988; Kinsolving and Bain 1993; Scheidegger and Bain 1995; Bain 2009). Many aquatic species have specific habitat requirements and limited mobility (e.g., Edington 1968) and daily flow fluctuations modify the location and amount of habitat (depths and velocities and/or location of the channel margin), thereby, decreasing overall habitat quality and availability.

The effective habitat flow matrix tables and associated plots are presented in Appendix B2 (also see AQ 1 - TSR, Appendix M [PCWA 2011a; SD B]) for the peaking reach study sites (MF4.8 and MF14.1). The effective habitat matrix results show that for low mobility species/life stages, such as macroinvertebrates (food production), changes in flow cause a large reduction in habitat. Figures 43 and 50 in Appendix B2. For example, at Fords Bar (MF14.1) the amount of food production habitat available at 1018 cfs would be reduced by 56% if flows fluctuate down to approximately 100 cfs (107,696 to 47,017 feet²/1000 feet). Under this same scenario, the food production habitat at Buckeye Bar (MF4.8) would be reduced by 69% (90,811 to 28,151 feet²/1000 feet).

The effective habitat results for fish and FYLF are discussed in the Section 7.5.8 – Riverine Fish and Section 7.5.9 – Foothill Yellow-legged Frogs. Generally, the species/life stages with narrowest range of depth and velocity requirements (e.g., FYLF egg masses and tadpoles) shows a greater reduction in habitat with changing flow than species/life stages with broader depth and velocity habitat requirements (e.g., macroinvertebrate food production). Rainbow trout spawning was generally intermediate in sensitivity.

7.5.8 Riverine Fish

River study sites were sampled in 2007, 2008, and 2009 to identify the spatial distribution, condition, growth, and abundance of fish species. Fish populations were surveyed at a total of 26 river study sites, including sites on the bypass reaches, peaking reach, unimpaired comparison rivers, and upstream of MFP diversions and

dams. The surveys were conducted during the late summer/ early fall base flow period using a combination of electrofishing (shallow water), snorkeling (deep water), and gillnetting (open water) to determine the distribution and abundance of fish species (Map 7.5-4). Qualitative sampling was conducted to determine the upstream distribution of trout, hardhead, and Sacramento pikeminnow. The timing of emergence and relative abundance of fry in the vicinity of the diversions were surveyed in the spring/early summer 2007 and in the spring of 2009 using electrofishing and seining. The study sites and survey methods are described in the AQ 2 –TSR (PCWA 2011b; SD B) and AQ 7 – TSR (PCWA 2011h; SD B). Fish scales from trout and hardhead were collected to assist in the development of age versus growth relationships. Also, potential fish passage barriers were mapped along the rivers and streams (natural barriers, project infrastructure barriers, and other man-made barriers) (AQ 6 – TSR [PCWA 2011g; SD B]) to determine their potential effects on fish distributions.

Information discussed below on riverine fish includes: (1) distribution and diversity; (2) fish passage barriers; (3) growth and condition; (4) emergence/spawning timing; (5) abundance (standing crop); (6) fish stocking; (7) bypass reach habitat; and (8) peaking reach habitat.

7.5.8.1 Distribution and Diversity

Distribution – The pattern of species distribution in the study area was primarily indicative of water temperature (Figure 7.5-2, Map 7.5-3b) and fish barriers (Section 7.5.8.2, Fish Passage Barriers). Coldwater trout were the most widely distributed of the 15 species of fish observed at the study sites (Table 7.5-5, Map 7.5-4 for spatial location). Rainbow trout were present in all sampling locations and brown trout were present in all sampling locations except those in the Long Canyon creeks and the two comparison rivers (North Fork American River upstream of Lake Clementine and North Fork of the Middle Fork American River). The spatial pattern of average August water temperature indicates that most of the bypass reaches and peaking reach provide suitable water temperatures for trout (e.g., average monthly water temperature <70°F) (Hokanson et al. 1977).

Warmer water minnow species (hardhead, Sacramento pikeminnow, and California roach) were less abundant than trout and patchily distributed (Figure 7.5-2). Hardhead, in particular, were only observed in a few locations. The majority of the hardhead were found in Ralston Afterbay and the Middle Fork American and Rubicon rivers immediately upstream of Ralston Afterbay. Hardhead were also found in two isolated locations in the peaking reach downstream of Ralston Afterbay, including a pool in Otter Creek at its confluence with the Middle Fork American River and a small in-channel dredging pool in the Middle Fork American River at RM23.5 (upstream of Tunnel Chute). Young “mixed minnows” (<3 in.) were observed during snorkeling at several other locations, but they were too small to differentiate between hardhead and pikeminnow (Table 7.5-5).

Qualitative snorkeling during the summer and fall of 2007 and 2008 was used to determine the minnow distribution (hardhead, Sacramento pikeminnow, and California

roach) in the rivers upstream of Ralston Afterbay. Table 7.5-5 shows the sampling locations. In the Middle Fork American River, minnows were only observed from Ralston Afterbay upstream 0.5 mile to the first major barrier (Section 7.5.8.2 – Fish Passage Barriers). No minnows were found upstream of the barrier. In the Rubicon River, a large impassable barrier at RM6.0 appeared to limit the upstream distribution of hardhead (5.4 miles upstream of Ralston Afterbay) and a large impassable barrier at RM8.2 appeared to limit the upstream distribution of Sacramento pikeminnow (7.6 miles upstream of Ralston Afterbay). California roach were found as far upstream as RM14.3. In both the Middle Fork American and Rubicon rivers, hardhead and Sacramento pikeminnow presence was patchy, and the number of hardhead relative to other minnow species was low.

In the comparison rivers, hardhead and Sacramento pikeminnow presence was also patchy. At the North Fork American River site at RM31.3 downstream of Ponderosa Bridge, only one pool at the very bottom and one pool at the very top of the 1.3-mile-snorkeling site contained hardhead or Sacramento pikeminnow. At the qualitative snorkeling site upstream at RM36 near Shirttail Creek and Bunch Canyon (approximately 1 mile long), a small side pool at the confluence with Bunch Canyon was the only location that contained hardhead and/or Sacramento pikeminnow. In the North Fork of the Middle Fork American River, hardhead and Sacramento pikeminnow were only found in the lower snorkeling sight near the confluence with the Middle Fork American River. Hardhead were not observed farther upstream at the Circle Bridge snorkeling site, RM2.3, but a few (6) small, Sacramento pikeminnow were observed.

Sacramento sucker and sculpin were the most widely distributed species other than trout. They were found together in the same sampling locations including sites in the peaking reach, the comparison rivers, the lower portion of the Rubicon River, and the Middle Fork American River immediately upstream of Ralston Afterbay. Centrachids (smallmouth bass and green sunfish) were only captured at one location, the comparison site in the North Fork American River upstream of Lake Clementine. White catfish were also captured at this location.

Diversity – The highest river fish diversity (6–8 species) was found in the warmer sections of river (Table 7.5-5). These were the Middle Fork American River and Rubicon River sampling sites just upstream of Ralston Afterbay and in the comparison river sampling sites (North Fork American River upstream of Lake Clementine, North Fork of the Middle Fork American River) (Table 7.5-5). The lowest diversity was found in the higher elevations (colder water) streams. Trout were the only species present in the Middle Fork American River upstream of Middle Fork Interbay and in Duncan Creek (rainbow trout and brown trout) and in Long Canyon creeks (rainbow trout only).

7.5.8.2 Fish Passage Barriers

Many natural and man-made fish barriers unrelated to the MFP (e.g., Tunnel Chute) were present throughout the peaking and bypass reaches Map 7.5-5 (also see AQ 6 – TSR [PCWA 2011g; SD B]). Barriers to upstream movement were frequent in nearly all river reaches; little opportunity existed for fish to move long distances upstream in the

bypass reaches due to the presence of barriers. MFP facilities (four large dams, three small diversion structures, one tunnel stream crossing, one road crossing, three gage weirs) created additional barriers to upstream fish movement. However, these barriers were located in reaches that contain natural barriers and typically did not preclude fish from accessing large sections of river due to the nearby presence of natural and non-Project barriers.

Natural barriers limit the upstream distribution of hardhead and pikeminnow in the Middle Fork American and Rubicon Rivers and may be a factor in the absence of brown trout in the Long Canyon creeks. The upstream limit to the hardhead and pikeminnow distribution on the Middle Fork American River was a large natural barrier complex 0.5 mile above Ralston Afterbay. The upstream limit to their distribution on the Rubicon River above Ralston Afterbay was a series of natural barriers along several miles of river (RM3.4 to RM8.2). The hardhead distribution ended at a natural waterfall at RM6.0 and the Sacramento pikeminnow distribution approximately ended at a large natural waterfall at RM8.2. In the Long Canyon creeks, where only rainbow trout are present, apparently brown trout from the Rubicon River have not been able to move upstream into these streams due to natural barriers in Long Canyon Creek.

Natural barriers in the tributaries to the MFP streams limit the ability of fish to utilize these streams. Nearly all of the tributaries to the MFP bypass and peaking reaches that were surveyed had natural barriers very near their confluence with the bypass and peaking reach rivers that precluded upstream fish movement into the tributaries (16 of the 18 evaluated). Two tributaries to the peaking reach provided accessible habitat for fish: North Fork of the Middle Fork American River and Otter Creek (approximately the lower 1.5 miles of Otter Creek). MFP operations did not affect access to the bypass and peaking reach tributary streams (the only exception was a potential critical riffle temporary barrier at the Otter Creek confluence when flows were very low in Otter Creek and daily peaking flow in the peaking reach was low).

7.5.8.3 Growth and Condition

Trout throughout the study area rivers/streams were relatively small. In the small streams (Duncan Creek and the Long Canyon creeks), most fish were less than approximately 9.1 inches (230 mm) (e.g., Figure 7.5-3) (Figure AQ 2-10a and Figure AQ 2-10b, AQ 2 – TSR [PCWA 2011b; SD B]). In the large rivers, most fish were less than 12 inches (305 mm). The largest trout were observed in the pools of the large rivers. The study sites with the largest number and percentage of trout greater than 12 inches (305 mm) were in the peaking reach study sites (NF 18.4, MF4.8, MF14.1, and MF23.5). In 2008, size classes during snorkeling surveys were adjusted to include a category for fish greater than 18 inches (457 mm). At each of the peaking reach sites sampled in 2008 (MF4.8, MF14.1, and MF23.5), trout of this size were observed; however, the majority of the 18+ inch fish were observed at the farthest upstream site, MF23.5 (nearly 75%) (AQ 2 – TSR [PCWA 2011b; SD B]).

An analysis of age and growth for rainbow trout captured in 2007 showed variability in age structure and growth rate between sampling sites (Figure 7.5-4) (age measured

from scales). However, rainbow trout captured in the peaking reach (MF14.1) and lower Rubicon River (R3.5) had the fastest growth rates and typically the largest fish at each age class. Rainbow trout in the small streams had the slowest growth rates. Sizes at age 0+ and 1+ were similar between the small streams and larger river sites, but by age 2+ and 3+, fish in the larger rivers were larger. The oldest rainbow trout captured was an age 4+ fish (one fish) in the peaking reach (MF14.1) (Figure 7.5-4). At most sampling sites, the oldest rainbow trout captured were age 3+. Older fish likely were present in the large river sites where snorkeling was used as the primary sampling method, but these fish were not captured for age analysis.

The condition factors (Fulton) of trout in the rivers and streams (including comparison streams) were on average 1.08 in 2007 and 1.1 in 2008 (Table AQ 2-12; AQ 2 – TSR [PCWA 2011b; SD B]) (Nielson and Johnson 1985). There was no obvious difference between the condition factors of fish at the different river study sites and little variability in condition factor within or between sites.

Few adult hardhead or Sacramento pikeminnow were observed or captured AQ 2 – TSR (PCWA 2011b; SD B). Hardhead ranged in size from 35–471 mm. Sacramento pikeminnow ranged in size from 25–445 mm. The largest fish of both species were collected from Ralston Afterbay (see discussion in Section 7.5.10).

7.5.8.4 Emergence/Spawning Timing

The timing of fry emergence in streams was monitored in 2007 and 2009. In 2007, sampling for young-of-the-year (YOY) was conducted in the bypass and peaking reaches. In 2009, sampling was limited to trout emergence upstream of the small diversions (Duncan Creek, North Fork Long Canyon Creek, and South Fork Long Canyon Creek) (AQ 2 – TSR [PCWA 2011b; SD B]).

TROUT

In 2007, rainbow trout YOY were observed by the end of June at all of the qualitative sampling sites and it appears that spawning occurred in April and May in the higher elevation streams and perhaps as early as March in low elevation tributaries. The earliest rainbow trout YOY (and brown trout YOY) were found during the first sampling date, May 11, 2007 in Gas Canyon Creek, a tributary to the peaking reach. Rainbow trout YOY were found in the Middle Fork American River and Rubicon River just upstream of Ralston Afterbay and in North Fork Long Canyon Creek upstream of the diversion in early June 2007 (June 5–7). Brown trout fry were found in the Middle Fork American River just upstream of Ralston Afterbay at the same time. Approximately three weeks later (June 26), rainbow trout YOY were captured in Duncan Creek and South Fork Long Canyon upstream of the diversions. Rainbow trout eggs hatch and emerge in five–seven weeks (at 10–15°C) (Moyle 2002). The fry observation dates coupled with the water temperature data collected suggest that rainbow trout spawning occurred approximately in April and May in Duncan Creek, North Fork Long Canyon Creek, and South Fork Long Canyon Creeks. Rainbow trout in Gas Canyon Creek may have spawned in March (AQ 2 – TSR [PCWA 2011b; SD B]).

In 2009, YOY rainbow trout were first observed upstream of the small diversion structures on June 23 in North Fork Long Canyon Creek and approximately two weeks later (July 6) in Duncan Creek and South Fork Long Canyon Creek (Table 7.5-6). Estimated spawning dates were developed using measured water temperature and back calculating 630 degree-days (i.e., time within the gravel before emerging) (Behnke 1992). In Duncan Creek, North Fork Long Canyon Creek, and South Fork Long Canyon Creek the estimated spawning dates in 2009 were May 3, April 23, and May 11, respectively (AQ 7 – TSR [PCWA 2011h; SD B]).

In the small streams, the timing of the observed trout emergence in 2007 and 2009 coincided with the approximate timing of the end of the diverting season (Table 7.5-6 and Figure 7.5-5). Based on the period of record (1975–2007), diverting at all three diversion structures had ceased by July 1 in most years (Figure 7.5-5). In both 2007 and 2008, YOY were first observed in North Fork Long Canyon Creek. North Fork Long Canyon Creek is the earliest stream to stop diverting; since 1975 (1975–2007), diverting has not extended past June 27. At Duncan Creek, diverting sometimes continued into mid-July (seven of 34 years, mainly during wet water years). In South Fork Long Canyon Creek, flow diversion typically ceased by early July in all but four of 34 years (Figure 7.5-5) (AQ 7 – TSR [PCWA 2011h; SD B]).

Based on the literature (Moyle 2002), it appears that hardhead mainly spawn in April and May, but spawning may extend into August. YOY data collected in the AQ 2 – TSR (PCWA 2011b; SD B) were inconclusive for determining the hardhead spawning date. It is assumed that hardhead may be spawning from early April into the summer.

Small Sacramento pikeminnow (22–28 mm) were captured in the Middle Fork American and Rubicon rivers upstream of Ralston Afterbay in the early June sampling (June 5–7, 2007). It appears Sacramento pikeminnow spawned in April–May consistent with the existing literature (Moyle 2002). Sacramento sucker were observed actively spawning in the Rubicon River immediately upstream of Ralston Afterbay on May 11, 2007. Sacramento sucker YOY were first captured approximately two months later (July 16) in a different sampling location (Middle Fork American River immediately upstream of Ralston Afterbay).

7.5.8.5 Abundance (Standing Crop)

Trout (rainbow and brown) abundance was measured in terms of both density (fish per mile and fish per acre) and biomass (pounds per mile and pounds per acre). For other species (e.g., hardhead) the abundance was low and the number of fish sampled was used as an index of abundance. Fish abundance data are presented below in the following categories: (1) trout density and biomass; (2) comparison sites (trout); and (3) hardhead and Sacramento pikeminnow.

Trout Density

Trout density data for 2007 and 2008 are shown in Figure 7.5-6a and Figure 7.5-6b (also see AQ 2 – TSR [PCWA 2011b; SD B]). Trout density was greatly affected by the

number of YOY present. Generally, the small streams had the highest trout density, intermediate-sized streams/rivers had intermediate density, and the largest rivers had the lowest density (Figures 7.5-6a–b). The highest linear trout densities (3,500–6,500 fish per mile) were found in the Long Canyon Creek drainage (Long Canyon Creek, South Fork Long Canyon Creek, and North Fork Long Canyon Creek) and at one site on the Middle Fork American River upstream of French Meadows Reservoir. Intermediate densities (800–3,500 trout per mile) were observed in Duncan Creek, the Middle Fork American River between French Meadows Reservoir and Middle Fork Interbay, and the upper Rubicon River (although, fish per mile at the Ellicott Bridge site [RM20.9] was slightly less than 800 in 2008). The lowest densities (<800 trout per mile) were found in the comparison river sites (North Fork American River and North Fork of the Middle Fork American River), the Middle Fork American River and Rubicon River sites immediately upstream of Ralston Afterbay, and the peaking reach sites.

The pattern of YOY trout abundance (per mile and per acre) was generally similar to the total trout densities. The highest densities were in Long Canyon Creek, North Fork Long Canyon Creek, and South Fork Long Canyon Creek. The Middle Fork American River in the low gradient section just upstream of French Meadows Reservoir had similarly high densities of YOY per mile (sampled only in 2007). However, YOY densities per acre were lower at this location because of the wide channel (large area per length of stream). Intermediate YOY trout densities (per mile and per acre) were found in Duncan Creek, the Middle Fork American River upstream of Middle Fork Interbay (sampled only in 2007), and in the Rubicon River from Ellicott Bridge upstream (in 2007). Comparatively, low densities of YOY trout were found in the comparison river sites (North Fork American River and North Fork of the Middle Fork American River), in the sampling sites just upstream of Ralston Afterbay (Rubicon River and Middle Fork American River), the Rubicon River near Ellicott Bridge (in 2008), and in the peaking reach.

Trout Biomass

At the various study sites, rainbow and brown trout biomass varied depending on whether biomass was evaluated linearly (pounds per mile) or on an area basis (pounds per acre) (Figures 7.5-6a–b) (also see AQ 2 – TSR [PCWA 2011b; SD B]). Generally the large, wide streams had large linear (biomass per mile) estimates and small streams had large area basis biomass estimates (pounds per acre). Linear biomass was highest (>150 lbs/mile) at several of the large river bypass and peaking reach sites (e.g., MF14.1, MF23.5, and R25.7). On an area basis, biomass was highest at the small stream sites, Long Canyon creeks and Duncan Creek (>50 lbs/acre). The high biomass large river sites (e.g., MF14.1 and MF23.5) were composed primarily of relatively fewer, but larger fish, while the high biomass small stream sites were composed primarily of relatively more, but smaller fish.

The sites with the lowest biomass (e.g., <50 lbs/mile or <10 lbs/acre) were generally the same for both reporting methods (biomass per mile or per area). The comparison river site on the North Fork American River (NF31.3) had the lowest trout density. Summer water temperatures were relatively high at this location (Map 7.5-3b). The other low

biomass sites were the farthest downstream site in the peaking reach (NF18.4) and the Rubicon River (R3.5), and the highest elevation site on the Middle Fork American River upstream of French Meadows Reservoir (MF51.8). The downstream Rubicon River site (R3.5) had relatively high summer water temperatures and the upper Middle Fork American River site (MF51.8 upstream of French Meadows Reservoir) was wide, shallow, and had low flow and relatively warm water temperatures. This site was dominated by YOY.

Comparison Sites (Trout)

The upstream and downstream diversion comparison sites were very similar based on linear fish density (fish/mile) and biomass (lbs/mile) estimates (Figures 7.5-7a-c) (AQ 2 – TSR [PCWA 2011b; SD B]). However, at other comparison sites, fish standing crop varied depending on the metric used (Figures 7.5-8a–b). For example, sometimes density was higher at the comparison sites but biomass was lower, or vice versa. For one set of comparisons there was a consistent difference. The comparison site on the North Fork American River (NF31.3), that was chosen as a potential reference site to compare to the peaking reach sites (NF18.4, MF4.8, MF14.1, and MF23.5), had lower trout density and biomass than the peaking reach sites. Water temperature was higher in the North Fork American River relative to the peaking reach. The density of other species at this comparison river site was relatively low as well.

Hardhead and Sacramento Pikeminnow Abundance

Hardhead, particularly adults, were present in relatively low abundance in the bypass and peaking reaches. They were also present in relatively low abundance in the comparison streams (AQ 2 – TSR [PCWA 2011b; SD B]). A total of 218 hardhead were observed and just over 12% of these were adults (≥ 6 inches) (Table 7.5-7). Hardhead were most abundant in Ralston Afterbay and the bypass stream reaches above Ralston Afterbay (Rubicon and Middle Fork American rivers). The comparison river reaches (North Fork American and North Fork of the Middle Fork American rivers) had the next highest density of hardhead. The peaking reach of the Middle Fork American River (below Ralston Afterbay), had very low numbers of hardhead. There was a number of small “mixed minnow” fish (too small to identify the species) observed at the sampling sites. However, based on qualitative electrofishing and seining surveys, the majority of the fish comprising the mixed minnow guild appeared to be Sacramento pikeminnow and California roach.

Sacramento pikeminnow were slightly more abundant in the study area than hardhead, but adult fish were also relatively rare. A total of 696 Sacramento pikeminnow were observed and just over 19% were adults (≥ 6 inches) (Table 7.5-7). Similar to hardhead, Sacramento pikeminnow were most abundant in Ralston Afterbay and the Project bypass stream reaches above Ralston Afterbay (Rubicon and Middle Fork American River). The comparison river reaches (North Fork American and North Fork of the Middle Fork American rivers) had the next highest density of hardhead. The peaking reach of the Middle Fork American River (below Ralston Afterbay) had very low numbers of Sacramento pikeminnow.

7.5.8.6 Fish Stocking

Fish species in the bypass and peaking reaches are naturally reproducing populations and no stocking currently occurs. Historical fish stocking records indicate that Duncan Creek was stocked with rainbow trout, brook trout, brown trout, and steelhead (last known stocking record was 1953) (PCWA 2007). Historically, the Middle Fork American and Rubicon rivers were stocked with variety of salmonid species, including rainbow trout, brown trout, brook trout, and steelhead (last known stocking record was 1953). No stocking records were located for the Long Canyon creeks. Under its current designation as a Wild Trout Stream, the Rubicon River management objective is for natural reproduction with no stocking of domestic strains of trout.

7.5.8.7 Bypass Reach Habitat

The habitat versus flow relationships and habitat time series analyses for rainbow trout (spawning, adult, juvenile, fry) and hardhead (juvenile and adult) (including Sacramento pikeminnow) fish species are summarized below. Plots and tables of WUA and percent of maximum WUA are presented for each study site in Appendix B2. Detailed presentation of the material is provided in the AQ 1 – TSR (PCWA 2011a; SD B).

Habitat versus Flow

Habitat versus flow relationships indicated that relatively large flows (in comparison to the natural unimpaired summer flow) provide the maximum habitat for species and life stages that use fast and deep water, such as adult rainbow trout. That is, the channels in the bypass and peaking reaches are relatively large, presumably because of frequent high magnitude winter and spring flow events, and are capable of providing habitat for fast/deep water species/life stages at high flow. However, natural summer base flows in these rivers are very low. Table AQ 1-10 in AQ 1 – TSR (PCWA 2011a; SD B) provides information on impaired and unimpaired flows for the streams/rivers associated with the MFP.

The rainbow trout adult habitat versus flow relationships typically reached a maximum at the highest discharge evaluated for all species/life stages. The species and life stages with the next highest habitat versus flow relationships, in descending order, were typically rainbow trout spawning, adult hardhead and Sacramento pikeminnow, juvenile rainbow trout, juvenile hardhead, pikeminnow, fry, and FYLF egg masses and tadpoles.

Rainbow trout spawning sensitivity HSC were used to test uncertainty of deep water (>3 feet) spawning in the habitat versus flow relationships. The depth sensitivity HSC assumed that deep water was suitable for spawning. The empirical data used to create the primary HSC showed that spawning did not occur in water deeper than 3 feet. The deep water sensitivity HSC produced habitat versus flow relationships different than those for the primary rainbow trout spawning HSC in the large rivers where deep water was prevalent. The resulting habitat-flow relationships were the same between the two HSC in the small streams because of the absence of deep water habitats. In the large rivers the deep water sensitivity HSC indicated that higher flows, compared to the

primary spawning HSC, produced the most spawning habitat. Because the primary spawning HSC are based on empirical data, however, the results from the primary spawning HSC were used for the spawning habitat analysis and the depth sensitivity HSC were used as a secondary reference.

The amount of spawning habitat under current Project operations in the bypass reaches compared to the maximum habitat possible using the habitat versus flow analysis is shown in Table 7.5-8. The analysis uses the proposed water year types (Section 7.3 – Water Use Affected Environment). Two analyses were conducted: one that did not account for inflow accretion in the river reaches and one that used a conservative amount of accretion (95% exceedance). The percent of maximum spawning habitat the current FERC License minimum flows provide in North Fork and South Fork Long Canyon was lowest (19–43%). The amount of spawning habitat in the other stream reaches ranged from 42–93% depending on water year type (based on using the accretion approach).

Habitat Time Series

Extensive time series analyses of impaired and unimpaired flow conditions were used to provide an estimate of the difference between existing habitat (impaired) and the natural habitat potential (unimpaired) in the streams/ivers associated with the MFP. The data and detailed discussion are presented in AQ 1 – TSR (PCWA 2011a; SD B). A summary of the results is provided below.

SMALL STREAMS

In the small streams (Duncan, North and South Fork Long Canyon, and Long Canyon creeks), the amount of rainbow trout spawning habitat for impaired conditions was less than spawning habitat for unimpaired. This was due to flow diversion during the spring. The amount of rainbow trout adult, juvenile, and fry habitat was generally the same for both impaired and unimpaired conditions. This occurred because water was typically not diverted from the stream during the summer or fall, except during June.

MIDDLE FORK AMERICAN RIVER BYPASS REACH

In the Middle Fork American River bypass reach (French Meadows Dam to Middle Fork Interbay, Middle Fork Interbay to Ralston Afterbay), the impaired flow rainbow trout spawning and rearing habitat was, in general, equal to or greater than unimpaired flow habitat conditions. The same was true for hardhead and Sacramento pikeminnow habitat in the reach of river below Middle Fork Interbay. The few exceptions to these results identified, were as follows: (1) the spawning depth sensitivity run HSC indicated reduced spawning conditions at the top of the two reaches (immediately below French Meadows Dam and immediately below Middle Fork Interbay), where the lowest flows occur; and (2) at these same locations, impaired adult rainbow trout habitat, was higher or equal to unimpaired habitat for the right side of the habitat exceedance plots (50 to 100% exceedance values), but lower for habitat on the left side of the exceedance plots

(exceedance values from 0 to 50%). That is, part of the time there was more habitat under impaired conditions and part of the time less habitat.

In general, the impaired habitat values in the Middle Fork American River exceeded those for the unimpaired habitat. This is in part due to augmented summer base flows required in the current FERC License minimum flow releases compared to the historic unimpaired flows.

RUBICON RIVER

The results in the Rubicon River produced a pattern similar to that in the Middle Fork American River bypass reaches. In the upper half of the Rubicon River, impaired flow habitat for rainbow trout adult rearing was typically higher than unimpaired flow habitat for the 50 to 100% exceedance habitat values (right side of the exceedance plots) and lower for exceedance values less than 50%. The amount of spawning habitat was greater for impaired flows versus unimpaired flows for the primary spawning HSC, but lower under impaired flows compared to unimpaired flows when using the depth sensitivity spawning HSC. However, for all other species and life stages and locations in the Rubicon River, impaired habitat was equal to or greater than unimpaired habitat. Again, in part, this occurred due to the current FERC License minimum flows being greater than unimpaired base flows.

7.5.8.8 Peaking Reach Habitat

Generally the rainbow trout spawning (primary HSC or depth sensitivity HSC) and FYLF breeding habitat for impaired flow was similar to or greater than for unimpaired flow at the two peaking reach study sites (MF4.8 and MF14.1). Because of flow fluctuations in the peaking reach, however, an effective habitat analysis is the more appropriate way to quantify breeding habitat (AQ 1 – TSR [PCWA 2011a; SD B]). Flow fluctuations can also result in stranding of fish.

Effective Habitat Analysis

Effective habitat flow analysis methods and matrix tables/associated plots are discussed in detail in the AQ 1 – TSR (PCWA 2011a; SD B). The effective habitat tables/plots are provided in Appendix B2. The effective habitat matrix results show that for rainbow trout spawning and incubation, changes in flow cause a large reduction in habitat Figures 37, 38, 39, 40, 44, 45, 46, and 47 in Appendix B2. For example, at Fords Bar (MF14.1) the amount of spawning habitat available at 1018 cfs would be reduced by 78% if flows fluctuate down to approximately 100 cfs (3563 to 792 feet²/1000 feet). Under this same scenario, the spawning habitat at Buckeye Bar (MF4.8) would be reduced by 89% (2011 to 222 feet²/1000 feet).

Effective rainbow trout incubation habitat at the two peaking reach study sites was only slightly less sensitive to flow fluctuations compared to rainbow spawning habitat, even though incubation had less restrictive depth and velocity requirements than spawning.

Empirical Stranding Evaluation

During the peaking flow stranding study conducted on June 5, 2008, a total distance of 2.1 miles of the peaking reach was surveyed immediately after cessation of a daily peaking event of 900 cfs (900 cfs down to approximately 100 cfs) (AQ 1 – TSR [PCWA 2011a; SD B]). The areas surveyed represent areas with a high potential for stranding, characterized by large bar features with varying topography (e.g., low-lying or backwater areas) and relatively shallow slopes. One dead sculpin was observed stranded in the Fords Bar study area and approximately 289 live fish were observed temporally trapped (isolated) in disconnected pools in the Gray Eagle Bar – American Bar study area (Maps 7.5-6a–b and Table 7.5-9). No fish were observed that were permanently trapped. The majority of fish temporarily trapped (approximately 250 fish) were located in a dredge hole developed by recent mining activities. Temporarily trapped/isolated fish consisted of a mix of species (trout fry, California roach, hardhead, Sacramento pikeminnow, and sculpin) that were found swimming in pool areas isolated from the main channel. It was estimated that the trapped fish would survive until another peaking event inundated the habitat. The trapping pools were very near to the active channel, and in most cases had some flow-through or were at groundwater level (i.e., had subsurface hydraulic connectivity to the main channel) (see photographs in Appendix F, Attachment A, AQ 1 – TSR [PCWA 2011a; SD B]).

7.5.9 Foothill Yellow-Legged Frogs

Surveys for FYLF were conducted in spring and/or late summer and early fall along the bypass, peaking, and comparison reaches and their tributaries at a total of 30 study sites to document the distribution and abundance of FYLF (Map 7.5-7) (AQ 12 – TSR [PCWA 2011m; SD B]). All of the surveys, except incidental one-time site visits to help refine distribution, followed the Visual Encounter Protocol described in *Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians* (Heyer et. al. 1994). The study sites and survey methods are described in the AQ 12 –TSR (PCWA 2011m; SD B).

7.5.9.1 Habitat

Most of the perennial streams and rivers in the vicinity of the MFP below 4,500 feet in elevation provided suitable geomorphic habitat for one or more lifestages of the FYLF. Adults in particular are adaptable and can use most types of stream habitat for foraging or refuge provided it has perennial or even occasionally ephemeral flow. Notable exceptions are large instream reservoirs that likely prohibit movement and contain large predatory fish. For a population to persist, however, adults must live in proximity, likely less than several kilometers (km) (R. Bourke, unpublished data), to suitable breeding and rearing habitat.

Suitable geomorphic breeding and rearing habitat were available in many of the study streams; however, it was limited in the upper Middle Fork American River, Duncan Creek, lower Long Canyon Creek, and some of the tributary streams due to confined channel conditions and high stream gradients. Map 7.5.8 shows the distribution of

suitable, limited, and unsuitable breeding and rearing habitats across the study area based on geomorphic channel characteristics.

Non-native bullfrogs and smallmouth bass, potential predators of FYLF, were only observed in the comparison river study site in the lower North Fork American River upstream and downstream of Lake Clementine. This was the warmest reach of river in the study area. Bullfrogs and smallmouth bass were not observed in the cooler river reaches associated with the MFP. These species may be a factor in the apparent absence of FYLF below Lake Clementine (not a part of the MFP). In the bypass and peaking reaches associated with the MFP, non-native brown trout and crayfish were observed at several locations. Native aquatic garter snakes, a known predator of FYLF, were present throughout the study area. The presence of native and non-native predators may limit reproductive success for FYLF and, thus, may decrease the quality of suitable breeding and rearing habitat in the study area, but the magnitude or importance of the relationship is uncertain.

Cold water temperatures and fluctuating flows can limit the suitability of breeding and rearing habitat (Jones et al. 2005; Kupferberg et al. 2007) of FYLF. Cold water temperatures (e.g., <60°F during summer) were observed in the upper portion of the following reaches: Middle Fork American River downstream of French Meadows Reservoir, Middle Fork American River downstream of Middle Fork Interbay, Middle Fork American River downstream of Ralston Afterbay, and in the Rubicon River downstream of Hell Hole Reservoir. Fluctuating late spring and summer flows were observed in the peaking reach of the Middle Fork American River downstream of Oxbow Powerhouse.

7.5.9.2 Distribution and Abundance

FYLF were dispersed widely throughout the study area in varying densities depending on stream size, flow regulation, and water temperatures (Map 7.5-9). Abundance was highest in the downstream reaches of the Rubicon River and in comparison reaches and tributaries. Abundance was low in the Middle Fork American River bypass reach upstream of Ralston Afterbay, and individuals were observed rarely in the Middle Fork American River peaking reach. No individuals were observed above approximately 1,800 feet in elevation on the Middle Fork American River, 3,350 feet elevation on the Rubicon River, and above 1,550 feet elevation on Long Canyon Creek (near the Long Canyon Creek confluence with the Rubicon River).

In the study area, breeding was observed in the lower portions of the Rubicon River and Middle Fork American River bypass reaches, in four lower elevation tributaries to the peaking reach (American Canyon Creek, Gas Canyon Creek, Todd Creek, and Otter Creek), and in the comparison river reaches (Map 7.5-8). No egg masses were observed in the mainstream of the Middle Fork American River peaking reach. Fall surveys results for adult, YOY, and tadpoles generally reflected the egg mass distribution with the highest number of observed tadpoles and young-of-the-year in the Rubicon River, peaking reach tributaries, and at comparison sites (Map 7.5-8).

The density of egg masses at breeding locations, a common index of FYLF population size, varied by river reach (Map 7.5-8). The Rubicon River bypass reach had the highest density of egg masses (19 egg masses/km in the three lower sites) and the Middle Fork American River bypass reach had one of the lowest densities of egg masses (2 egg masses/km). The tributaries along the peaking reach (Todd Creek, Gas Canyon and Otter Creek) had moderate egg mass densities (average of 9 egg masses/km). Two of the unregulated comparison sites, Shirttail Creek and the upper site on the North Fork of the Middle Fork American River, had high egg mass densities similar to the lower Rubicon River of 17 egg masses/km and 14 egg masses/km, respectively. Two of the comparison survey sites, North Fork of the Middle Fork American River near the confluence with the Middle Fork American River and the mainstem of the North Fork American River near Shirttail Creek, had low egg mass densities (3 egg masses/km and 2 egg masses/km, respectively).

7.5.9.3 Breeding Timing

The timing of FYLF breeding is largely dependent on spring flows and water temperatures. Observations in the bypass and peaking reaches have shown that breeding season can extend from early May to mid-June. In the Rubicon River breeding was observed from early to mid-May in 2007, 2008, and 2009 (AQ 12 – TSR [PCWA 2011m; SD B], AQ 1 – TSR [PCWA 2011a; SD B]; Yarnell, pers. comm., June, 2010). In 2010, oviposition was delayed until mid-June, likely due to a relatively wet and cold spring (Yarnell, pers. comm., June, 2010). In the Middle Fork American River upstream of Ralston Afterbay breeding was observed in the last week of May and early June in 2007–2010. In tributaries to the peaking reach where FYLF breeding was observed (American Canyon Creek, Gas Canyon Creek, Todd Creek, Slug Gulch, Otter Creek, and the North Fork of the Middle Fork American River) breeding began from early to mid-May (AQ 12 – TSR [PCWA 2011m; SD B]; pers. comm. with R. Peek).

7.5.9.4 Habitat Suitability Criteria

Habitat suitability criteria (water depth, water velocity, and substrate) for FYLF breeding and larval development (tadpoles) were developed as part of the AQ 12 – TSR (PCWA 2011m; SD B) and (AQ 1 – TSR [PCWA 2011a; SD B]). The highest suitability for egg masses and tadpoles was in slow, shallow water (approximately <1 m deep and <30 cm/s velocity) (Appendix M, AQ 12 – TSR [PCWA 2011m; SD B]). Twenty percent or greater of breeding substrate (e.g., cobbles, boulders) in a substrate polygon was used to determine the suitability for breeding.

7.5.9.5 Habitat versus Flow

Aquatic habitat for FYLF was characterized as a function of flow at two study sites where FYLF populations were found in the bypass reaches (MF26.2 and R3.5) and the two peaking reach study sites (MF14.1 and MF4.8) (AQ 1 – TSR [PCWA 2011a; SD B]). Specifically, standard WUA versus flow relationships were developed for FYLF egg masses and tadpoles using the univariate HSC. The results show that for both breeding

and tadpoles the greatest amount of habitat occurs at low flows (Appendix B2) when the most slow, shallow habitat is available.

The WUA relationships were also combined with hydrology (1975–2007 impaired and unimpaired flow conditions) at the FYLF study sites to develop habitat time series plots and habitat exceedance plots. Time series plots for FYLF for each site by water year type are provided in the AQ 1 – TSR, Appendix N (PCWA 2011a; SD B).

Both egg masses and tadpoles are sensitive to fluctuating flow events (e.g., releases or spills). Reservoir spills or sudden high flow events have the potential to disrupt breeding, destroy egg masses, and flush tadpoles downstream. Additionally, a rapid decrease in flow has the potential to dewater egg masses and tadpoles. The effective habitat under fluctuating flows was quantified and summarized in the AQ 1 – TSR (PCWA 2011a; SD B) and the plots are also provided in Appendix B2.

Based on the FYLF effective habitat matrices (Appendix B2; Figures 41, 42, 48, and 49) a relatively narrow range of flow fluctuations would be required in the peaking reach to maintain breeding or tadpole habitat. For example, at MF4.8 a flow change from 1018 cfs to 407 cfs would reduce the initial FYLF breeding habitat available by 83% (5202 to 895 feet²/1000 feet). Under this same scenario, breeding habitat at Fords Bar (MF14.1) would be reduced by 86% (2451 to 351 feet²/1000 feet). If flow changed from 1018 to approximately 100 cfs, only about 1–3% of the breeding habitat would remain.

7.5.10 Reservoirs and Diversion Pools

The MFP impoundments consist of large reservoirs (French Meadows and Hell Hole), two medium reservoirs (Middle Fork Interbay and Ralston Afterbay), and three small diversion pools (Duncan Creek, North Fork Long Canyon Creek, and South Fork Long Canyon Creek). The reservoir physical habitat characterized includes habitat associated with water surface elevations (storage volume), water temperature, dissolved oxygen, and inlet barriers to upstream migration. The biological resources characterized primarily were the existing fish populations.

Physical habitat and fish population data are available from several sources. Reservoir water surface elevations have been collected as part of PCWA's gaging and operations. Inlet stream and potential fish passage barriers data for each of the reservoirs were collected as part of the AQ 6 – TSR (PCWA 2011g; SD B). Water temperature and dissolved oxygen data were collected at each of the reservoirs and diversion pools as part of the early relicensing studies (PCWA 2007) and the AQ 11 – TSR (PCWA 2011i; SD B). Monthly reservoir profiles (temperature, dissolved oxygen, and specific conductance) were collected at the three largest reservoirs (French Meadows, Hell Hole, and Ralston Afterbay) in 2005–2008 (Maps 7.5-10a–c). Fish population information at each of the reservoirs was collected and reported in the AQ 2 – TSR (PCWA 2011b; SD B) and information on the reservoir minimum pool fish habitat in the large and medium reservoirs is available in the AQ 8 – TSR (PCWA 2011i; SD B).

The MFP reservoir physical habitat (water surface elevations, water temperature, dissolved oxygen) and fish populations are discussed in the following categories: (1) large reservoirs; (2) medium reservoirs; and (3) small diversion pools.

7.5.10.1 Large Reservoirs

French Meadows has a maximum active storage of 127,358 acre-feet (ac-ft) (1,408 surface acres) and a maximum depth of 204.5 feet (spillway elevation to stream bed). Hell Hole Reservoir has a maximum active storage of 205,057 ac-ft (1,253 surface acres) and a maximum depth of 390 feet (spillway elevation to stream bed). Both reservoirs are cold water reservoirs with high oxygen concentrations. Both reservoirs operate to store and release water for water supply and power generation purposes.

Physical Habitat

WATER SURFACE ELEVATIONS

The existing FERC License minimum pool requirements are shown in Table 3-14 and on Figures 7.5-9a–b. The historic water surface elevations are also shown on Figures 7.5-9a–b. Both reservoirs have an annual spring fill and summer/fall release pattern. Generally, the water surface elevations stay well above the minimum pool for both reservoirs. During, wetter water years at French Meadows Reservoir, however, the historical water surface elevation were often draw down consistently to the minimum pool in the winter/early spring. This was done to make as much room in the reservoir as possible to store spring inflows.

WATER TEMPERATURE AND DISSOLVED OXYGEN

In French Meadows and Hell Hole, reservoir temperature and dissolved oxygen profile sampling was conducted at three locations in each reservoir (Map 7.5-10a–b). In general, a site was selected near the dam, near the middle of the reservoir, and at the upstream end of the reservoir. The reservoir profile measurements generally included water temperature and dissolved oxygen at 1-meter- (m) depth intervals throughout the depth of the reservoir.

FRENCH MEADOWS RESERVOIR

The French Meadows Reservoir temperature profile data from June–October at each of the individual sampling locations and sampling dates are provided in Figures B-4 to B-6 in Appendix B of AQ 8 – TSR (PCWA 2011i; SD B). The dissolved oxygen profiles are in Figures B-7 to B-8. A summary of all of the temperature and all the dissolved oxygen profiles plotted together is shown in Figure 7.5-10a.

Temperature in the reservoir ranged from about 42°F in the hypolimnion to about 72°F at the water surface. The hypolimnion temperatures were very similar for all months and years sampled (42–47°F). The surface water temperature ranged from 54–72°F. Surface temperatures were coolest in June and October (e.g., 54°F to 60°F), and were

warmest in July and August (>65°F). The depth of the thermoclines ranged from about 20 to 75 feet deep. The depths of the thermoclines were shallowest in June and July and became progressively deeper from August through October.

During the 2005–2008 sampling period, dissolved oxygen was typically greater than 5–6 mg/L (protective of coldwater species [Bjornn and Reiser 1991]) throughout the water column and there was generally always large amounts of the water column either in the epilimnion or hypolimnion with dissolved oxygen 7.0 mg/L or greater (Basin Plan objective [CVRWQCB 2007]).

Dissolved oxygen concentration typically reflected the temperature differences in the epilimnion and hypolimnion (less dissolved oxygen in the warmer water). In the hypolimnion, the dissolved oxygen concentration was typically the same throughout the depth of the hypolimnion and there was little depletion of the dissolved oxygen even into the fall. In 2008, however, there was some fall depletion of hypolimnetic dissolved oxygen. The October 2008 dissolved oxygen profile exhibited the lowest observed dissolved oxygen concentration; concentrations in the hypolimnion ranged from just under 5 mg/L near the metalimnion to 3 mg/L at the reservoir bottom (Figure B-7 [PCWA 2011e; SD B]). Periodically in the dissolved oxygen profiles low dissolved oxygen was observed very near the water-sediment interface, (Figure 7.5-10a).

HELL HOLE RESERVOIR

The Hell Hole Reservoir temperature profile data from June–October at each of the individual sampling locations on each sampling date are provided in Figures B-9 to B-11 in Appendix B of AQ 8 – TSR (PCWA 2011i; SD B). The dissolved oxygen profiles are in Figures B-12 to B-13. A summary of all of the temperature and all the dissolved oxygen profiles plotted together is shown in Figure 7.5-10b.

Temperature in the reservoir ranged from about 42°F in the hypolimnion to about 69°F at the water surface. The hypolimnion temperatures, for all months and years sampled, ranged from approximately 42–50°F. The surface water temperature ranged from 54–69°F. Surface temperatures were coolest in June and October (e.g., 54°F to 60°F), and were warmest in July and August (>65°F). The shapes of the temperature profiles did not exhibit distinct thermoclines. Often during the summer there was a very shallow, warm epilimnion (e.g., 20 feet) and then a long gradual thermocline over a wide range of depths (100+ feet). In September and October the epilimnion was the most fully developed and much deeper, 100–150 feet. The lack of a distinct thermocline may be related to operations of the French Meadows Powerhouse at Hell Hole Reservoir, which discharges up to 400 cfs of cold water diverted from French Meadows Reservoir into Hell Hole Reservoir throughout the spring, summer, and fall.

During the 2005–2008 sampling period, dissolved oxygen was greater than 6 mg/L and typically greater than 7 mg/L. There were always large portions of the water column with dissolved oxygen concentrations 7.0 mg/L or greater (Basin Plan objective [CVRWQCB 2007]). Dissolved oxygen concentration typically was similar throughout the water column and there was no indication of depletion of the dissolved oxygen in the

hypolimnion (Figure B-12 [PCWA 2011e; SD B]). Periodically in the dissolved oxygen profiles low dissolved oxygen was observed very near the water-sediment interface, (Figure 7.5-10b).

Fish Populations

In French Meadows Reservoir, brown trout, rainbow trout, tui chub, and kokanee salmon were captured (Table 7.5-10 and Figure 7.5-11). Brown trout, were common (typically >0.1 fish/net hour). There were fewer rainbow trout (>0.03 fish/net hour). Only one kokanee and Tui chub were caught during surveys. The kokanee salmon was likely an anomaly as no known kokanee stocking has occurred in this reservoir. Crayfish were also abundant. Most of the rainbow and brown trout captured were between approximately 230 and 520 mm in length, with a few larger fish up to 730 mm in length.

Hell Hole Reservoir had the greatest fish species diversity of the two reservoirs with six species total, including brown trout, rainbow trout, lake trout, kokanee salmon, tui chub, and Sacramento sucker (Table 7.5-10 and Figure 7.5-11). Brown trout were common (>0.1 fish/net hour). There were few rainbow trout. Sacramento sucker was the most abundant species in Hell Hole Reservoir (>0.5 fish/net hour) and kokanee salmon were common (>0.06 fish/net hour). Crayfish were also abundant. Most of the rainbow and brown trout captured were between approximately 180 and 560 mm in length. Kokanee salmon ranged from about 300 to 420 mm in length.

The available stocking data for the reservoirs are provided in Table 7.5-11a-b. In Hell Hole Reservoir, lake trout were historically stocked and currently are self-sustaining. Currently, kokanee salmon and brown trout are stocked annually. Between 2001 and 2009, an average of 24,566 kokanee fingerlings/year and 5,542 rainbow trout catchables/year were stocked. In French Meadows Reservoir, primarily rainbow trout have been trout stocked at an average of 9,906 catchables/year (2001–2009).

7.5.10.2 Medium Reservoirs

Middle Fork Interbay is relatively small. It has a maximum active storage of 173 ac-ft (7.6 surface acres) and a maximum depth of 64 feet (maximum operation elevation to streambed). Ralston Afterbay is about 10 times larger with a maximum active storage of 1,804 ac-ft (76.8 surface acres) and a maximum depth of 79 feet (maximum operation elevation to streambed). Both reservoirs are coldwater reservoirs with high oxygen concentrations. Both reservoirs operate as forebays and afterbays for upstream and downstream powerhouses.

Physical Habitat

WATER SURFACE ELEVATIONS

Middle Fork Interbay and Ralston Afterbay do not have seasonal fill and release patterns like Hell Hole or French Meadows reservoirs. Water surface elevations and pool volumes in Middle Fork Interbay are typically fairly constant throughout most of the

year, ranging from 2524 to 2528 feet elevation. Ralston Afterbay water surface elevations are more variable due to variable powerhouse inflows and outflows. Water surface elevations typically range from 1169 to 1175 feet elevation. During the fall both reservoirs are drawn down at least to the level of the bottom of the spill gates for annual maintenance and inspection. Periodically the reservoirs are drained for sediment removal/maintenance (Section 7.7 – Geomorphology Affected Environment).

WATER TEMPERATURE AND DISSOLVED OXYGEN

In Ralston Afterbay, water temperature and dissolved oxygen profile sampling was conducted at one location near the dam (Map 7.5-10c). Middle Fork Interbay is small and generally completely mixed; therefore, water temperature and dissolved oxygen profile samples were not collected. Water temperature and dissolved oxygen was sampled at the inflow and outflow of the reservoir.

RALSTON AFTERBAY

The water temperature and oxygen sampling location in Ralston Afterbay is shown in Map 7.5-10c. The Ralston Afterbay temperature profile data from June–October for each individual sampling date are provided in Figure B-14 in Appendix B of AQ 8 – TSR (PCWA 2011i; SD B). The dissolved oxygen profiles are in Figure B-15. A summary of all of the water temperature and all the dissolved oxygen profiles plotted together is shown in Figure 7.5-10c.

Ralston Afterbay was relatively cold with high oxygen concentrations. Cold water inflows from Ralston Powerhouse are the dominate factor affecting water temperature in Ralston Afterbay during the summer and fall. Temperature stratification of the reservoir was very weak. Water temperature ranged from about 48–53°F at the bottom of the reservoir to a maximum at the water surface of about 66°F (range 53–66°F). In the top 6–14 feet of the reservoir there was often a 5–15°F linear warming profile (bottom to top) during the summer; however, on some sampling dates there was very little warming of the surface layer. Dissolved oxygen concentrations were always greater than 7 mg/L (Basin Plan objective [CVRWQCB 2007]). Dissolved oxygen concentration was the lowest at the surface and highest at the bottom of the reservoir (up to about 11 mg/L), inversely related to observed water temperatures.

MIDDLE FORK INTERBAY

Water in Middle Fork Interbay was cold due to the cold water inflows from Middle Fork Powerhouse (releases water from the bottom of Hell Hole Reservoir). Because of its small size and daily operations that discharge water into and divert water out of Middle Fork Interbay, the reservoir does not stratify. Water temperature releases from the reservoir represent the mixed water temperature in the reservoir. Release water temperatures were nearly always below 55°F. Only on few days (2006–2008) did daily average water temperature range between 55 and 60°F (Figure 7.5-1b).

Dissolved oxygen concentration samples collected immediately upstream, in, and downstream of Middle Fork Interbay in the spring and fall ranged from 7.7 to 9.3 mg/L

(AQ 11 – TSR [PCWA 2011I; SD B]) greater than the Basin Plan objective (CVRWQCB 2007) of 7.0 mg/L.

Fish Population

RALSTON AFTERBAY

Ralston Afterbay contained rainbow trout, brown trout, hardhead, Sacramento sucker, and Sacramento pikeminnow (Table 7.5-10 and Figure 7.5-11). Sacramento sucker was the most abundant species captured. In addition to gill net surveys, Ralston Afterbay was sampled using electrofishing and sonar to characterize (to the extent possible) the relative and absolute abundance of hardhead fry, juvenile, and adults compared to other species.

Sonar sampling produced an estimate of 11,128 fish (fish species could not be determined using sonar) during the early summer sampling and 12,128 fish during the fall sampling (AQ 2 – TSR [PCWA 2011b; SD B]). The majority of the fish were in shallow water (90% ≤10 feet depth).

Shoreline electrofishing densities of hardhead and Sacramento pikeminnow were greater than 100 fish per mile (107 to 121) for each species during both the early summer and fall electrofishing sampling. Sacramento sucker density was 135 fish per mile and 68 fish per mile during the early summer and fall sampling period, respectively. Trout density (brown trout and rainbow trout combined) was less than 20 fish per mile during both early summer and fall sampling. The total amount of Ralston Afterbay shoreline was 3 miles (AQ 2 – TSR [PCWA 2011b; SD B]).

Gill netting catch per unit effort (CPUE) for all species combined in Ralston Afterbay was 0.56–0.86 fish/hour (Table 7.5-10). Hardhead constituted 3% of the catch. Seventy-seven percent of the fish captured during the combined gill net sampling (including 2007) were large (13–22 inches [325–555 mm]) Sacramento sucker. The remainder of the fish captured were rainbow trout (8%), brown trout (8%) and Sacramento pikeminnow (3%).

Potential electrofishing and gill netting gear sampling biases, both in terms of fish size and water sampling depth, made it difficult to definitively determine either the total abundance or percentage of different species or fish sizes in Ralston Afterbay. Shoreline electrofishing collected primarily small, 3–6 inch (80–150 mm), hardhead, Sacramento pikeminnow, and Sacramento sucker and some larger 16+ inch (>400 mm) Sacramento sucker and brown trout. Very small YOY fish <3 inches (<80 mm), if present, were not sampled in the electrofishing. Gill netting primarily sampled only deep (>3 feet) open water habitat. Only fish greater than about 9 inches (>230 mm) were captured in the nets even though variable sized mesh was used. Very small YOY fish and medium sized fish, 6–16 inch (150 to 400 mm) sized fish were not present or were in low abundance in the combined electrofishing and gill netting sample results. Whether this was the result of gear sampling biases is unknown (AQ 2 – TSR [PCWA 2011b; SD B]).

For hardhead and Sacramento pikeminnow throughout the study sampling, the largest fish of both species were collected from Ralston Afterbay. The five largest hardhead captured in 2007 (347–471 mm) were aged using scale samples. The fish ranged from 4+ to 8+ years old. The three largest pikeminnow captured in 2007 that could be aged (some scale samples collected had regenerated scales and could not be aged) were 3+ to 7+ years old (245–445 mm). Nine smaller pikeminnow and two hardhead collected in the fall of 2007 between 57–149 mm were aged. The fish greater than approximately 100 mm were 1+ and those less than approximately 100 mm were age 0+.

MIDDLE FORK INTERBAY

Only rainbow and brown trout were captured in Middle Fork Interbay. Abundance was similar for both species. The combined trout gillnet catch was 0.15 fish/hour (Table 7.5-10 and Figure 7.5-11).

7.5.10.3 Small Diversion Pools

The North and South Fork diversion pools are less than 1.0 surface acre when full and the Duncan Creek Diversion pool is 2.2 surface acres (20 ac-ft) at full pool. When the diversions are operating the diversion pools are full. The maximum depths when full are 22, 6, and 17 feet at Duncan Creek, North Fork Long Canyon Creek, and South Fork diversion pools, respectively.

Physical Habitat

The small diversions typically do not divert water in the summer or early fall due to low flow conditions. During this time period the North Fork and South Fork Long Canyon creek diversion pools are essentially dewatered, with the creeks running through the short length of the pool bed. During the summer the Duncan Creek Diversion continues to impound water at an elevation of 5,260 feet (5 feet below the spillway crest of 5,265 feet) even when no water is being diverted. There is a weir wall upstream of the diversion dam that maintains the water surface elevation in the diversion pool. However, the actual amount of water impounded is variable due to periodic sedimentation and sediment removal activities.

Water temperature and dissolved oxygen in the small diversion pools is similar to the inflow and outflow streams as the diversion pools are too small to stratify. The water temperature data in the streams upstream and downstream of the small diversion dams are shown in Figures 7.5-1e–h. Observed water temperature ranged from 32–75°C. Spot measurements of dissolved oxygen upstream and downstream of the diversion pools during the spring and fall showed high dissolved oxygen 7.0 to 9.7 mg/L (AQ 11 – TSR [PCWA 2011i; SD B]).

Fish Populations

Rainbow trout are present in the North and South Fork Long Canyon creek diversion pools and both rainbow and brown trout are present in the Duncan Creek Diversion Pool. Fish sampling results in the fall indicated that very low numbers of fish were

present (<15 observed) in each of the diversion pools (AQ 2 – TSR [PCWA 2011b; SD B]).

7.5.10.4 Fish Passage Barriers at Reservoir and Small Stream Diversion Pool Inlets

All major inlets to reservoirs and diversion pools were free from natural or reservoir created fish passage barriers except the Hell Hole Reservoir inlet and the South Fork Long Canyon Diversion inlet Figure 7.5-5 (also see Table AQ 6-6; AQ 6 – TSR [PCWA 2011g; SD B]).

At the inlet to Hell Hole Reservoir, there were five natural channel barriers in the Rubicon River below the Hell Hole Reservoir high water mark (i.e., river barriers when the reservoir was not at full pool). There were also three natural impassable barriers in the Rubicon River just upstream of the reservoir (above the high water mark) that precluded upstream passage in the river regardless of reservoir elevation. The details of the elevations of the barriers below the full pool water mark are discussed in AQ 6 – TSR (PCWA 2011g; SD B). The barriers located in the Rubicon River upstream of the reservoir were very near the reservoir confluence. Upstream of these barriers, there appeared to be at least 0.6 mile of the Rubicon River free of barriers. Detailed surveys were not conducted farther upstream.

There was also a potential natural stream barrier on Five Lakes Creek approximately 13 to 14 feet below the Hell Hole Reservoir high water mark. Upstream from the high water mark, there was a section of creek free of barriers. Detailed surveys were not conducted within this section of creek, but from the aerial imagery, topography maps, and various helicopter fly-overs there appears to be less than 0.7 mile of creek that would be barrier free. Upstream of this, the topography is very steep and numerous barriers (falls) are assumed to exist.

The South Fork Long Canyon Diversion pool created a gravel delta at the inlet. When the diversion pool was full, fish passage out of the diversion pool was possible. When the diversion pool was not full a critical riffle was exposed on the gravel delta that created a potential barrier to upstream movement from out of the diversion pool area into the stream. However, this only occurs when the diversion is not diverting (e.g., summer/fall) and, at that time, there is only a small shallow pool in the bottom of the diversion pool area.

7.5.11 Fish Entrainment

The locations where fish entrainment could result in fish translocation or mortality (e.g., through MFP powerhouses) include: (1) the large reservoir tunnel and low level outlets (French Meadows Reservoir and Hell Hole Reservoir); (2) the medium reservoir tunnel and low level outlets (Middle Fork Interbay and Ralston Afterbay); and (3) the small stream diversions (Duncan Creek, North Fork Long Canyon Creek, and South Fork Long Canyon Creek).

7.5.11.1 Large Reservoirs

Potential entrainment of fish at French Meadows Reservoir would result from fish entering the French Meadows – Hell Hole Tunnel and going through the French Meadows Powerhouse (Francis turbine with low mortality potential for smaller fish) (Tables 7.5-12 and 7.5-13) or passage of fish through the dam outlet pipes into the river below the dam. Potential entrainment of fish at Hell Hole Reservoir would result from fish entering the Hell Hole – Middle Fork Tunnel and going through the Middle Fork Powerhouse (Pelton turbine with high mortality potential) (Table 7.5-13) or passage of fish through the dam outlet pipes. Fish going through the outlet pipes could enter the Hell Hole Powerhouse (Francis turbine with low mortality potential for smaller fish) (Table 7.5-13) or through one of two energy dissipating valves and into the river below the dam (Table 7.5-12).

Entrainment vulnerability was estimated to be very low at the large reservoirs. Sonar estimates of fish associated with the deep water tunnel intakes in French Meadows Reservoir (145 feet deep at full pool) and Hell Hole Reservoir (308 feet deep at full pool) indicate that few fish are present at the depth of the intakes (AQ 7 –TSR [PCWA 2011h; SD B]). In French Meadows Reservoir, 98% of the fish observed were at an elevation higher than the elevation of the tunnel intake. In Hell Hole Reservoir, 100% of the fish observed were at an elevation higher than the elevation of the intake. The maximum approach velocities at the tunnel intake grates were estimated to be ≤ 1.1 feet per second based on the size of the tunnel intakes and the rates of diversion. Only larger fish were present in the deep water portions of the reservoirs (smaller fish were near the surface) and the larger fish could easily escape the vicinity of the intake. The outlet works at both of the large reservoirs are located deeper than the tunnel intakes and, thus, the entrainment potential for the outlet works is expected to be lower than that of the tunnel intakes.

7.5.11.2 Medium Reservoirs

Potential entrainment of fish at Middle Fork Interbay would result from fish entering the Middle Fork – Ralston Tunnel and going through the Ralston Powerhouse (Pelton turbine with high mortality potential) (Table 7.5-13) or passage of fish through the dam outlet pipes into the river below the dam. Potential entrainment of fish at Ralston Afterbay would result from fish entering the Ralston – Oxbow Tunnel and going through the Oxbow Powerhouse (Francis turbine with very low mortality potential for a wide range of fish sizes) (Table 7.5-13) or passage of fish through the dam outlet pipes into the river below the dam (Table 7.5-12).

Fish populations in the river reaches immediately upstream of Middle Fork Interbay and Ralston Afterbay are relatively low as are populations within the reservoirs themselves. Middle Fork Interbay contains only rainbow trout and brown trout; Ralston Afterbay contains a variety of species including hardhead. The intakes to the tunnels/powerhouses are relatively large and approach velocities at the intake grates are relatively low (<2 feet per second). It is anticipated that entrainment at the two facilities is relatively low and fish entrained from Ralston Afterbay (e.g., hardhead) would have a

high survival rate through the Francis turbine in Oxbow Powerhouse (Winchell et al. 2000).

A study has been implemented to directly measure entrainment at the two reservoirs (AQ 7 – Entrainment Direct Sampling Approach – Contingency Study contained in the 2008 Study Implementation Progress Report for the Middle Fork American River Project, January 21, 2009 [PCWA 2009]). The direct sampling study has been inconclusive, however, due to milling fish at the intakes and the ability of the sonar data to differentiate between milling and entrainment. A future study conducted by PCWA in 2010–2011, in consultation with the resource agencies, will be used to evaluate entrainment.

7.5.11.3 Small Diversions

Any potential entrainment of fish at the Duncan Creek Diversion would result in translocation of fish into French Meadows Reservoir (via Duncan Creek – Middle Fork Tunnel) or passage of fish through the dam outlet pipes into Duncan Creek downstream (Table 7.5-12). Potential entrainment of fish at the North Fork and South Fork Long Canyon creek diversions would result in either fish going into the Hell Hole – Middle Fork Tunnel and through the Middle Fork Powerhouse (Pelton Turbine with high mortality potential) (Table 7.5-13) or passage of fish through the dam outlet pipes into the streams below the diversions (Table 7.5-12).

Fish entrainment was studied at the Duncan Creek Diversion intake via a tagging study of approximately 1,000 fish (fall 2008–summer 2009) (AQ 7 –TSR [PCWA 2011h; SD B]). The study was designed to be used as a surrogate for the North Fork Long Canyon Creek and South Fork Long Canyon Creek diversion intakes as well. The timing of fry emergence in the spring was also sampled at all of the small diversions (spring 2007 and spring 2009) to illustrate the potential overlap between diversion operations and fry emergence.

A total of 0.9% of the trout population within the first 2 miles upstream of the Duncan Creek Diversion was estimated to be entrained annually (43 of an estimated 4836 fish extrapolated from the tagging study results and fish population data) (AQ 7 –TSR [PCWA 2011h; SD B]). A similar small percentage of the fish population (<1%) in the 2 miles above the North and South Fork Long Canyon Creek diversions would be expected to be entrained.

The timing of emergence in each of the small streams occurred after the diversions had been closed for the year (in both years studied); therefore, no entrainment of emerging fish occurred. Also see the timing of fry emergence discussion in Section 7.5.8.4.

7.5.12 Special-Status Species

7.5.12.1 Special-status Aquatic Mollusks

PCWA conducted studies within the MFP and at comparison river sites at 26 study sites to determine the presence, or lack thereof, of one special-status mussel species

(California floater, *Andante Californians*) and two special-status aquatic snail species (scalloped juga, *Juga [Calibasis] toccata*; and Great Basin rams-horn snail, *Heliostat Newberry*) (AQ 3 – Aquatic Mollusk TSR [PCWA 2011d; SD B]).

No live specimens or shells of special-status mollusk species including California Floater, scalloped juga, or Great Basin rams-horn were found at any of the study sites.

7.5.12.2 Hardhead

Hardhead distribution and abundance in the MFP was discussed above for the rivers (Section 7.5.8) and in the reservoirs section (7.5.10). Hardhead, particularly adults, were present in relatively low abundance in the bypass and peaking reaches. They were also present in relatively low abundance in the comparison streams. Hardhead abundance was greatest in Ralston Afterbay and in the Rubicon River (5.4 miles of river) and Middle Fork American River (0.5 mile of river) upstream of Ralston Afterbay.

A total of 127 hardhead were captured in 2007 and 2008 at the river and reservoir quantitative sampling sites. Nearly 90% (111) of these hardhead were small fish less than 6 inches. Over 95% (121) of the total number of fish captured were from Ralston Afterbay (112 from electrofishing, 9 from gill netting). The remainder of the hardhead were captured in the Middle Fork American River upstream of Ralston Afterbay. In contrast, over 7,000 rainbow trout were observed (electrofishing and snorkeling surveys) at the same quantitative sampling sites over the same time period (AQ 2 – TSR [PCWA 2011b; SD B]).

7.5.12.3 Foothill Yellow-legged Frogs

The abundance and distribution of FYLF and FYLF habitat in the bypass and peaking reaches are discussed in Section 7.5.9, above. FYLF were abundant in the Rubicon River and common in the Middle Fork American River upstream of Ralston Afterbay. FYLF were also abundant in several tributaries to peaking reach downstream of Ralston Afterbay. FYLF were rare in the peaking reach and there was no observed breeding.

7.5.12.4 California Red-legged Frogs

There is only one known CRLF record within 1 mile of the MFP study area. This record is a single adult CRLF that was observed in a pond on the western end of Ralston Ridge in the right-of-way below a Pacific Gas & Electric (PG&E) transmission line. No individuals have been observed at this location since 2001. This site was burned in the Ralston Ridge wildfire of 2006. The closest known population outside the MFP is located on private land more than a mile north of the MFP at Michigan Bluff. There is no United States Fish and Wildlife Service (USFWS) designated critical habitat for CRLF in the immediate vicinity of the MFP. The closest critical habitat units are the ELD-1 unit, located in El Dorado County approximately 30 miles south of the MFP, and the NEV-1 unit, located in Nevada County approximately 40 miles to the northwest of the MFP. Detailed life history information and habitat requirements of the CRLF are provided in Appendix B of the Draft Biological Assessment/Biological Evaluation (BA/BE) (PCWA 2011o; SD C)

A site assessment and field studies were completed as part of the MFP relicensing to determine the presence of CRLF populations and potential habitat in the vicinity of the MFP (AQ 12 – TSR [PCWA 2011m; SD B]) and (AQ 12 – Special-Status Amphibian and Aquatic Reptile Supplemental Report: California Red-legged Frog Protocol-Level Survey Report (AQ 12 – Supplemental TSR [PCWA 2011n; SD B])). Based on the site assessments, field surveys, and consultation with USFWS, it was determined that rivers and reservoirs associated with the MFP do not represent CRLF aquatic breeding habitat. As defined by USFWS (2006), these large rivers and reservoirs (e.g., the Middle Fork American River, Rubicon River, Hell Hole Reservoir, and Ralston Afterbay) represent barriers that would restrict the northward and/or southward movement of CRLF throughout the study area.

Potential aquatic breeding habitat was identified by USFWS at three off-channel ponds at Horseshoe Bar (ponds C, E, and F) (PCWA 2011m; SD B). As requested by USFWS, protocol-level surveys were completed at these sites. No CRLF were observed (AQ 12 – Supplemental TSR [PCWA 2011n; SD B])). Potential CRLF upland habitats in the MFP would include riparian areas, grasslands that contain seeps and springs (USFWS 2002), or deeply shaded forest streams immediately adjacent to aquatic breeding areas (PCWA 2011m; SD B). However, any upland habitat that does not contain significant barriers to dispersal may potentially be used by CRLF (USFWS 2002).

7.5.12.5 Western Pond Turtle

Eight WPTs were observed during the 2007 CRLF, FYLF, and fish population surveys (AQ 12 – TSR [PCWA 2011m; SD B])). Six of these observations were in the Middle Fork American River or tributaries downstream of Ralston Afterbay (peaking reach) and two were in the North Fork American River (comparison river not affected by the MFP). Two hatchlings were observed in Otter Creek (tributary to the peaking reach), while the remaining individuals were adults.

Several off-channel pond and wetland habitats were identified during CRLF site assessment survey and protocol level surveys (AQ 12 – TSR [PCWA 2011m; SD B]) and (AQ 12 – Supplemental TSR [PCWA 2011n; SD B])). WPT were documented in some of the surveyed ponds located at Horseshoe Bar on the Middle Fork American River.

Map 7.5-11 shows the locations of the 2007 WPT sightings and the historical WPT sightings in the study area. In addition to the WPT observations downstream of Ralston Afterbay in the peaking reach and in the Horseshoe Bar ponds (see above), WPTs also were observed historically in a pond in Wallace Canyon (a tributary to Long Canyon Creek). Wallace Canyon is not affected by operation of the MFP.

Geographic information system (GIS) and field mapping of potential WPT nesting habitat at the Project reservoirs and along bypass and peaking reaches found the following (AQ 12 – TSR [PCWA 2011m; SD B])):

- Due to steep slopes, vegetation, and rocky soils, the amount of WPT nesting habitat on the Project reservoirs was very limited.
- Along the bypass and peaking river reaches there are abundant locations of potential WPT nesting habitat (appropriate slope and aspect characteristics).

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TABLES

Table 7.5-1. Summary of Management Objectives that Apply to Aquatic Resources.

Management Objective
<p>California Wild Trout Program</p> <p>In 1971, the CDFG established the California Wild Trout Program (Program) to protect and enhance wild trout fisheries. The primary purpose of the Program is to preserve stream trout fisheries, which are naturally sustained by wild strains of trout. The general management objectives of the Program are summarized as follows:</p> <ul style="list-style-type: none"> • Maintain wild trout population levels necessary to provide satisfactory recreational angling opportunities for wild trout. • Maintain and enhance, where possible, the habitat required for optimum wild trout production. • Preserve the natural character and aesthetic beauty of the streamside environment. <p>The Rubicon River was included in this Program following the recommendations of the Eldorado National Forest (ENF). The designated wild trout section of the river extends from Hell Hole Dam to Ralston Afterbay. In 1979, the CDFG Inland Fisheries Branch published the Rubicon River Wild Trout Management Plan (RRWTMP) as required by the California Wild Trout Program (CDFG 1979).</p>
<p>Eldorado National Forest Land and Resources Management Plan</p> <p>The Eldorado National Forest Land and Resource Management Plan (ENF-LRMP), was developed by the United States Department of Agriculture-Forest Service (USDA-FS) to the direct management of the ENF (USDA-FS 1988). The ENF-LRMP formally recommended that the United States Congress designate three segments of the Rubicon River between Hell Hole Dam and Ralston Afterbay under the Wild and Scenic Rivers System (Section 7.9 – Recreation Resources Affected Environment). However, Congress has not yet acted to officially designate the river. Regardless, the ENF manages the Rubicon River, and a 0.25 mile corridor, to protect the “outstandingly remarkable values” (ORV) identified in their Wild and Scenic River Eligibility Study.</p>
<p>Tahoe National Forest Land and Resources Management Plan</p> <p>Similarly, the TNF-LRMP was developed by the USDA-FS to direct management of the TNF (USDA-FS 1990). This plan includes a “water program” designed to address management direction for water resources and development. The purpose of the water program is described as follows:</p> <p>“To afford optimum protection to the water resources compatible with other program practices, including timber, wildlife, fisheries, range, recreation, engineering, and mining. Where opportunities arise, watershed improvement measures will be implemented and water quantities and timing of flow will be improved. The water program on the TNF has primarily served as a support function for other resource activities. The various types of support include planning, inventories, analyzing project proposals, monitoring, and administration.”</p>
<p>National Park Service – Nationwide Rivers Inventory</p> <p>The National Park Service has compiled and maintains a Nationwide Rivers Inventory (NRI), a register of river segments that potentially qualify as national wild, scenic or recreational river areas (NPS 2006). The NRI is considered relevant because it identifies the Rubicon River as a candidate for Wild and Scenic River status. Of the three eligible segments of the Rubicon River (between Hell Hole Dam and Ralston Afterbay), none are located within the existing MFP boundary with the exception of a small segment below the Hell Hole Dam (0.48 mile) and a small section above Ralston Afterbay (0.12 mile). While not formally designated, state and federal resource agencies are required to manage the river and the area within 0.25 mile of the river to protect the ORVs that cause it to be considered eligible (Section 6.0 – Statutory and Regulatory Requirements).</p>

Table 7.5-1. Summary of Management Objectives that Apply to Aquatic Resources within the Middle Fork Project (continued).

Management Objective
<p>United States Bureau of Reclamation (USBR) – American River Water Resources Investigation: Wild and Scenic River Eligibility Study and Preliminary Classification</p> <p>In January 1993 the USBR published the report entitled, “American River Water Resources Investigation, Wild and Scenic Rivers Eligibility and Preliminary Classification” (USBR 1993). The investigation is relevant to the MFP because it discusses a portion of the Middle Fork American River and North Fork American River within the peaking reach downstream of Oxbow Powerhouse. The investigation was conducted as part of a larger land and water resource planning effort known as the American River Water Resources Investigation (also known as the Auburn Dam Project). In this study, three river segments were found “Eligible” for Wild and Scenic designation under the Wild and Scenic Rivers Act (WSRA). Two of these segments are located downstream of the MFP and are described in the USBR report as follows:</p> <ul style="list-style-type: none"> • Middle Fork American River: From Oxbow Dam to the confluence with the North Fork American River (approximately 23 miles). • North Fork American River: The North Fork, from North Fork Debris Dam to the intake of the Auburn Dam Diversion Tunnel (approximately 5 miles). <p>The summary statement in the 1993 study indicated that the next step in the process would be a suitability study to determine if the eligible river segments are suitable for designation to the National Wild and Scenic River System. According to the USBR, a suitability study has not been conducted and there are no plans to conduct a suitability study at this time (R. Schroeder, pers. comm. 2010). Although not formally designated, state and federal resource agencies are required to manage the river and the area within 0.25 mile of the river to protect the ORVs that cause it to be considered eligible.</p>
<p>Water Quality Control Plan (Basin Plan) – Central Valley Region, the Sacramento River Basin and San Joaquin River Basin</p> <p>For stream reaches, the applicable management objectives of the Central Valley Water Quality Control Board (CRWQCB) Basin Plan (CRWQCB 1998, Fourth Edition revised February 2007) include the following beneficial uses related to aquatic resources:</p> <ul style="list-style-type: none"> • Warm Freshwater Habitat (WARM) – Uses of water that support warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates. • Cold Freshwater Habitat (COLD) – Uses of water that support cold water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.

Table 7.5-2a. Middle Fork American River below Middle Fork Interbay Water Temperature Profiles (July–August) and the Corresponding River Mile at which the Water Temperature Reaches 17°C and 20°C.

Modeled Temperature Profile	River Mile	
	17°C	20°C
Critical		
No-Action Alternative (12 cfs)	22.84	20.73
Dry		
No-Action Alternative (23 cfs or Natural Inflow) (Typically about 18 cfs)	22.07	NA ¹
Below Normal		
No-Action Alternative (23 cfs)	21.16	NA ¹

¹ Not applicable because the temperature doesn't reach 20°C.

Table 7.5-2b. Rubicon River Water Temperature Profiles (July–August) and the Corresponding River Mile at which the Water Temperature Reaches 17°C and 20°C.

Modeled Temperature Profile	River Mile	
	17°C	20°C
Critical		
No-Action Alternative (10 cfs)	22.68	19.42
Dry		
No-Action Alternative (20 cfs)	21.33	16.25
Below Normal		
No-Action Alternative (20 cfs)	21.33	16.25

Table 7.5-3. Depth and Velocity Guilds for the Aquatic Species for Use in the Spatial Niche Analysis.

Guild Name (by water depth / velocity type)	Life Stage	Species Members	Velocity Range (ft/s)	Depth Range (ft)
Very Shallow	All:	Limited use by all species	All	<0.25
Shallow / Slow	Fry:	All Species	0 - 0.6	0.25 - 1.9
	Juvenile:	Hardhead, Sac Sucker, Sac Pikeminnow, Trout California Roach, Sculpin, Speckled Dace		
	Breeding/Tadpole:	Foothill Yellow-Legged Frog		
	Aquatic:	Macroinvertebrates		
Shallow / Medium	Spawning:	Trout Sculpin, Speckled Dace, California Roach	>0.6 - 1.6	0.25 - 1.9
	Juvenile:	Trout, Sac Sucker ¹		
	Aquatic:	Macroinvertebrates		
Shallow / Fast	Spawning:	Trout Sculpin, Speckled Dace	>1.6 - 2.5	0.25 - 1.9
	Adult:	Sac Sucker ¹		
	Aquatic:	Macroinvertebrates		
Medium / Slow	Adult:	Hardhead, Sac Pikeminnow, Sac Sucker, Trout	0 - 0.6	>1.9 - 4.0
	Juvenile:	Hardhead, Sac Pikeminnow, Sac Sucker, Trout		
	Aquatic:	Macroinvertebrates		
Medium / Medium	Adult:	Trout, Hardhead, Sac Pikeminnow, Sac Sucker	>0.6 - 1.6	>1.9 - 4.0
	Juvenile:	Trout, Sac Sucker ¹		
	Aquatic:	Macroinvertebrates		
Medium / Fast	Adult:	Sac Sucker ¹ , Trout ¹	>1.6 - 2.5	>1.9 - 4.0
Deep / Slow	Adult:	Hardhead, Sac Pikeminnow, Sac Sucker, Trout ¹	0 - 0.6	>4.0 ⁺
	Juvenile:	Hardhead, Sac Pikeminnow		
	Aquatic:	Macroinvertebrates ¹		
Deep / Medium	Adult:	Hardhead, Sac Pikeminnow, Sac Sucker, Trout	>0.6 - 1.6	>4.0 ⁺
	Aquatic:	Macroinvertebrates ¹		
Deep / Fast	Adult:	Sac Sucker ¹ , Trout ¹	>1.6 - 2.5	>4.0 ⁺
	Aquatic:	Macroinvertebrates ¹		
Very Fast	All:	Limited use by species except for macroinvertebrates in shallow to medium depth water (0.25 - 4 ft) and velocity less than 4 ft/s	>2.5 ⁺	All

¹Limited use in this niche.

Table 7.5-4. Species and Life Stage Periodicities.

Species	Month											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Rainbow Trout												
Spawning												
Incubation												
Fry												
Juvenile												
Adult												
Brown Trout												
Spawning												
Incubation												
Fry												
Juvenile												
Adult												
Sacramento Pikeminnow												
Spawning												
Incubation												
Fry												
Juvenile												
Adult												
Hardhead												
Spawning												
Fry												
Juvenile												
Adult												
California Roach												
Spawning												
Incubation												
Fry												
Juvenile												
Adult												
Sacramento Sucker												
Spawning												
Incubation												
Fry												
Juvenile												
Adult												
Foothill Yellow-Legged Frog												
Breeding												
Incubation												
Tadpoles												
Juvenile												
Adult												

**Biologically sensitive time periods, based on AQ 2 - TSR (PCWA 2011b; SD B) surveys, are denoted with hatch marks.

Table 7.5-5. Summary of Fish Species Observed during the 2007–2009 Fish Population Sampling.

Study Site	DATE	Sample Type ¹	Fish Species ²														
			RBT	BNT	HH	SPM	MXD	SS	SCULP	SD	CAR	SMB	GSUN	KOK	TCB	LKT	WCF
Middle Fork American River Downstream of Ralston Afterbay																	
MF4.8	10/3/2007; 9/29/08	QUANT	•	•			•	•	•								
MFAR at RM4.8	10/3/2007; 8/6/08	QUAL				•		•	•								
MF14.1	10/2/2007; 10/16/07; 9/30/08	QUANT	•	•				•	•								
Otter Creek at MF14.1	10/2/07; 10/16/07; 8/6/08	QUAL	•		•	•	•	•	•				•				
Gas Canyon	5/7/07	QUAL	•	•					•								
MF23.5	10/8/07	QUANT	•	•			•										
MFAR at RM23.5	6/5/08	QUAL	•	•	•	•		•	•								
Middle Fork American River from Middle Fork Interbay to Ralston Afterbay																	
MF26.2	9/18/2007; 9/15/08	QUANT	•	•	•	•	•	•	•	•	•						
MFAR at RM26.2	6/5/07; 6/25/07; 7/16/07; 7/16/08	QUAL	•	•	•	•	•	•	•	•	•						
MFAR at RM26.6	7/16/08	QUAL	•	•													
MFAR at RM29.4	10/24/07	QUAL	•	•													
Middle Fork American River Upstream of Middle Fork Interbay																	
MF36.2	9/21/07	QUANT	•	•													
MF44.7	9/26/07; 10/27/08	QUANT	•	•													
MF51.8	10/11/07	QUANT	•	•													
Rubicon River																	
Rubicon River RM0.0 - 0.5	5/11/07; 6/7/07; 6/27/07; 7/17/07	QUAL	•		•	•	•	•	•	•	•						
Rubicon at RM3.5	6/12/07; 7/15/08	QUAL	•	•	•	•	•	•	•	•	•						
R3.5	9/17/07	QUANT	•	•	•	•	•	•	•	•	•						
Rubicon River at RM5.2	10/24/07; 7/21/08	QUAL	•	•	•	•	•						•				
Rubicon River at RM6.2	7/21/08	QUAL	•	•	•	•							•				
Rubicon River at RM8.0	8/8/08	QUAL	•	•		•							•				
Rubicon River at RM9.9	9/27/07; 8/8/08	QUAL	•	•									•				
Rubicon River at RM14.3	9/27/07	QUAL	•	•									•				
R20.9	9/19/07; 9/26/08	QUANT	•	•				•									
R25.7	9/25/07	QUANT	•	•													
R36.2	9/27/07	QUANT	•	•							•						
Long Canyon Creek																	
LC at RM0.2	7/15/08	QUAL	•	•	•	•							•				
LC9.0	10/8/07	QUANT	•														
North Fork Long Canyon Creek																	
NFLC1.9	8/30/07	QUANT	•														
NFLC3.8	9/5/07	QUANT	•														
NFLC RM3.6 - 5.0	5/17/07; 6/16/07; 6/26/07	QUAL	•														

Table 7.5-5. Summary of Fish Species Observed during the 2007–2009 Fish Population Sampling (●) (continued).

Study Site	DATE	Sample Type ¹	Fish Species ²														
			RBT	BNT	HH	SPM	MXD	SS	SCULP	SD	CAR	SMB	GSUN	KOK	TCB	LKT	WCF
South Fork Long Canyon Creek																	
SFLC2.3	8/28/07; 9/9/08; 10/5/09	QUANT	●														
SFLC3.0	10/6/09	QUANT	●														
SFLC4.2	8/29/07; 9/10/08; 10/7/09	QUANT	●														
SFLC5.2	10/9/09	QUANT	●														
SFLC RM5.7 - 9.4	5/17/07; 6/16/07; 6/26/07	QUAL	●														
Duncan Creek																	
D6.3	9/6/07, 10/22/08	QUANT	●	●													
D8.3	10/23/08	QUANT	●	●													
D9.0	9/7/07, 10/28/08	QUANT	●	●													
D10.0	10/29/08	QUANT	●	●													
Duncan Creek RM9.0 - 13.6	5/17/07; 6/16/07; 6/26/07	QUAL	●	●													
North Fork of the Middle Fork American River																	
NFMF at RM0.2	7/17/08	QUAL	●	●	●	●					●						
NFMF2.3	10/1/07; 9/24/08	QUANT	●			●			●	●	●	●					
North Fork American River																	
NF18.4	10/9/07	QUANT	●	●				●	●								
NF31.3	10/21/07	QUANT	●			●	●	●	●			●	●				
NF at RM31.3	10/21/07; 8/14/08	QUAL	●		●	●		●	●			●	●				●
NF at RM36.0	8/15/08	QUAL	●		●	●						●					
NF53.7	8/31/07; 9/25/08	QUANT	●			●	●	●	●	●	●						
Diversion Pools																	
NFLC	9/4/07	QUANT	dry														
SFLC	9/4/07	QUANT	●														
Duncan	10/2/2007; 10/26/2007	QUANT	●	●													
Reservoirs																	
Ralston Afterbay	9/13/07; 6/26/08; 9/4/08	Gill netting/ electrofishing	●	●	●	●			●								
Middle Fork Interbay	9/20/07-9/21/07	Gill netting	●	●													
French Meadows	9/11/07-9/13/07	Gill netting	●	●										● ³	●		
Hell Hole	9/10/07-9/12/07	Gill netting	●	●					●					●	●	●	

¹QUAL = Qualitative Sampling (multi-pass electrofishing, multiple lane snorkeling, and gill netting); QUANT = Quantitative sampling (snorkeling, single pass electrofishing, or seining)

²Species: RBT = Rainbow Trout; BNT = Brown Trout; HH = Hardhead; SPM = Sacramento Pikeminnow; MXD = Mixed Minnow; SS = Sacramento Sucker; SCULP = Sculpin; SD = Speckled Dace; CAR = California Roach; SMB = Smallmouth Bass; GSUN = Green Sunfish; KOK = Kokanee; TCB = Tui Chub; LKT = Lake Trout; WCF = White Catfish

³Anomalous Kokanee observation at French Meadows Reservoir

Table 7.5-6. Rainbow Trout Observed Emergence Dates Above the Small Stream Diversion Pools.

Site	2007	2009
Duncan Creek	6/26	7/6
North Fork Long Canyon Creek	6/5	6/23
South Fork Long Canyon Creek	6/26	7/6

Table 7.5-7. Hardhead and Sacramento Pikeminnow Observations from Quantitative and Qualitative Fish Sampling

Site	Year	Sampling Effort	Hardhead				Sacramento Pikeminnow				Mixed Minnow ¹	
			YOY	3 - 6 inches	6 - 12 inches	12+ inches	YOY	3 - 6 inches	6 - 12 inches	12+ inches	YOY	3 - 6 inches
Middle Fork American River												
MF4.8	2007	Approx. 1 mile of quantitative snorkeling, 132 ft. of qualitative e-fishing	0	0	0	0	2	0	0	0	450	0
	2008	Approx. 1 mile of quantitative snorkeling, 1 mile of qualitative snorkeling	0	0	0	0	0	0	0	13	0	0
MF14.1	2007	Approx. 0.5 miles of quantitative snorkeling, 2500' of qualitative e-fishing	0	2	0	0	0	0	0	0	0	0
	2008	Approx. 0.5 miles of quantitative snorkeling, 0.5 miles of qualitative snorkeling	0	0	0	0	0	0	6	0	0	0
	2008 Otter Creek Confluence Pool ²	Electrofishing in first pool upstream of Middle Fork American River	0	20	0	0	0	20	0	0	0	0
MF23.5	2008	Fish observed in dredge hole during Stranding Studies	0	0	0	0	0	0	0	0	2502	0
	2008	2500' of qualitative snorkeling	0	0	0	0	0	0	0	0	10	0
MF26.2	2007	971' of quantitative e-fishing and snorkeling, 300' of qualitative e-fishing and snorkeling	0	1	0	0	7	15	0	0	87	80
	2008	980' of quantitative e-fishing and snorkeling, qualitative snorkeling in 3 large pools	0	50	0	0	1	76	0	0	27	12
Rubicon River												
R3.5	2007	1427' of quantitative e-fishing and snorkeling, qualitative snorkeling in 1 run	0	0	0	0	8	0	0	0	596	850
	2008	Qualitative snorkeling in 3 large pools	0	102	10	0	0	225	25	0	0	0
R5.2	2007	Qualitative snorkeling in 2 large pools	0	0	0	0	0	0	0	0	0	0
	2008	Approx. 0.5 miles of quantitative snorkeling	0	11	10	0	0	150	10	0	0	0
North Fork of the Middle Fork American River (Comparison River)												
NFMF0.0	2007	Not sampled in 2007	--	--	--	--	--	--	--	--	--	--
	2008	Four pools, approx. 150' each, qualitatively snorkeled	0	4	0	0	0	3	0	0	0	0
NFMF2.3	2007	818' of quantitative e-fishing and snorkeling	0	0	0	0	2	0	0	0	0	0
	2008	864' of quantitative e-fishing and snorkeling	0	0	0	0	5	2	0	0	589	0
North Fork American River (Comparison River)												
NF31.3	2007	3195' of quantitative snorkeling, 366' of qualitative e-fishing, 1 pool qualitatively snorkeled	0	0	0	0	8	11	2	20	0	34
	2008	3195' of quantitative snorkeling, 3195' of qualitative snorkeling	0	2	5	0	0	0	54	3	0	0
NF36.0	2007	Not sampled in 2007	--	--	--	--	--	--	--	--	--	--
	2008	Approx. 3000' of qualitative snorkeling	0	0	1	0	0	8	0	0	0	0
NF53.7	2007	1823' of quantitative e-fishing and snorkeling, 1 run qualitatively e-fished	0	0	0	0	8	4	0	0	1340	7
	2008	1823' of quantitative e-fishing and snorkeling	0	0	0	0	8	0	0	0	11	0

¹Mixed minnow potentially included hardhead, Sacramento pikeminnow, and California roach.²This pool was located in Otter Creek, at the edge of the Middle Fork American River.

Table 7.5-8. Rainbow Trout Spawning Weighted Usable Area under Spring Minimum Flows With and Without Accretion.

Site / Release Location	WYT	Spawning Minimum Flow (cfs)	Resulting Weighted Usable Area (% Max)	
			Rainbow Trout Spawning Without Accretion ¹	Rainbow Trout Spawning With Accretion ²
Small Streams				
Duncan Creek	Wet	8	53	77
	Abv Normal			80
	Blw Normal			76
	Dry			72
	Critical			43
North Fork Long Canyon Creek	Wet	2	19	19
	Abv Normal			19
	Blw Normal			19
	Dry			19
	Critical			19
South Fork Long Canyon Creek	Wet	5	43	43
	Abv Normal			43
	Blw Normal			43
	Dry			43
	Critical			25
Long Canyon Creek	Wet	NA	NA	68
	Abv Normal			70
	Blw Normal			64
	Dry			63
	Critical			42
Middle Fork American River below French Meadows				
River Mile 47.1 - 36.0	Wet	8	63	89
	Abv Normal			93
	Blw Normal			88
	Dry			84
	Critical			42
Middle Fork American River below Middle Fork Interbay				
River Mile 35.5 - 26.0	Wet	23	69	88
	Abv Normal			88
	Blw Normal			84
	Dry			70
	Critical			45
Rubicon River below Hell Hole Dam				
River Mile 28.8 - 14.0	Wet	10	34	76
	Abv Normal			81
	Blw Normal			69
	Dry			65
	Critical			23

¹Resulting percent of maximum weighted usable area calculated without accretion at the Instream Flow Study Site nearest to the release point.

²Resulting percent of maximum weighted usable area calculated using 95% exceedance accretion and all Instream Flow Study Sites within the reach (total reach spawning habitat).

Table 7.5-9. Fish Stranding and Trapping / Isolation Observed in the Middle Fork American River Peaking Reach.

Gray Eagle Bar – American Bar (RM 22.3–22.8, 23.1–23.8)							
Date: June 5th, 2008 Time: 14:00 - 17:00 Flow: 98 - 246 cfs Total Length: 1.2 miles							
Potential Stranding/Trapping Areas	Area (sq. ft.)	Number of Fish Observed			Species Observed	Notes	Photograph Number ¹
		Stranding	Temporary Trapping	Permanent Trapping			
A	44685	0	0	0		Seven small stranding pools.	AB-A
B	43076	0	0	0		Large, broad flat area.	AB-B1, AB-B2
C	5942	0	~250	0	Mixed hardhead, Sacramento pikeminnow, California roach, sculpin	14" deep dredge hole on the margin of the river, all fish fry or young-of-the-year. All fish alive.	AB-C
D	22675	0	35	0	10 Sculpin, 25 mixed minnow / trout fry	Isolated pools with some flow. All fish alive, swimming between pools.	AB-D1, AB-D2
E	21632	0	3-5	0	Trout	Four small isolated pools with some flow. Trout fry observed swimming between pools.	AB-E
Fords Bar (RM 13.6–14.5)							
Date: June 5th, 2008 Time: 17:30–20:00 Flow: 98–246 cfs Total Length: 0.9 miles							
Potential Stranding/Trapping Areas	Area (sq. ft.)	Number of Fish Observed			Species Observed	Notes	Photograph Number
		Stranding	Temporary Trapping	Permanent Trapping			
A	4060	1	0	0	Sculpin	One stranded sculpin observed (dead).	FB-A1, FB-A2
B	1569	0	0	0			FB-B
C	2709	0	0	0			FB-C
D	4485	0	0	0		Small stranded pool in bedrock, no fish observed.	FB-D1, FB-D2
E	4122	0	0	0			FB-E
F	3091	0	0	0			FB-F
G	6117	0	0	0			FB-G
H	5412	0	0	0			FB-H
I	1779	0	0	0			FB-I
J	4706	0	0	0			FB-J
K	1841	0	0	0			FB-K
L	3187	0	0	0			FB-L
M	1942	0	0	0			FB-M
N	8173	0	0	0			FB-N
O	5483	0	0	0			FB-O
P	6500	0	0	0			FB-P
Q	1782	0	0	0			FB-Q
R	2748	0	0	0			FB-R

¹For photographs see AQ 1 – TSR (PCWA 2011a; SD B).

Table 7.5-10. Reservoir Gill Netting Catch and Catch Per Unit Effort (CPUE).

Date	Total Nets Deployed	Total Deployment Hours	Average Hours per Net	Reservoir Totals		RBT ¹		RBT X CT		BNT		HH		SPM		SS		KOK		TCB		LKT	
				Total Fish	fish per net hour	Total Fish	fish per net hour	Total Fish	fish per net hour	Total Fish	fish per net hour	Total Fish	fish per net hour	Total Fish	fish per net hour	Total Fish	fish per net hour	Total Fish	fish per net hour	Total Fish	fish per net hour	Total Fish	fish per net hour
French Meadows Reservoir																							
9/11/2007 ³	12	243.0	20.3	37	0.152	8	0.033			28	0.115							1	0.004	1	0.004		
8/21/1985	*	12.0	*	14	1.167	12	1.000			2	0.167												
6/2/1982	5	15.0	3.0	56	3.733	5	0.333			51	3.400												
5/24/1982	2	14.0	7.0	5	0.357	2	0.143			3													
9/16/1975	2	11.0	5.5	14	1.273	5	0.455			9	0.818												
Middle Fork Interbay																							
9/20/2007	4	80.0	20.0	12	0.150	5	0.063			7	0.088												
Ralston Afterbay																							
9/4/2008	6	117.2	19.5	65	0.555	6	0.051			4	0.034			2	0.017	53	0.452						
6/26/2008	6	122.6	20.4	105	0.856	8	0.065			8	0.065	3	0.024	2	0.016	84	0.685						
9/13/2007	6	110.7	18.4	92	0.831	6	0.054			10	0.090	6	0.054	4	0.036	66	0.596						
Hell Hole Reservoir																							
9/10/2007	10	194.5	19.4	141	0.725	0 ²				23	0.118					98	0.504	12	0.062	6	0.031	2	0.010
6/16/1983	3	54.0	18.0	332	6.148					9	0.167					219	4.056			104	1.926		
1/25/1978	2	30.8	15.4	455	14.797			3	0.098	10	0.325					41	1.333			401	13.041		
9/15/1975	2	11.0	5.5	6	0.545	1	0.091			4	0.364					1	0.091						
11/7/1974	2	14.0	7.0	91	6.500	2	0.143			7	0.500					62	4.429			20	1.429		
6/16/1971	6	81.0	13.5	791	9.765	5	0.062			19	0.235					228	2.815			539	6.654		
9/7/1967	2	12.0	6.0	95	7.917	2	0.167			1	0.083	2				88	7.333			4	0.333		
5/24/1966	1	12.0	12.0	25	2.083	10	0.833			2	0.167					13	1.083						

¹Species: RBT = Rainbow Trout; CT = Cutthroat Trout; BNT = Brown Trout; HH = Hardhead; SPM = Sacramento Pikeminnow; SS = Sacramento Sucker; KOK = Kokanee; TCB = Tui Chub; LKT = Lake Trout

²One RBT captured during qualitative methylmercury tissue sampling

³Anomalous Kokanee observation at French Meadows Reservoir

Table 7.5-11a. Historical Fish Stocking Records at Hell Hole Reservoir.

Year	Number of Fish Stocked (Fish/lb) ¹						
	Rainbow Trout ²	Brown Trout	Lake Trout	Kokanee	Coho Salmon	Cutthroat Trout ³	Brook Trout
1967	60,000						
1968	32,386						
1969	1,855	6,500					
1970	5,040						
1971	10,780						
1972	20,500						
1973	10,200					6,000	
1974	1,000				1,000	5,004	
1975						4,950	3,740
1976		10,200				22,300	
1978			2,852				
1979			3,000				
1989				45,000			
1992				73,500			
1994				74,960			
1995				71,750			
1996				51,975			
1997				50,050			
1998				35,600			
1999				25,000			
2000				25,026			
2001		6,380 (2.2)		26,600 (266)			
2002		8,100 (2.7)		25,272 (312)			
2003		7,500 (2.5)		24,960 (192)			
2004		4,200 (2.1)		22,275 (135)			
2005	A	4,400 (2.2)		25,000 (520)			
2006		3,600 (1.8)		14,350 (128)			
2007		3,800 (1.9)		16,416 (456)			
2008		4,700 (1.7)		37,950 (154)			
2009		7,200 (2.4)		28,272 (114)			

¹ Fish per pound data applied where available.

² Includes 2,800 Eagle Lake rainbows planted in 1971.

³ Including cutthroat hybrids.

^A The USDA-FS, Eldorado National Forest (USDA-FS 2006) reports that Hell Hole Reservoir presently is stocked with catchable rainbow trout; however, recent stocking records have not been located.

Table 7.5-11b. Historical Fish Stocking Records at French Meadows Reservoir.

Year	Number of Fish Stocked (Fish/lb) ¹		
	Rainbow Trout	Brown Trout	Eagle Lake Trout
1968	29,938		
1969	60,255		
1970	100,600		
1971	79,480		3,000
2001	10,050 (2.0)		
2002	12,500 (1.8)		4,000 (2.0)
2003	9,700 (1.9)		
2004	5,200 (1.7)		
2005	5,500 (1.8)		
2006	5,900 (2.0)		
2007	7,200 (1.8)		1,500 (1.5)
2008	12,800 (2.6)		
2009	20,300 (2.9)		

¹Fish per pound data applied where available.

Table 7.5-12. Middle Fork Project Facilities Inlet/Outlet Characteristics.

Facility	Hydraulic Capacity (cfs)	Frequency of Use (cfs)	Inlet/Outlet Type	Inlet Area (ft ²)	Approach Velocity (fps)	Intake Depth (ft)	Comments
French Meadows Reservoir							
French Meadows – Hell Hole Tunnel	400	Frequent during spring and summer	<u>Inlet:</u> 10-ft-diameter pipe <u>Trashrack:</u> 2.6-in bar spacing <u>Outlet:</u> vertical Francis turbine	<u>Inlet:</u> 78.5 <u>Trashrack:</u> 484	<u>Inlet:</u> 0–5.1 <u>Trashrack:</u> 0-0.8	145 ¹	
French Meadows Dam – Low Level Outlet	1,430	Infrequent	<u>Inlet:</u> 60-in pipe with slide gate <u>Trashrack:</u> 6-in bar spacing <u>Outlet:</u> 60-in Ring Jet Valve	<u>Inlet:</u> 28 <u>Trashrack:</u> 52	<u>Inlet:</u> 0–51 <u>Trashrack:</u> 0–28	211.5 ²	Energy dissipating valve discharges to a plunge pool
French Meadows Dam – Instream Flow Pipe Intake	4–8	Continuous	<u>Inlet:</u> 8-in pipe <u>Outlet:</u> 8-in Howell-Bunger Valve	<u>Inlet:</u> 0.35 <u>Trashrack:</u> 23	<u>Inlet:</u> 11.4–22.86 <u>Trashrack:</u> 0.2–0.4	194 ¹	Energy dissipating valve discharges to a plunge pool
Hell Hole Reservoir							
Hell Hole – Middle Fork Tunnel	800	Frequent	<u>Inlet:</u> 11.5-ft-diameter pipe. <u>Trashrack:</u> 2-in bar spacing <u>Outlet:</u> Two Pelton Turbines	<u>Inlet:</u> 104 <u>Trashrack:</u> 705	<u>Inlet:</u> 0–7.8 <u>Trashrack:</u> 0–1.1	308.1 ¹	Powerhouse discharges into Middle Fork Interbay

Table 7.5-12. Middle Fork Project Facilities Inlet/Outlet Characteristics.

Facility	Hydraulic Capacity (cfs)	Frequency of Use (cfs)	Inlet/Outlet Type	Inlet Area (ft ²)	Approach Velocity (fps)	Intake Depth (ft)	Comments
Hell Hole Dam Outlet Works	6–848	6–20 cfs: Continuous low flow ~65 cfs: Infrequent during outages 65–848 cfs: Infrequent and would cause facility damage	Rectangular inlet (with trashrack) into horizontal 13-ft horseshoe shaped tunnel (original tunnel opening shut with stop logs)	<u>Inlet</u> : 76 <u>Trashrack</u> : 300.3	<u>Inlet</u> : 0.08–11.2 <u>Trashrack</u> : 0.02–2.82	342 ³	Outlet works is a tunnel that leads to a 48-in-diameter pipe and 16-in-diameter pipe for the Hell Hole Powerhouse, instream flow pipe, and low level outlet
Hell Hole Dam Low Level Outlet ⁵	Calculated maximum capacity 848	Infrequent (would cause facility damage)	<u>Inlet</u> : 48-in-diameter pipe with butterfly valve <u>Outlet</u> : 48-in hollow-cone valve	12.6	48-in pipe opening <u>Inlet</u> : 0–67.3 ⁴	342 ³	Energy dissipating valve discharges to a plunge pool
Hell Hole Power House ⁵	Approx 45	Continuous except for maintenance	<u>Inlet</u> : 20-in-diameter pipe with control valve <u>Outlet</u> : horizontal Francis turbine	2.18	20-in pipe opening <u>Inlet</u> : 0–20.6 ⁴	342 ³	20-in-diameter penstock for powerhouse “Y”s” off of 48-in-diameter pipe. Hell Hole Powerhouse discharges to plunge pool
Hell Hole Dam Instream Flow Pipe ⁵	20	Infrequent (typically instream flow compliance is provided by Hell Hole Powerhouse) discharge	<u>Inlet</u> : 16-in-diameter pipe with butterfly valve <u>Outlet</u> : 12-in hollow-cone valve	0.8	16-in pipe opening <u>Inlet</u> : 0–25 ⁴	342 ³	Energy dissipating valve discharges to a plunge pool

Table 7.5-12. Middle Fork Project Facilities Inlet/Outlet Characteristics.

Facility	Hydraulic Capacity (cfs)	Frequency of Use (cfs)	Inlet/Outlet Type	Inlet Area (ft ²)	Approach Velocity (fps)	Intake Depth (ft)	Comments
Middle Fork Interbay							
Middle Fork – Ralston Tunnel	836	Frequent	<u>Inlet:</u> Tunnel with slide gate <u>Trashrack:</u> 3-in bar spacing <u>Outlet:</u> Pelton Turbine	<u>Tunnel Inlet:</u> 96 <u>Trashrack:</u> 680	<u>Inlet:</u> 0–8.71 <u>Trashrack:</u> 0–1.23	51 ⁶	Ralston Powerhouse discharges into Ralston Afterbay
Middle Fork Interbay Dam Low Level Outlet	895	Infrequent	<u>Inlet:</u> 60-in-diameter with slide gate <u>Grizzly:</u> 8-in bar opening <u>Outlet:</u> Open pipe	<u>Pipe Inlet:</u> 19.6 <u>Grizzly:</u> 62	<u>Inlet:</u> 0–45.7 <u>Trashrack:</u> 0–14.4	68.5 ⁶	Discharges to a plunge pool
Middle Fork Interbay Dam Stream Maintenance Pipe	12–23	Continuous	<u>Inlet:</u> 20-in-diameter pipe with slide valve <u>Trashrack:</u> 3-in bar opening <u>Outlet:</u> Open pipe	<u>Pipe Inlet:</u> 2.18 <u>Trashrack:</u> 6.0	<u>Inlet:</u> 5.5–10.6 <u>Trashrack:</u> 2.0–3.8	39.84 ⁶	Outlet discharges to a plunge pool

Table 7.5-12. Middle Fork Project Facilities Inlet/Outlet Characteristics.

Facility	Hydraulic Capacity (cfs)	Frequency of Use (cfs)	Inlet/Outlet Type	Inlet Area (ft ²)	Approach Velocity (fps)	Intake Depth (ft)	Comments
Ralston Afterbay							
Ralston – Oxbow Tunnel	1,088	Frequent	<u>Inlet:</u> Tunnel with slide gate <u>Trashrack</u> with 3-in bar spacing Outlet: vertical Francis turbine	<u>Tunnel Inlet:</u> 96 <u>Trashrack:</u> 590	<u>Inlet:</u> 0-11.3 <u>Trashrack:</u> 0-1.8	39 ⁶	Oxbow Powerhouse discharges into the Middle Fork American River
Ralston Afterbay Dam Low Level Outlet	1,671	Infrequent	<u>Inlet:</u> 72-in-diameter with slide valve <u>Grizzly:</u> 8-in bar opening <u>Outlet:</u> 72-in-diameter slide gate	<u>Pipe Inlet:</u> 28.3 <u>Grizzly:</u> 82.6	<u>Inlet:</u> 0–59.1 <u>Trashrack:</u> 0–20.33	74 ⁶	Discharges to a plunge pool
Ralston Afterbay Dam Stream Maintenance Pipe	75	<u>10 cfs:</u> Frequent <u>75 cfs:</u> Infrequent	<u>Inlet:</u> 30-in-diameter pipe with slide valve <u>Trashrack:</u> 3.88-in bar opening <u>Outlet:</u> 30-in-diameter Ring Jet valve	<u>Pipe Inlet:</u> 4.9 <u>Trashrack:</u> 36.2	<u>Inlet:</u> 2.04–15.31 <u>Trashrack:</u> 0.3–2.1	41.25 ⁶	Energy dissipating valve discharges to a plunge pool

Table 7.5-12. Middle Fork Project Facilities Inlet/Outlet Characteristics.

Facility	Hydraulic Capacity (cfs)	Frequency of Use (cfs)	Inlet/Outlet Type	Inlet Area (ft ²)	Approach Velocity (fps)	Intake Depth (ft)	Comments
Duncan Creek Diversion							
Duncan Creek – Middle Fork Tunnel	400	Frequent	<u>Inlet:</u> Tunnel with stop logs. <u>Trashrack:</u> 9-in bar spacing <u>Outlet:</u> Open tunnel	<u>Tunnel Inlet:</u> 51 <u>Trashrack:</u> 51	<u>Inlet:</u> 0–7.84 <u>Trashrack:</u> 0–7.84	4.25 ⁷	Discharges into French Meadows Reservoir
Duncan Creek Low Level Outlet	304	Infrequent	<u>Inlet:</u> 60-in-diameter pipe w/ slide gate <u>Grizzly:</u> 10-in bar spacing <u>Outlet:</u> Open pipe	<u>Pipe Inlet:</u> 19.6 <u>Grizzly:</u> 58.7	<u>Inlet:</u> 0–15.5 <u>Trashrack:</u> 0–5.2	13.5 ⁸	Discharges to a plunge pool
Duncan Creek Stream Maintenance Pipe	4–8	Continuous	<u>Inlet:</u> 10-in-diameter pipe with slide gate <u>Trash Screen:</u> 1.75-in openings) <u>Outlet:</u> Discharge weir	<u>Pipe Inlet:</u> 0.55 <u>Trash Screen:</u> 12.2	<u>Inlet:</u> 7.3–14.6 <u>Trashrack:</u> 0.33–0.66	5 ⁷	Outlet discharges to a plunge pool

Table 7.5-12. Middle Fork Project Facilities Inlet/Outlet Characteristics.

Facility	Hydraulic Capacity (cfs)	Frequency of Use (cfs)	Inlet/Outlet Type	Inlet Area (ft ²)	Approach Velocity (fps)	Intake Depth (ft)	Comments
North Fork Long Canyon							
North Fork Long Canyon Diversion Pipe	100	Frequently during winter and spring No diversion after July 1	<u>Inlet:</u> Parshall Flume with slide gate to a 36-in-diameter pipe. <u>Trashrack:</u> 2-in bar spacing <u>Outlet:</u> 403-foot-deep drop inlet to the Hell Hole - Middle Fork Tunnel	<u>Inlet:</u> 16 <u>Trashrack:</u> 68.7	<u>Inlet:</u> 0–6.25 <u>Trashrack:</u> 0–1.46	6 ⁹	Discharges to Hell Hole – Middle Fork Tunnel
North Fork Long Canyon Low Level Outlet	104	Infrequent	<u>Inlet:</u> 36-in-diameter pipe with slide gate <u>Outlet:</u> open pipe	<u>Inlet:</u> 7.1	<u>Inlet:</u> 0–14.7	5.5 ⁹	Discharges to streambed
North Fork Long Canyon Stream Maintenance Pipe	0–2	Continuous	<u>Inlet:</u> 12-in-diameter pipe with 12-in slide valve <u>Outlet:</u> 25-in-wide concrete channel with weir	<u>Inlet:</u> 0.8	<u>Inlet:</u> 0–2.5	6 ⁹	Discharges to streambed

Table 7.5-12. Middle Fork Project Facilities Inlet/Outlet Characteristics.

Facility	Hydraulic Capacity (cfs)	Frequency of Use (cfs)	Inlet/Outlet Type	Inlet Area (ft ²)	Approach Velocity (fps)	Intake Depth (ft)	Comments
South Fork Long Canyon							
South Fork Long Canyon Diversion Pipe	200	Frequently during winter and spring No diversion after July 1	<u>Inlet:</u> 42-in-diameter pipe with inlet weir <u>Trashrack:</u> 2.4-in bar spacing. <u>Outlet:</u> 387-ft-deep drop inlet to Hell Hole - Middle Fork Tunnel	<u>Inlet:</u> 36 <u>Trashrack:</u> 107	<u>Inlet:</u> 0–5.6 <u>Trashrack:</u> 0–1.87	11 ⁹	Discharges to Hell Hole – Middle Fork Tunnel
South Fork Long Canyon Low Level Outlet	136 136	Infrequent	<u>Inlet:</u> 36-in-diameter pipe with slide gate <u>Outlet:</u> open pipe	<u>Inlet:</u> 7.1	<u>Inlet:</u> 0–19.5	12.2 ⁹	Discharges to streambed
South Fork Long Canyon Stream Maintenance Pipe	2.5–5	Continuous	<u>Inlet:</u> 12-in-diameter pipe with 12-in slide valve <u>Outlet:</u> 48-in-wide concrete channel with weir	<u>Inlet:</u> 0.8	<u>Inlet:</u> 3.1–6.25	6 ⁹	Discharges to streambed

¹Maximum reservoir operating surface elevation minus intake surface elevation.²Maximum reservoir operating surface elevation minus curb intake elevation.³Maximum reservoir operating surface elevation minus intake elevation invert of Hell Hole Dam Outlet Works.⁴Intake velocity calculated at the pipe inlet inside the tunnel. Intake velocity to the tunnel is much lower (Hell Hole-Middle Fork Tunnel Intake).⁵Outlet branches off from tunnel. Inlet to tunnel is the Hell Hole Dam Outlet Works.⁶Maximum reservoir operating surface elevation minus intake elevation invert.⁷Diversion Dam Crest minus top of intake weir.⁸Diversion Dam Crest minus invert elevation.⁹Diversion Dam spillway crest minus invert elevation.

Table 7.5-13. Turbine Characteristics and Associated Estimated Mortality at MFP Facilities.

Name	Max. Hydraulic	Turbine Type	Runner Speed	Maximum Blade	Static Head Max - Min	Fish Size (mm)	Approx. % Survival ²	
							Immediate	48-Hour
French Meadows P.H.	400 ³	Vertical Francis	450	150 - 170	654 - 517	<100	70 (31-98)	72 (63-86)
						100 - 199	60 (34-83)	46 (16-78)
						200 - 299	39 (23-83)	32 (12-65)
						300+	19 (4-35)	6 (4-8)
Hell Hole P.H.	65 ⁴	Horizontal Francis	1200	62 - 94	391 - 101	<100	70 (31-98)	72 (63-86)
						100 - 199	60 (34-83)	46 (16-78)
						200 - 299	39 (23-83)	32 (12-65)
						300+	19 (4-35)	6 (4-8)
Oxbow P.H.	1025	Vertical Francis	200	66 - 76	90	<100	94 (86-100)	90 (81-101)
						100 - 199	92 (75-100)	88 (74-101)
						200 - 299	87 (59-100)	80 (47-96)
						300+	73 (36-100)	67 (34-94)
Middle Fork P.H. (2 units)	920 ⁵	Pelton	400	NA	2,096 - 1,806	All	~ 0	
Ralston P.H.	924	Pelton	240	NA	1,344	All	~ 0	

¹Approximate range based in diameter of scroll case and allowance for wicket gate assembly.

²Mean approximate mortality for all fish species combined (Winchell et al. 2000 table).

³Nominal tunnel capacity.

⁴Maximum flow capacity when supporting instream flow requirements below Oxbow PH during fall maintenance outage.

⁵Nominal capacity of Hell Hole – Middle Fork Tunnel.

FIGURES

Figure 7.5-1a. Water Temperature Measured at Four Locations in the Middle Fork American River between French Meadows Reservoir and Middle Fork Interbay (River Mile 46.6, 44.6, 39.4, and 36.1) in 2006, 2007, and 2008.

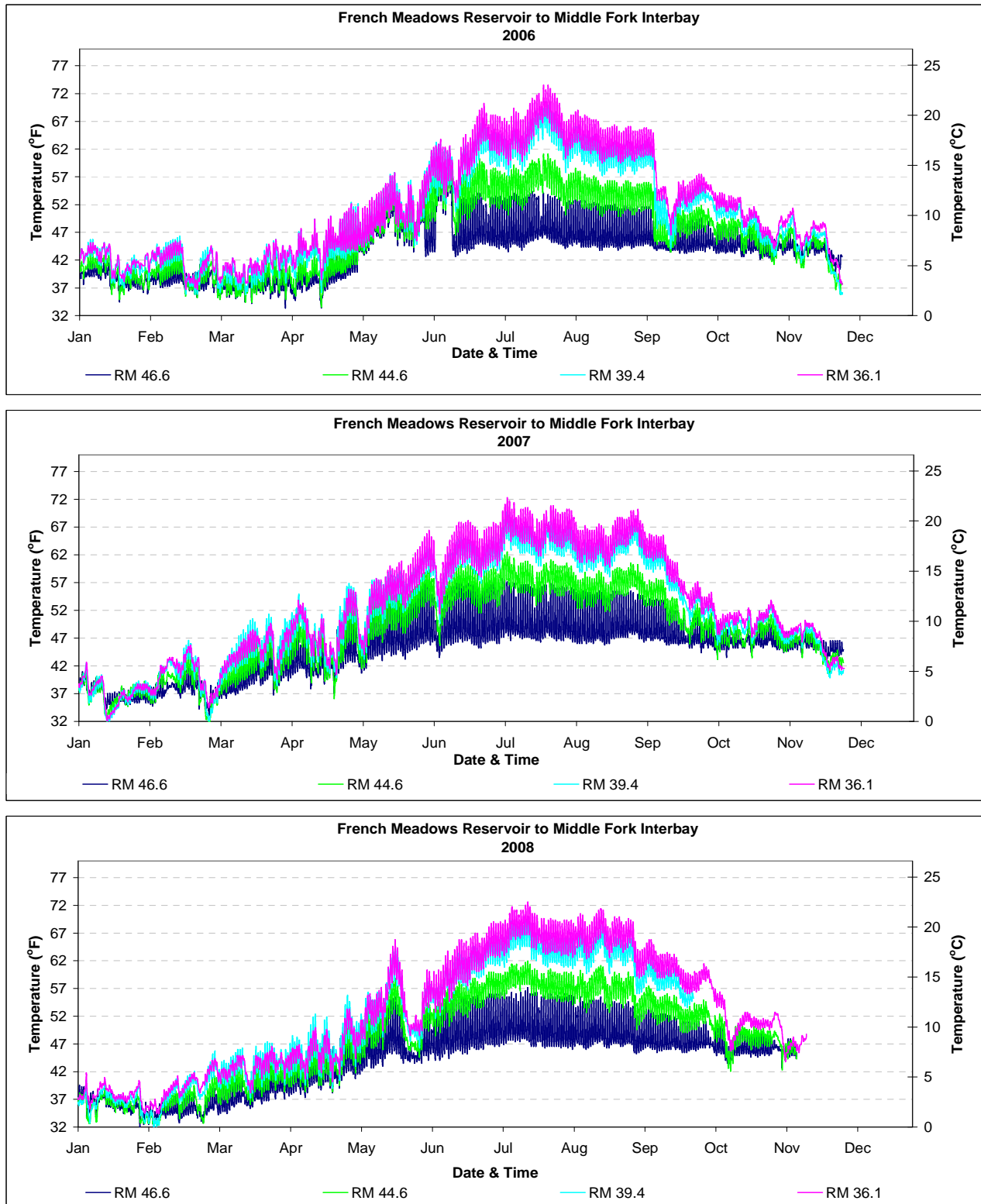


Figure 7.5-1b. Water Temperature Measured at Three Locations in the Middle Fork American River between Middle Fork Interbay and Ralston Afterbay (River Mile 35.5, 29.4, and 26.0) in 2006, 2007, and 2008.

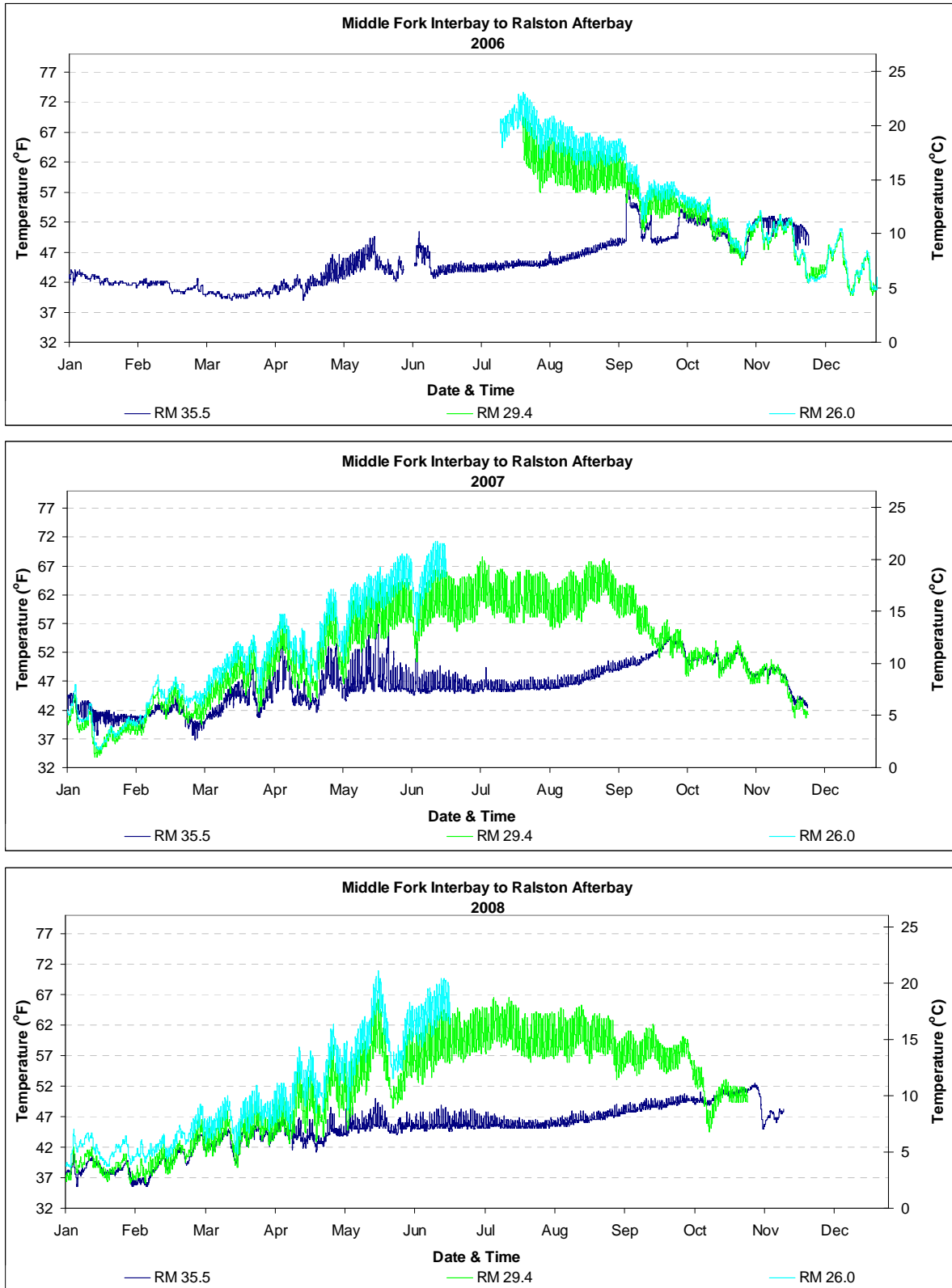


Figure 7.5-1c. Water Temperature Measured at Three Locations in the Middle Fork American River between Ralston Afterbay and the Confluence with the North Fork American River (River Mile 23.1, 14.3, and 0.1) and One Location in the North Fork American River below the Confluence (River Mile 20.8) in 2006, 2007, and 2008.

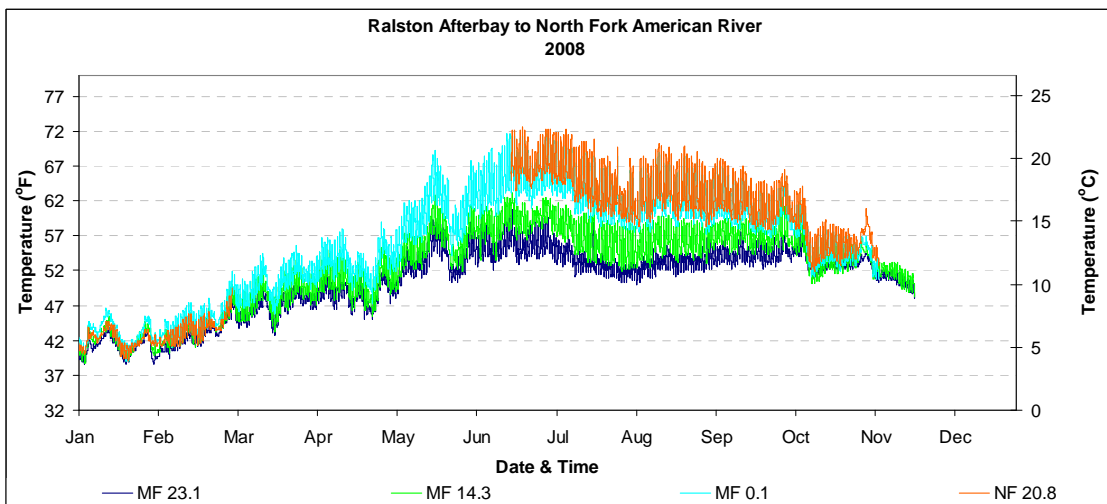
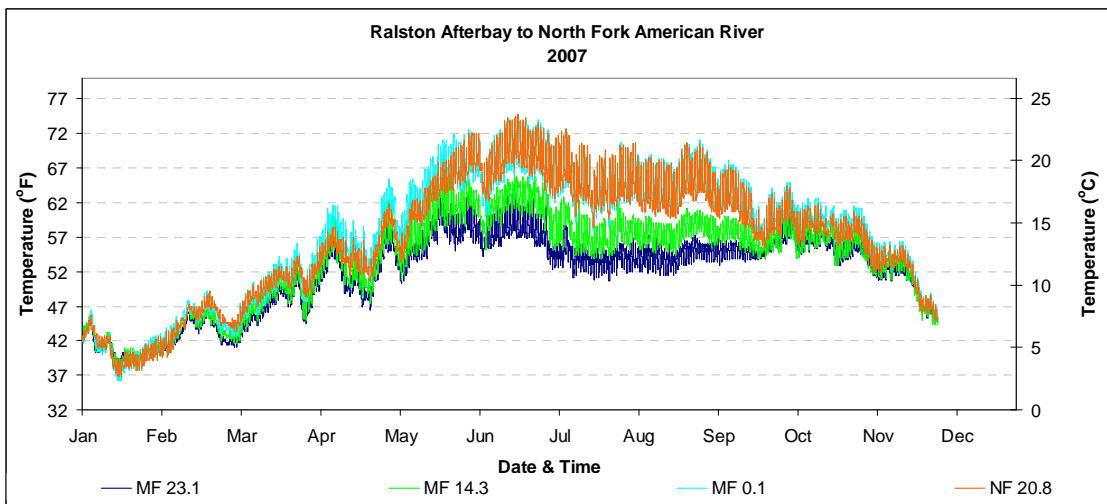
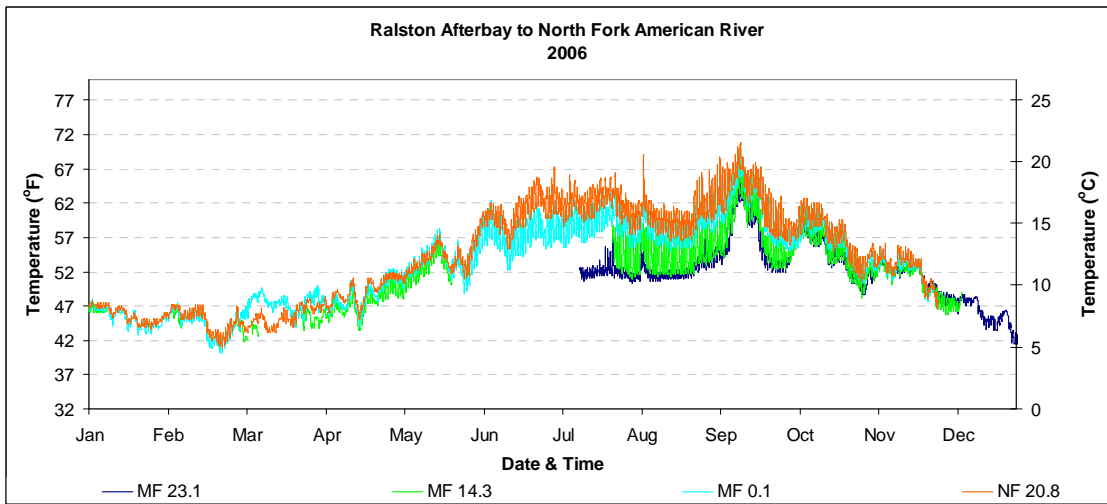


Figure 7.5-1d. Water Temperature Measured at Four Locations in the Rubicon River between Hell Hole Reservoir and Ralston Afterbay (River Mile 28.8, 22.5, 14.3, and 0.7) in 2006, 2007, and 2008.

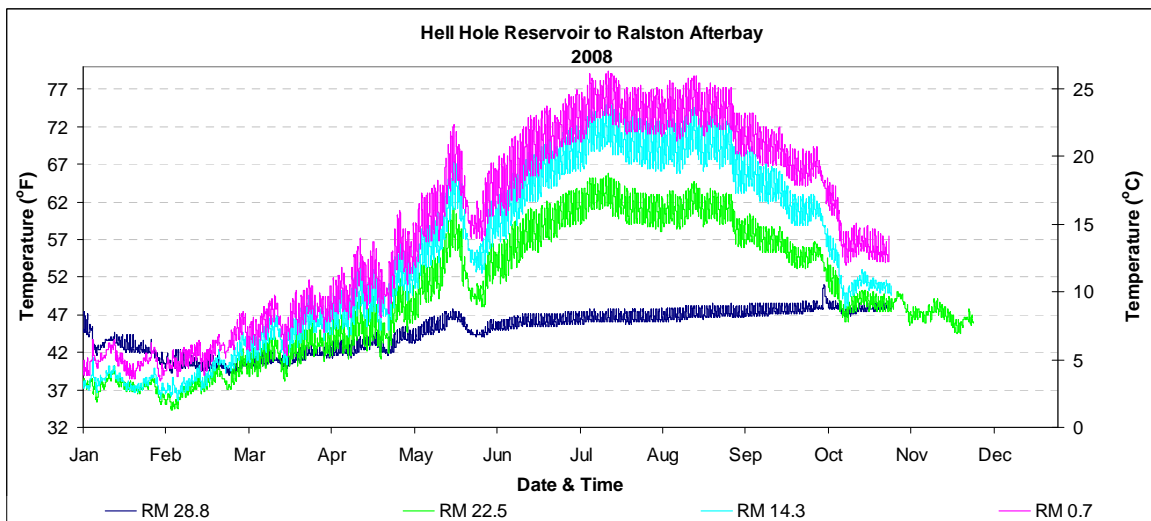
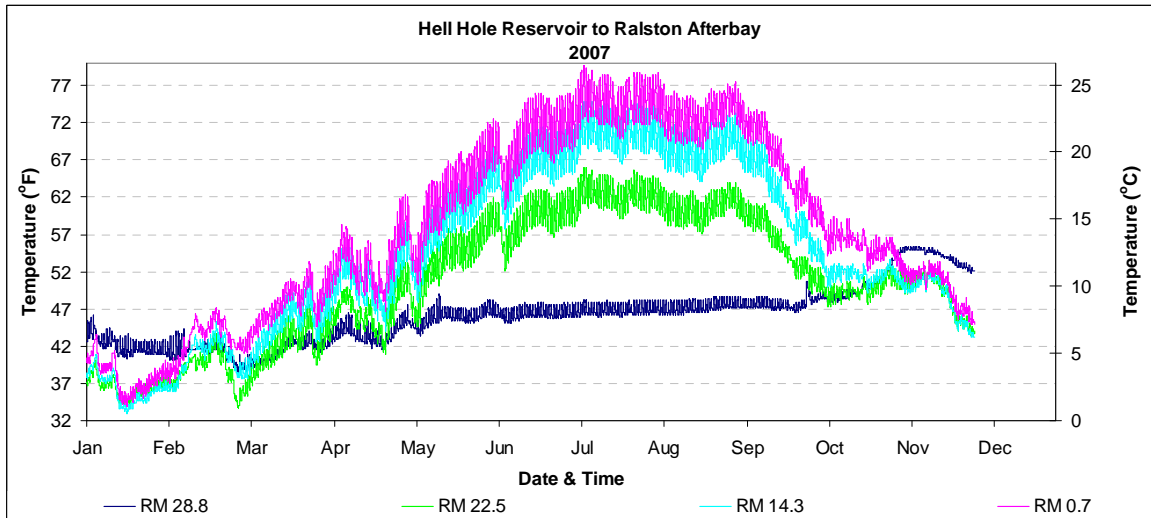
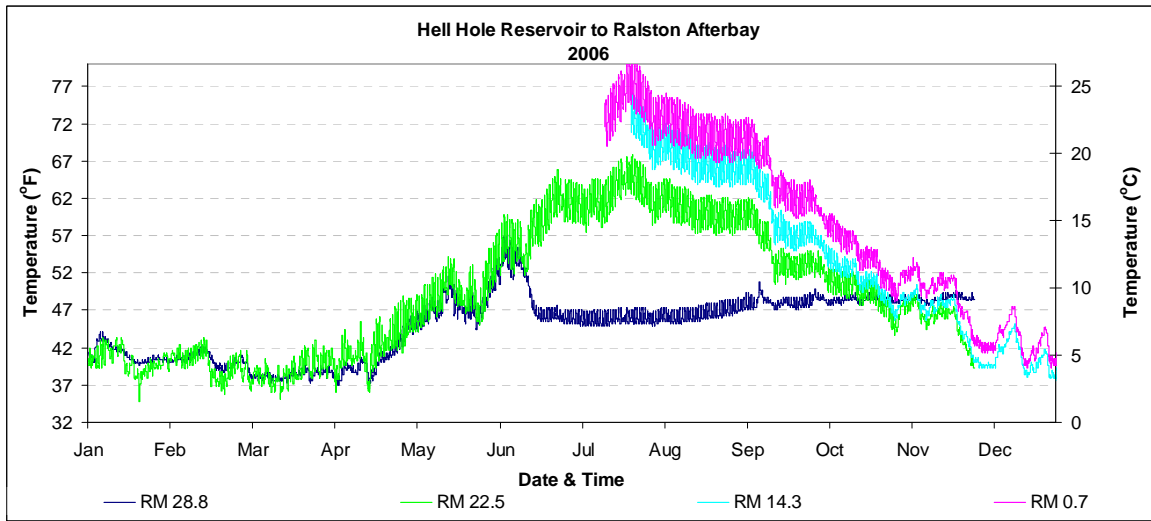
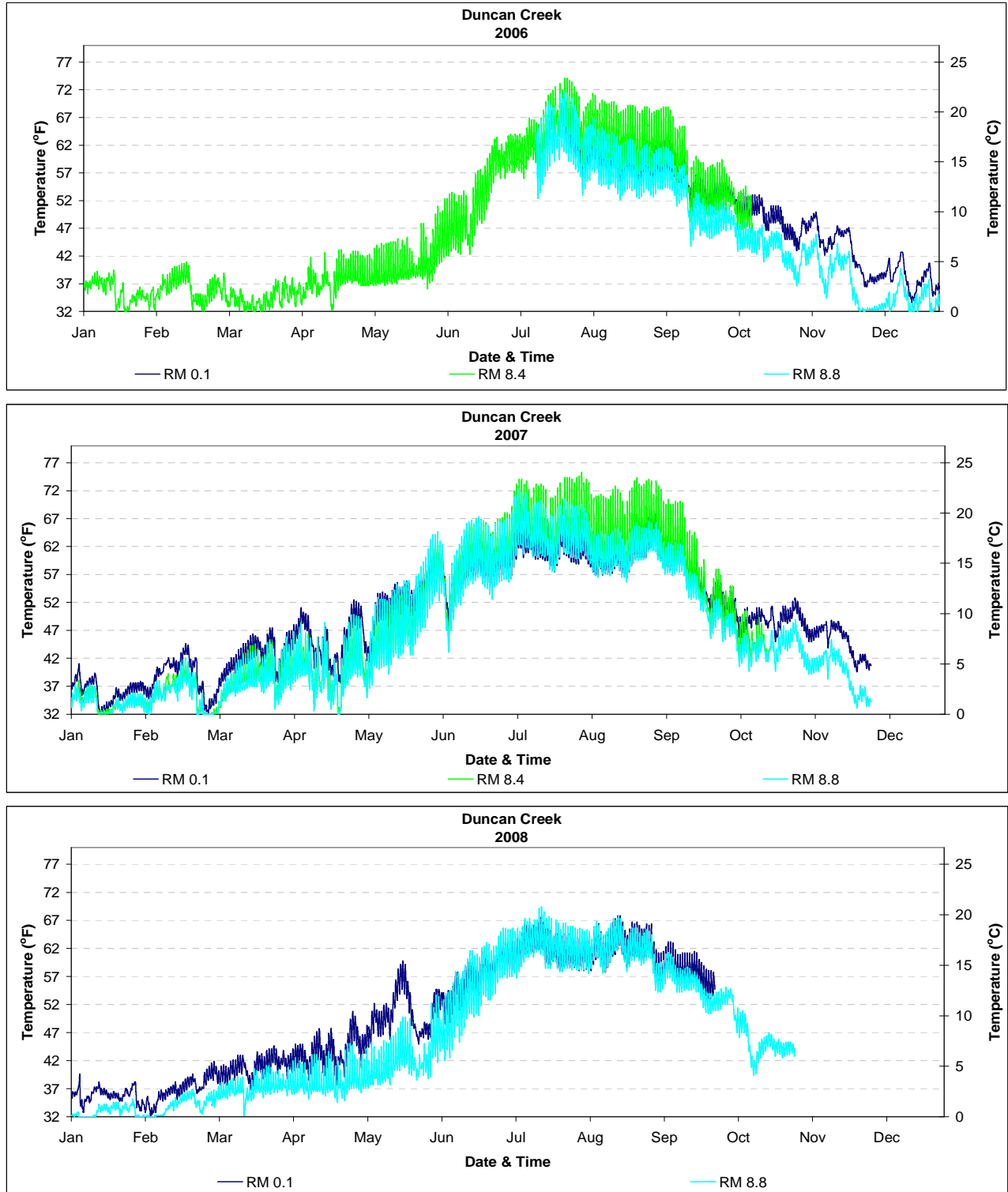


Figure 7.5-1e. Water Temperature Measured in Duncan Creek at Two Locations Below the Duncan Creek Diversion (River Mile 0.1 and 8.41) and One Location Above the Duncan Creek Diversion (River Mile 8.8) in 2006, 2007, and 2008.



¹Temperature at river mile 8.4 was not available in 2008.

Figure 7.5-1f. Water Temperature Measured in North Fork Long Canyon Creek at One Location Below the North Fork Long Canyon Diversion (River Mile 3.1) and One Location Above the North Fork Long Canyon Diversion (River Mile 3.2) in 2006, 2007, and 2008.

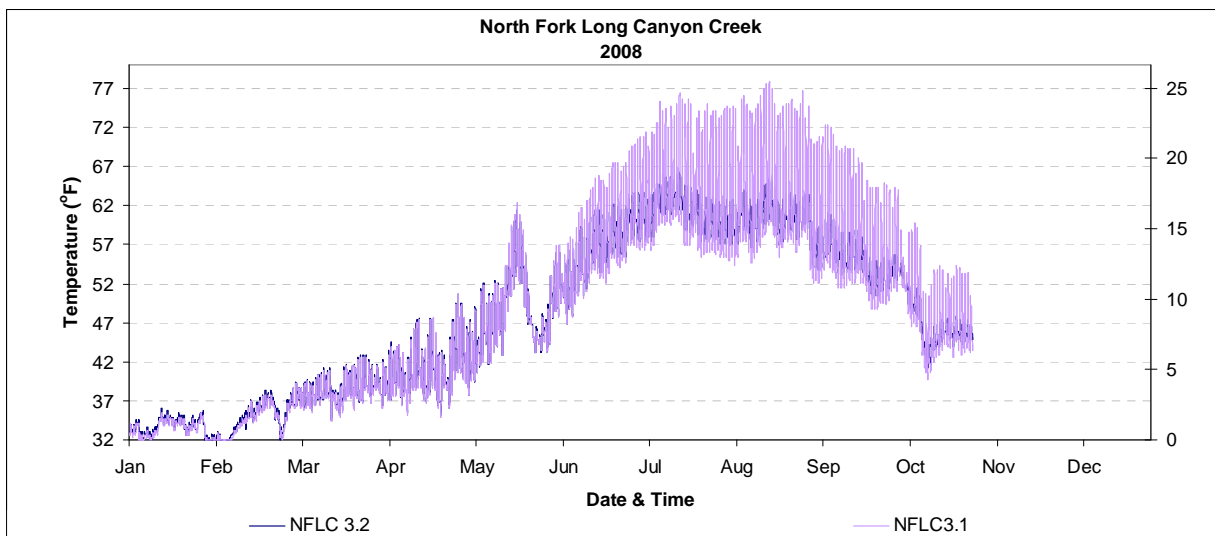
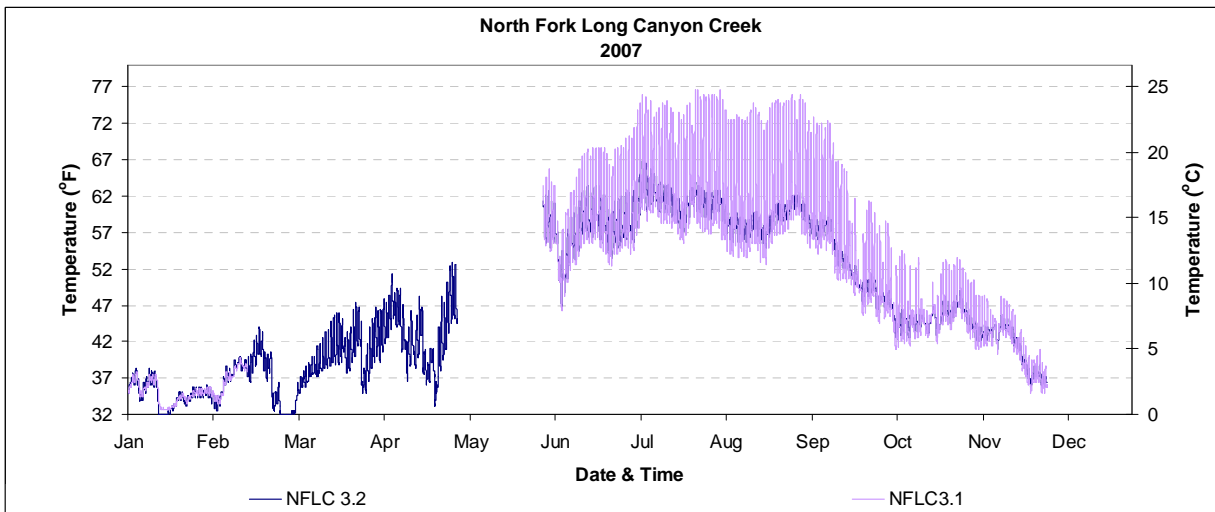
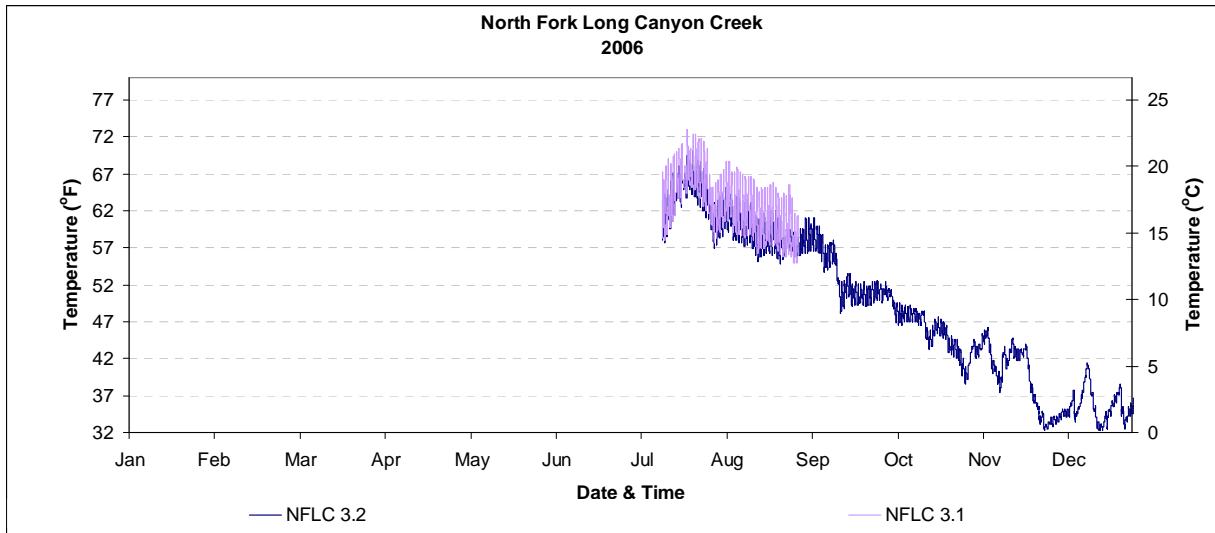


Figure 7.5-1g. Water Temperature Measured in South Fork Long Canyon Creek at Two Locations Below the South Fork Long Canyon Diversion (River Mile 0.1 and 3.2) and One Location Above the South Fork Long Canyon Diversion (River Mile 3.4) in 2006, 2007, and 2008.

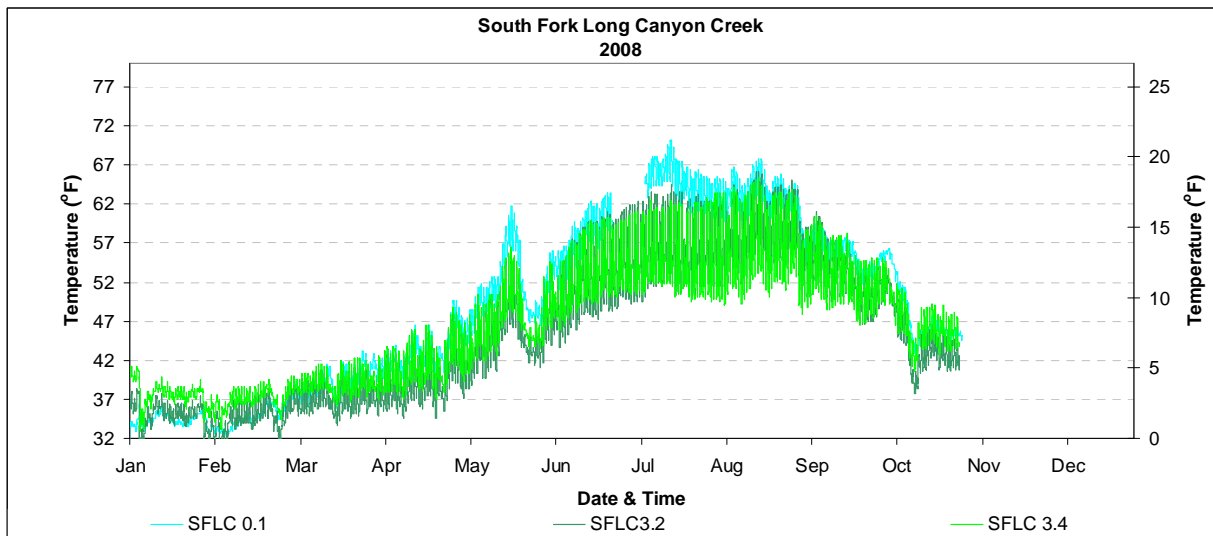
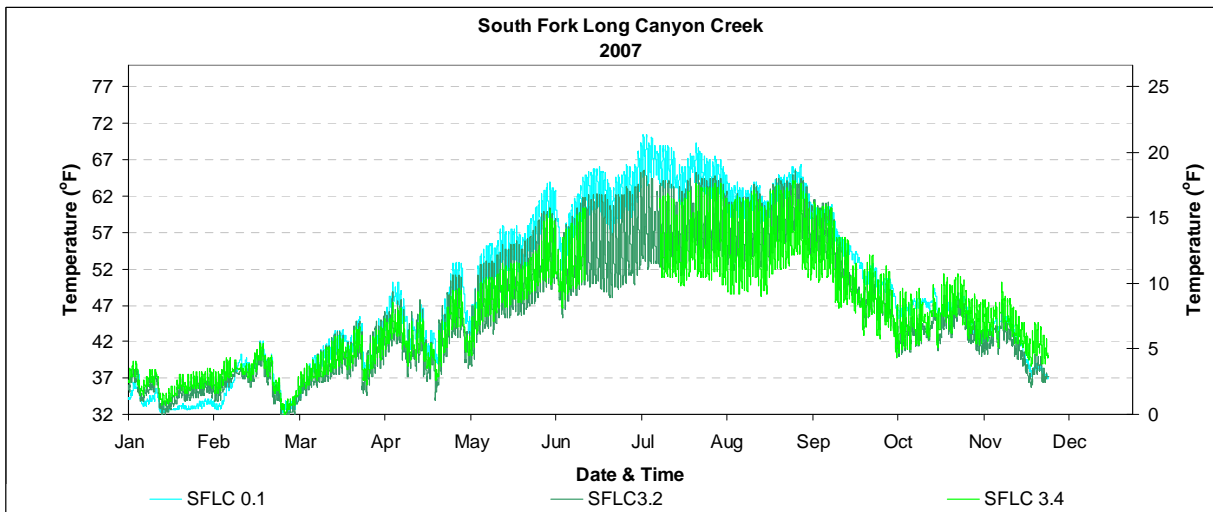
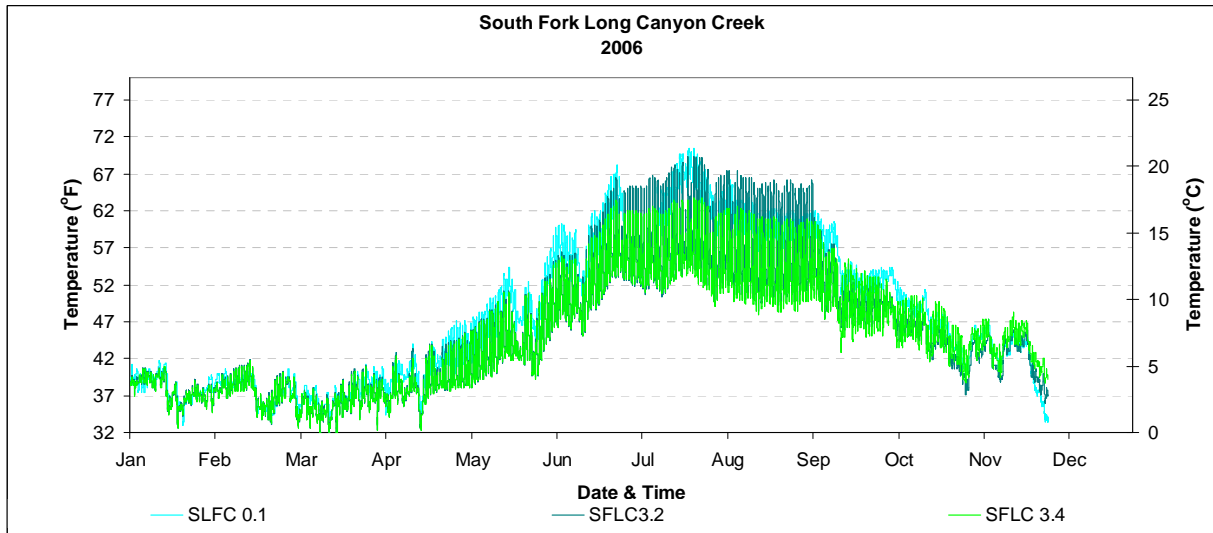


Figure 7.5-1h. Water Temperature Measured in Long Canyon Creek at Three Locations (River Mile 0.1, 6.8, and 11.1) in 2006, 2007, and 2008.

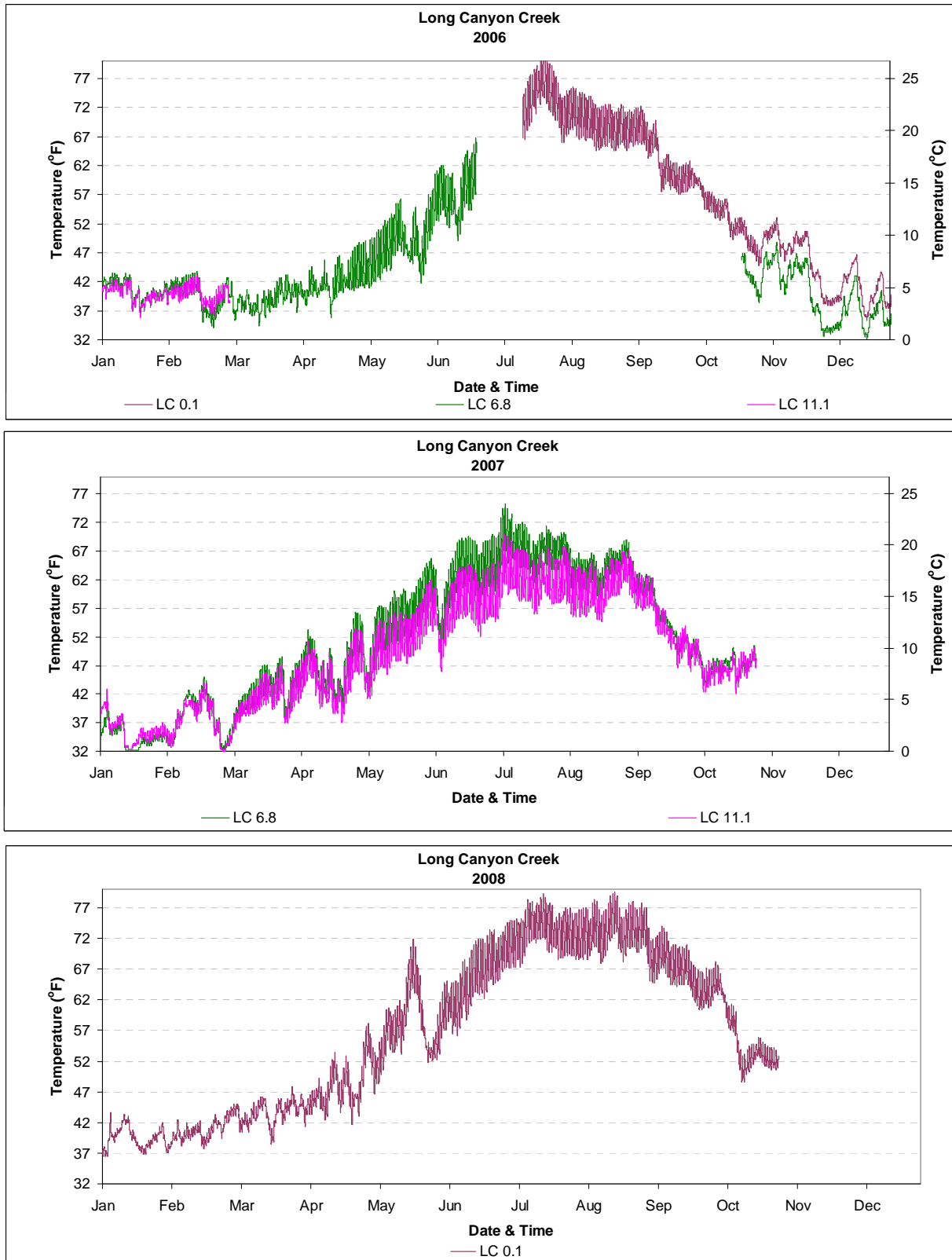


Figure 7.5-2. Fish Distribution in the Middle Fork American River, Rubicon River, Long Canyon Creek, North Fork Long Canyon Creek, South Fork Long Canyon Creek, Duncan Creek, and Little Duncan Creek.

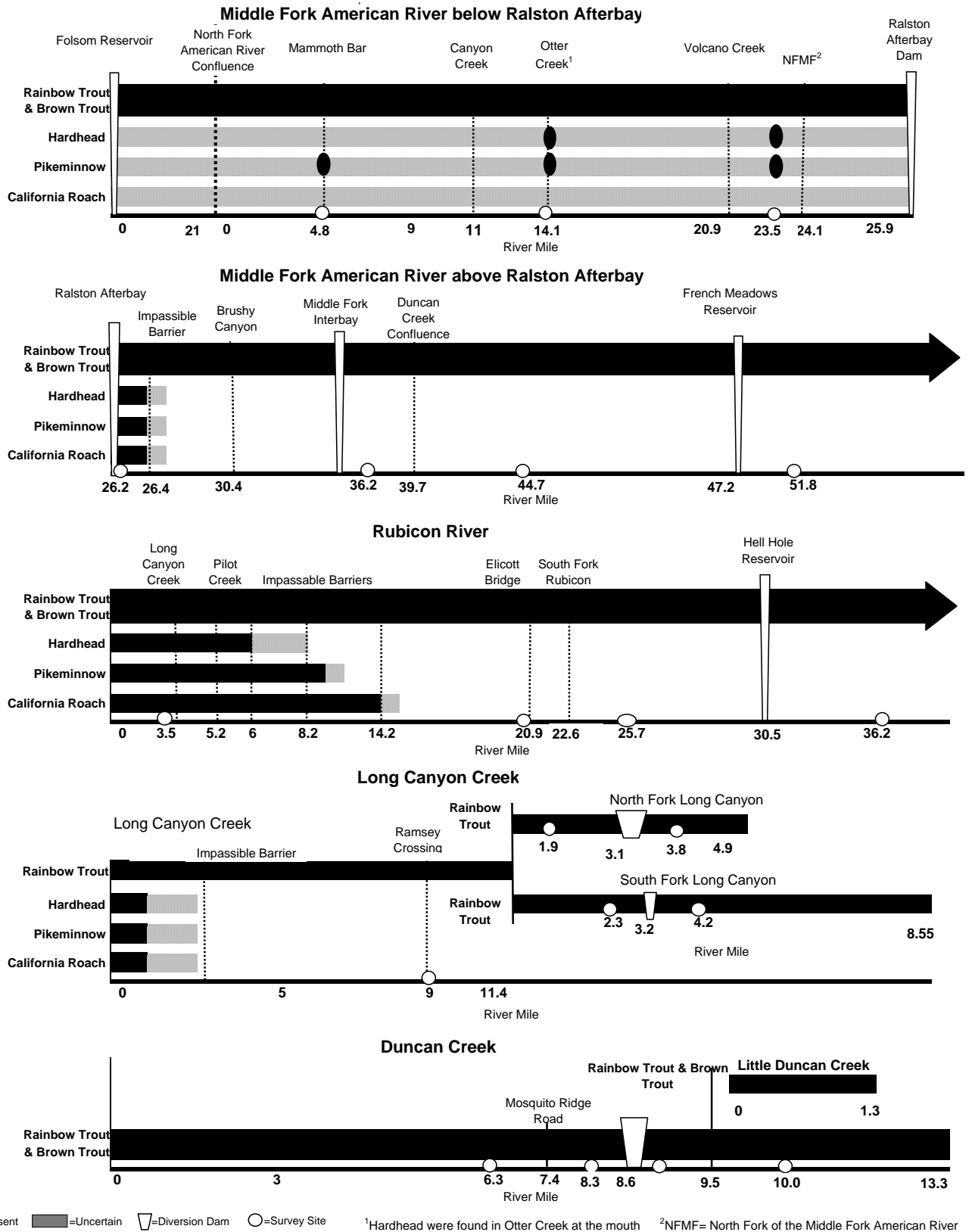
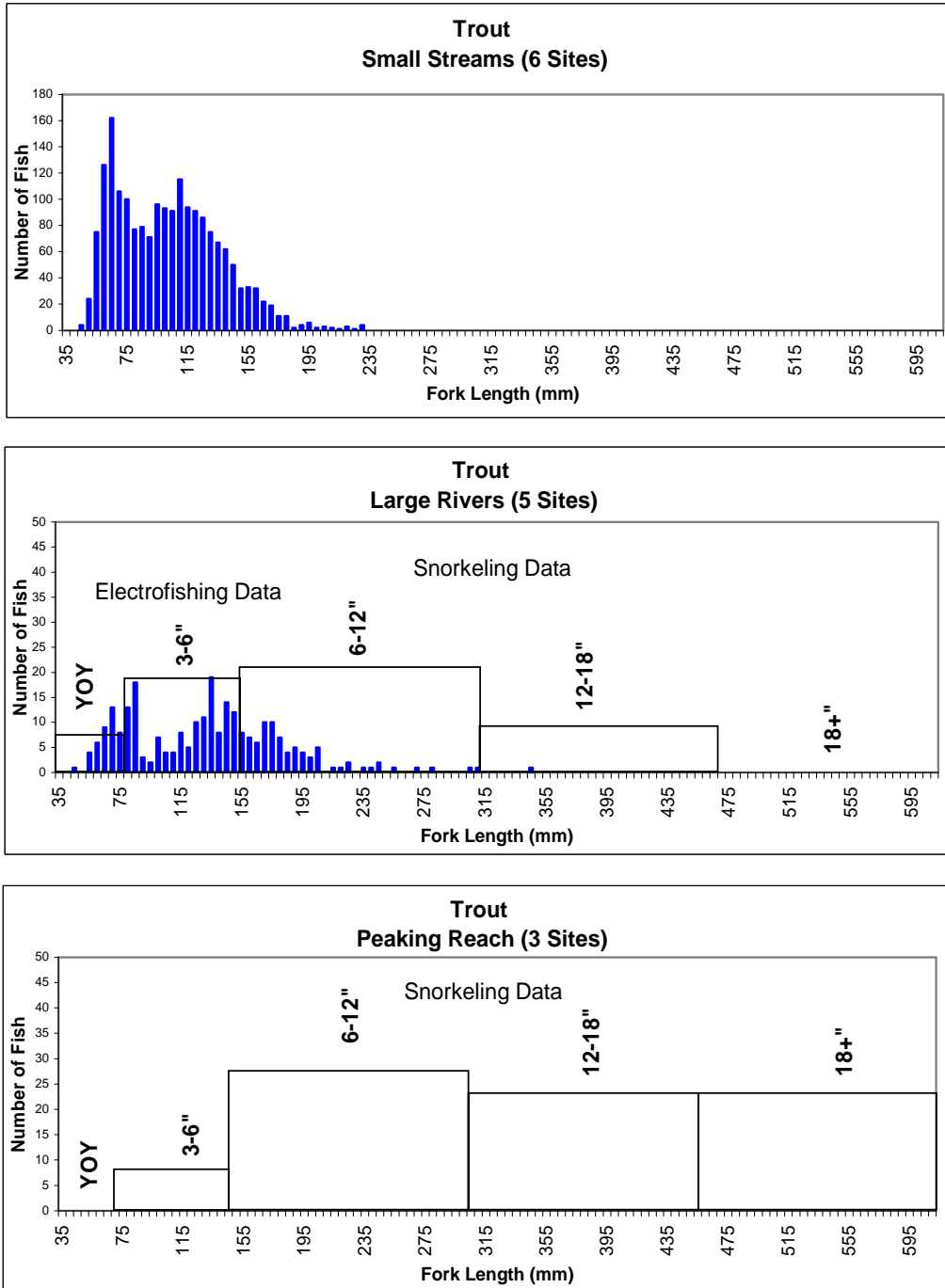


Figure 7.5-3. 2008 Length Frequency Histograms of Rainbow Trout and Brown Trout Captured During Electrofishing at Small Streams¹ (Top), Electrofishing and Snorkeling at Large River Sites² (Middle), and Snorkeling at Sites in the Peaking Reach³ (Bottom). (Electrofishing = Blue Bars, Snorkeling = White Bars)

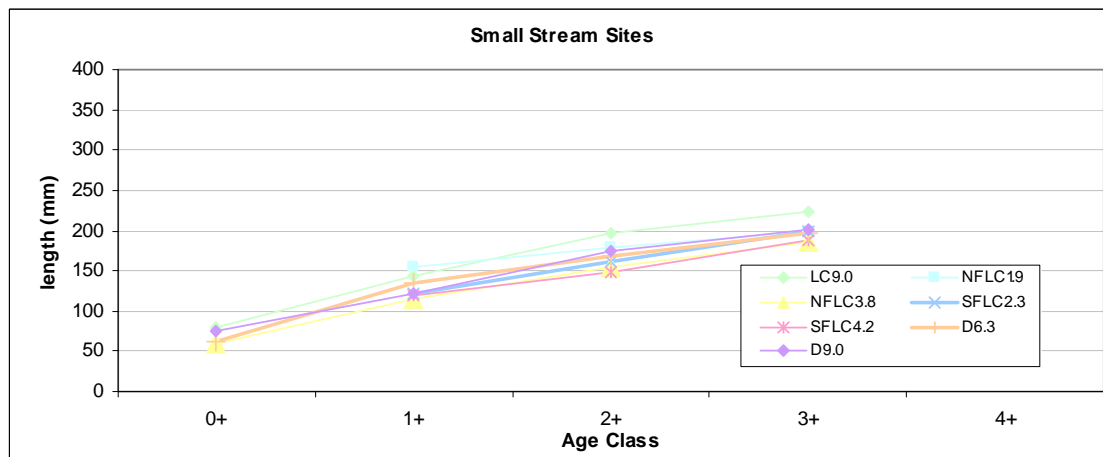
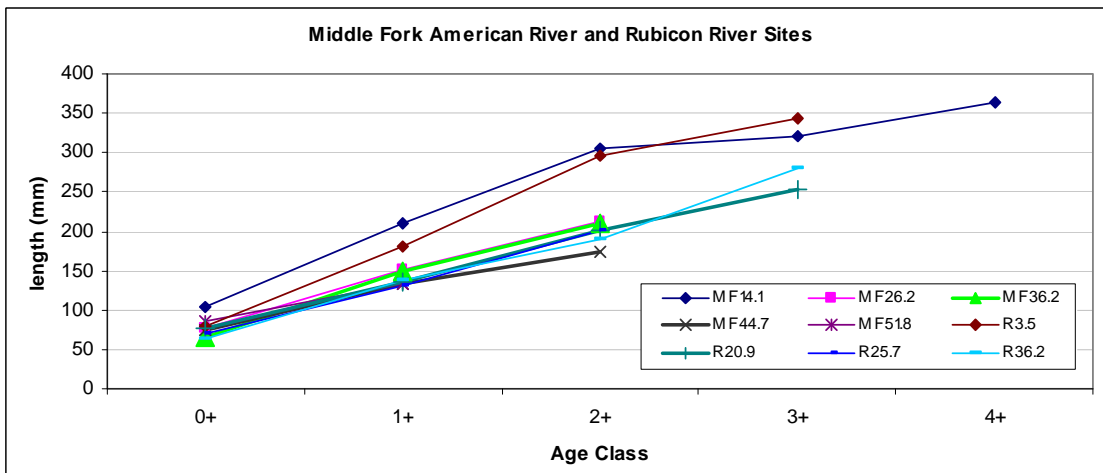
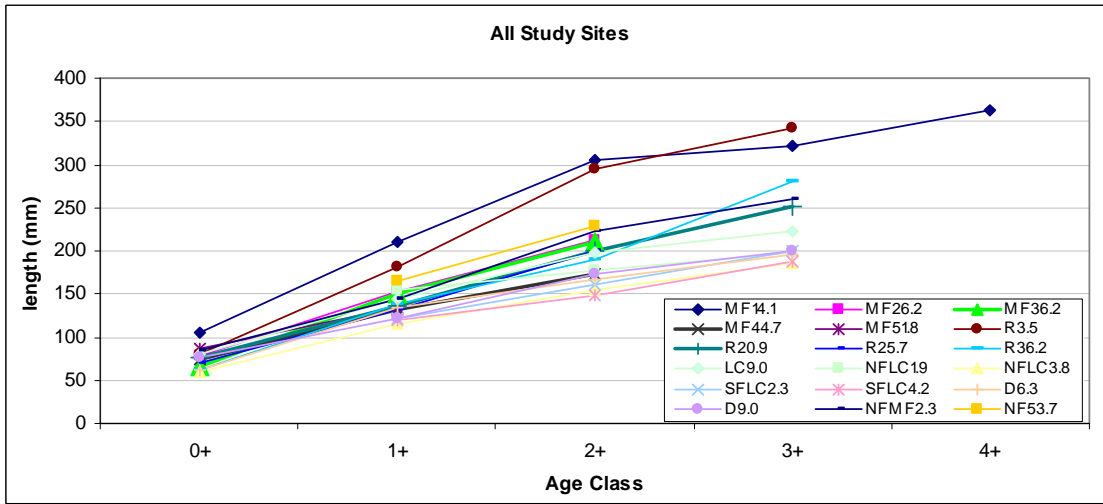


¹SFLC2.3, SFLC4.2, D6.3, D8.3, D9.0, D10.0

²MF26.2, MF44.7, R20.9, NFMF2.3, NF53.7

³MF4.8, MF14.1, MF23.5

Figure 7.5-4. 2007 Age and Growth Rates of Rainbow Trout at all Study Sites¹ (Top), Middle Fork American River and Rubicon River Sites (Middle), and Small Stream Sites (Bottom).



¹Age and growth rate data is unavailable for sites MF4.8, NF18.4, and NF31.3

Figure 7.5-5. The Cumulative Number of Years that Diverting was Occurring (1975-2007) at Duncan Creek (top), North Fork Long Canyon Creek (middle), and South Fork Long Canyon Creek (bottom).

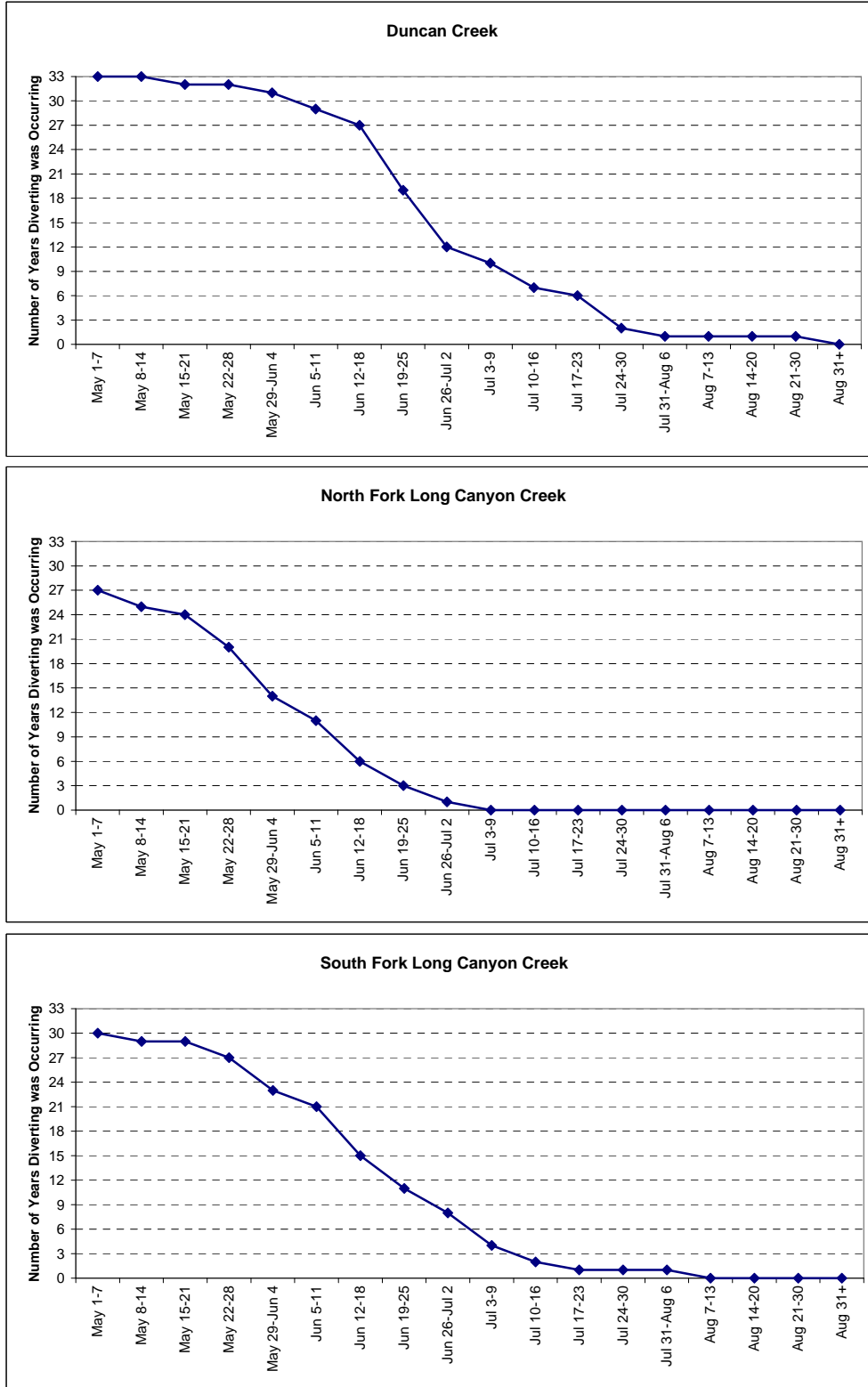
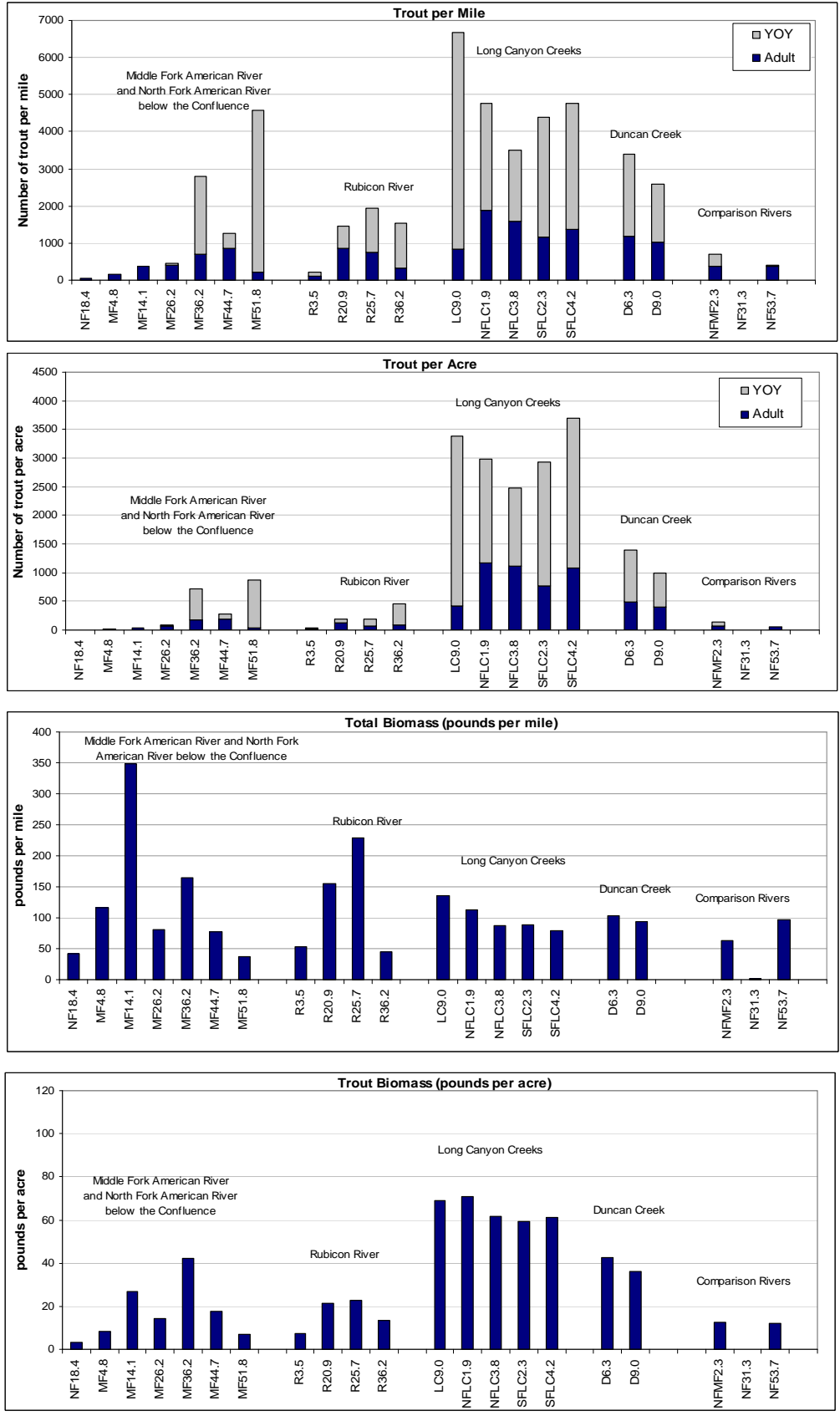
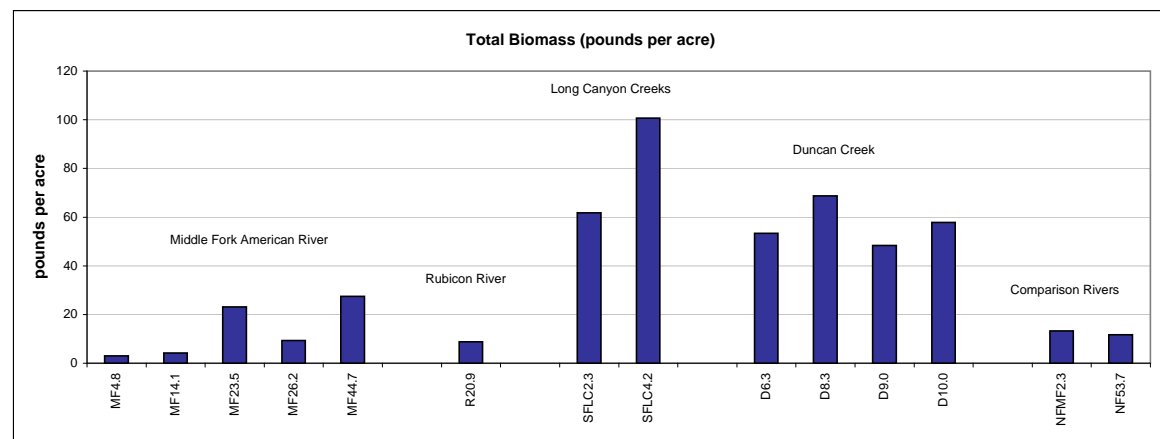
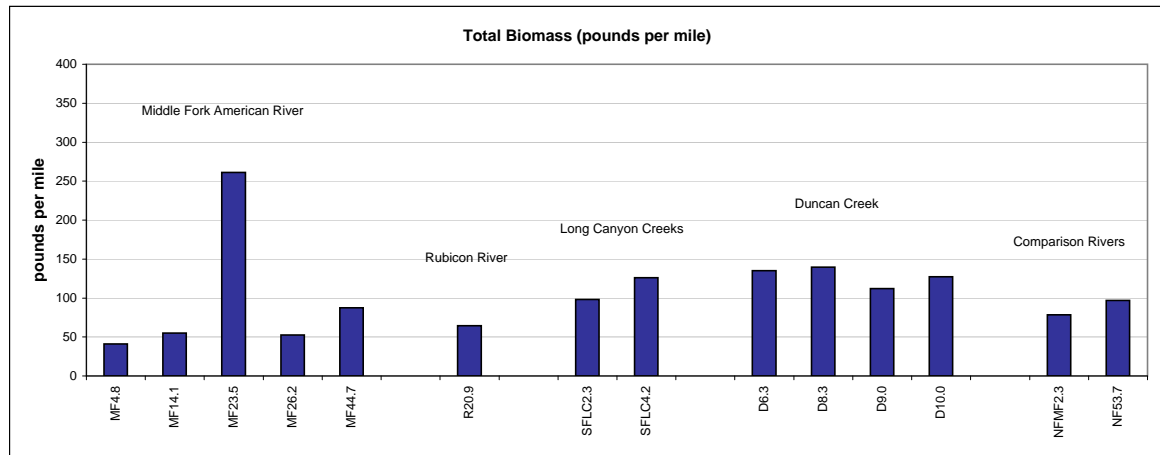
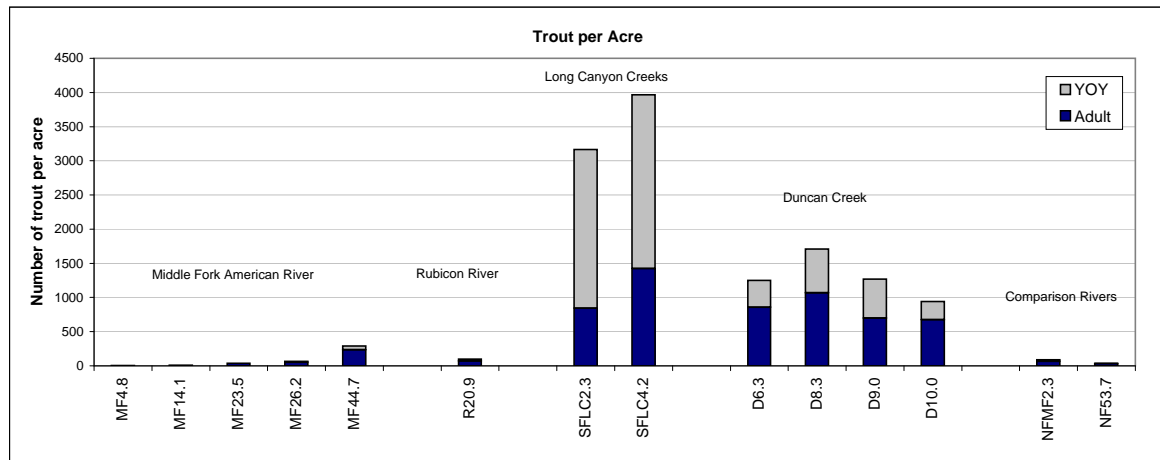
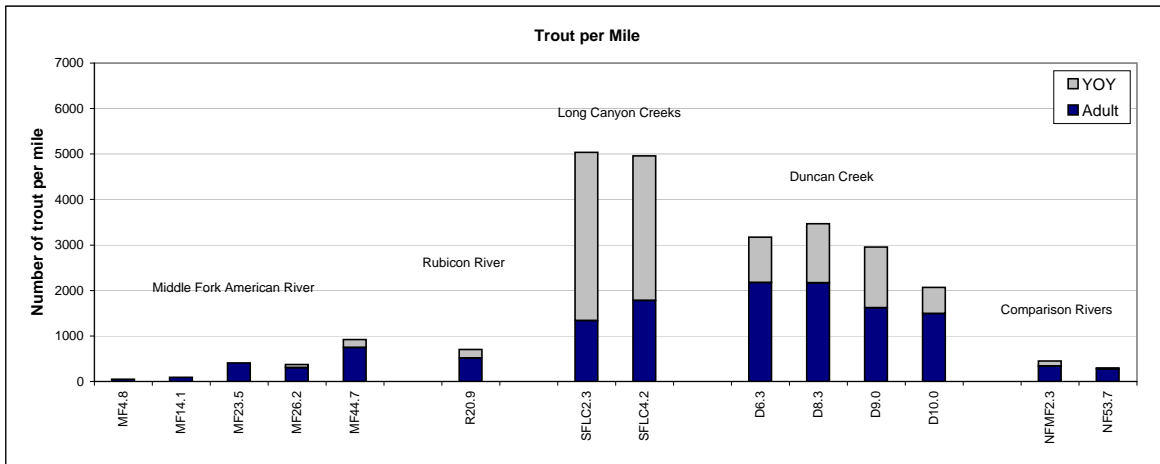


Figure 7.5-6a. The 2007 Density and Biomass of Trout in the Study Streams.



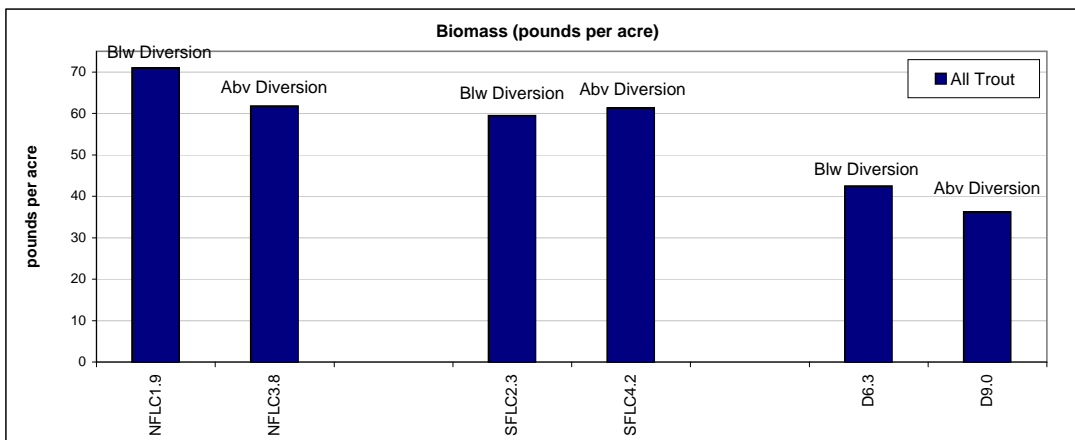
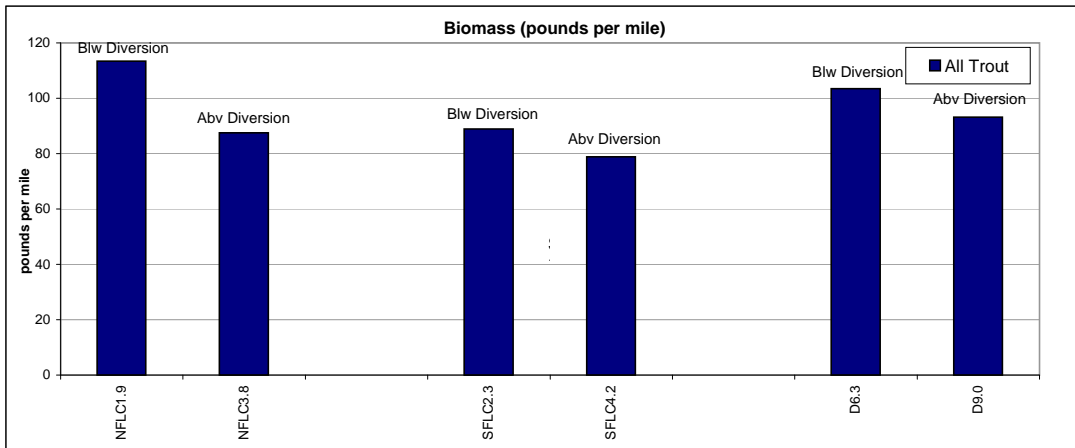
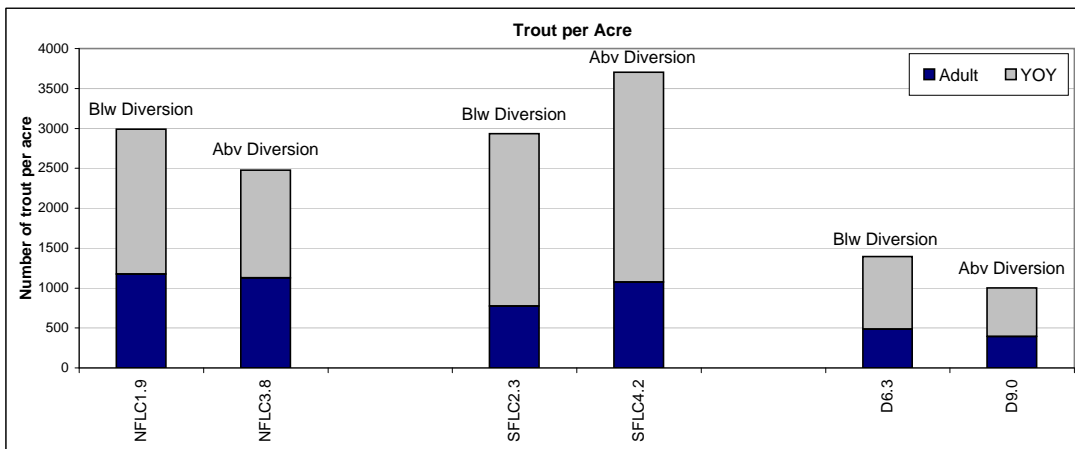
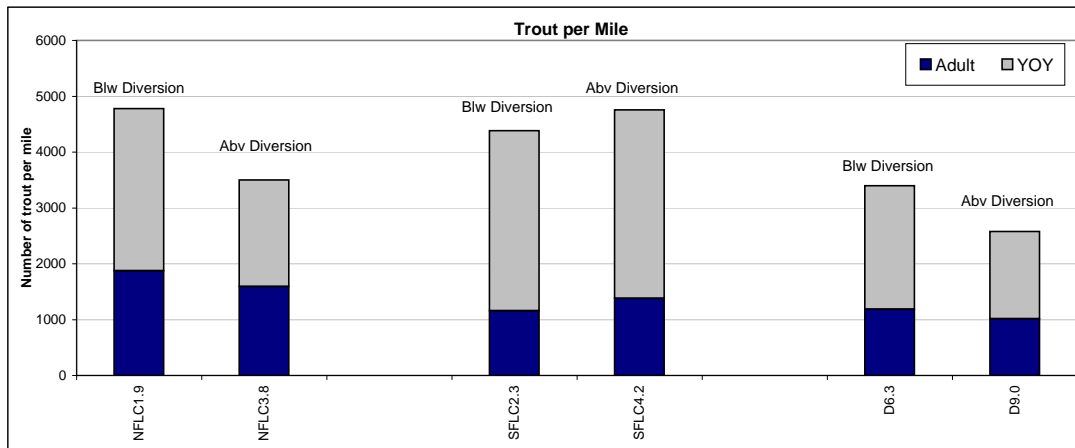
YOY: young-of-the-year

Figure 7.5-6b. The 2008 Density and Biomass of Trout in the Study Streams.



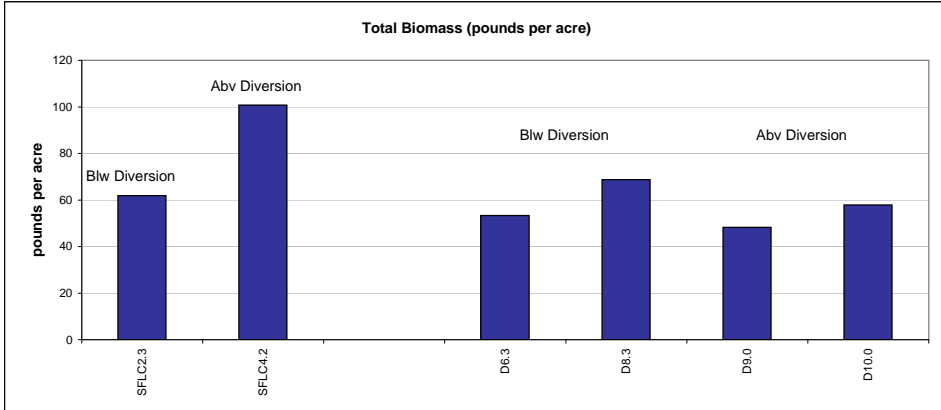
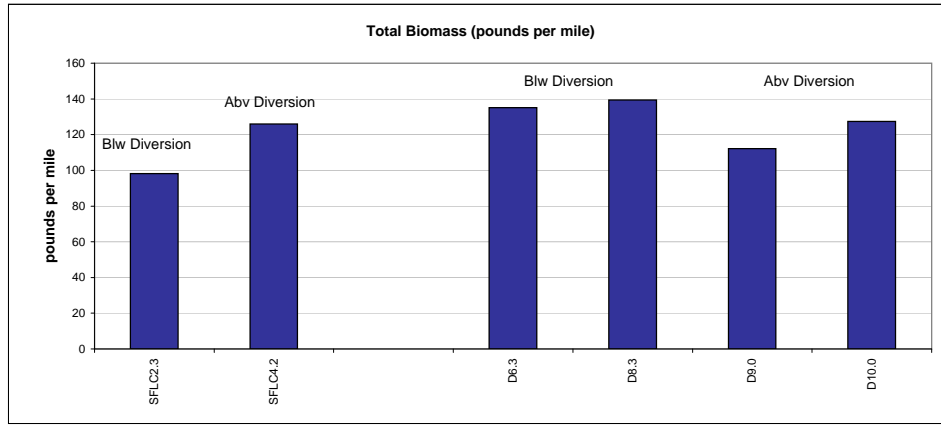
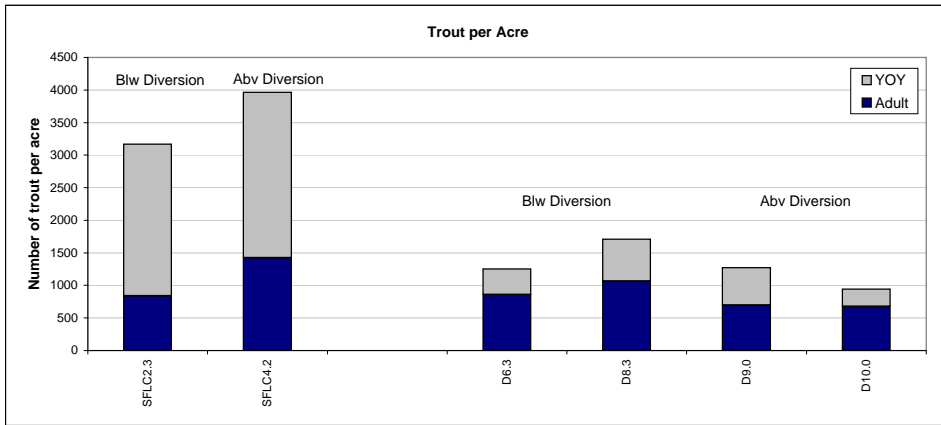
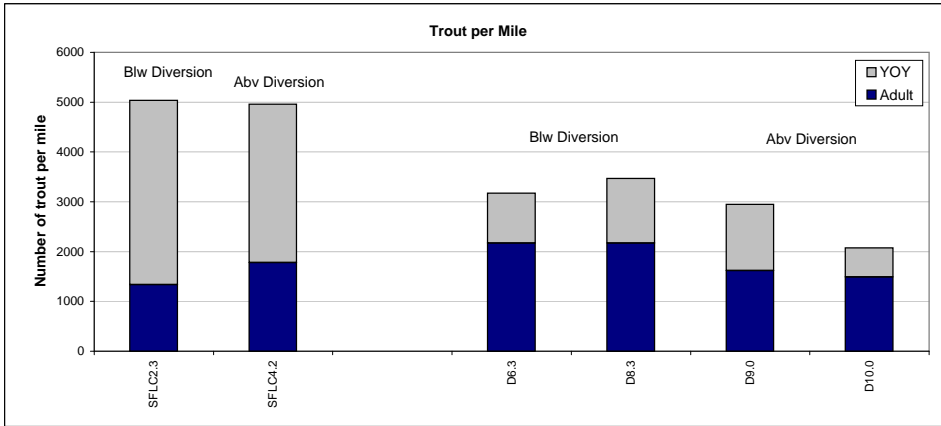
YOY: young-of-the-year

Figure 7.5-7a. The 2007 Density and Biomass of Trout Upstream and Downstream of Small Stream Diversions.



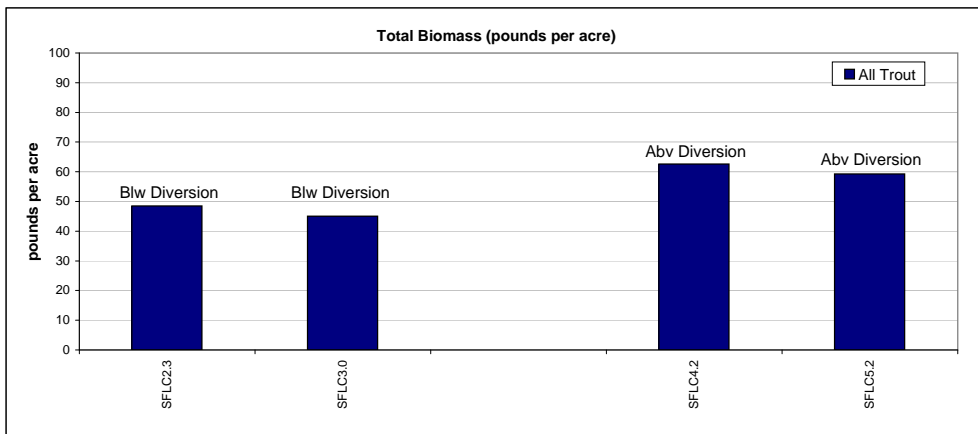
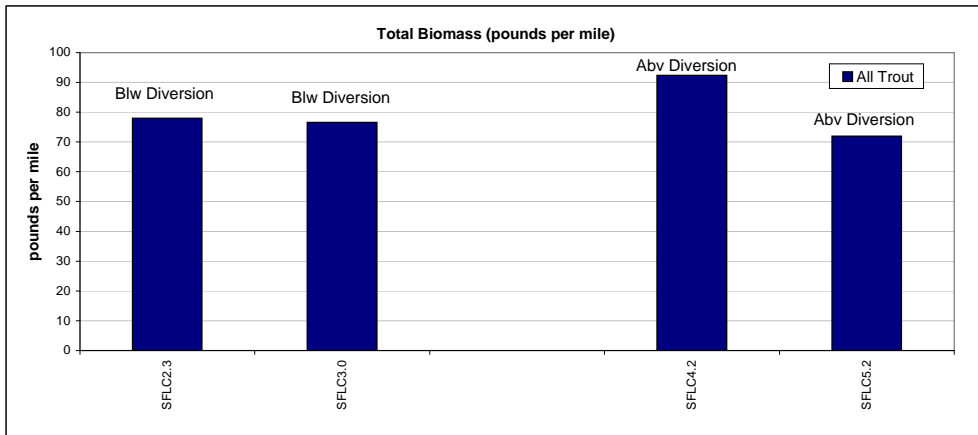
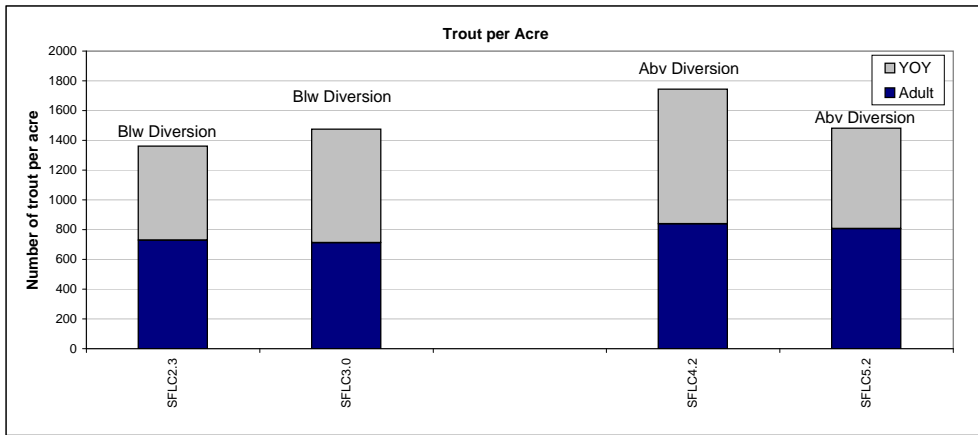
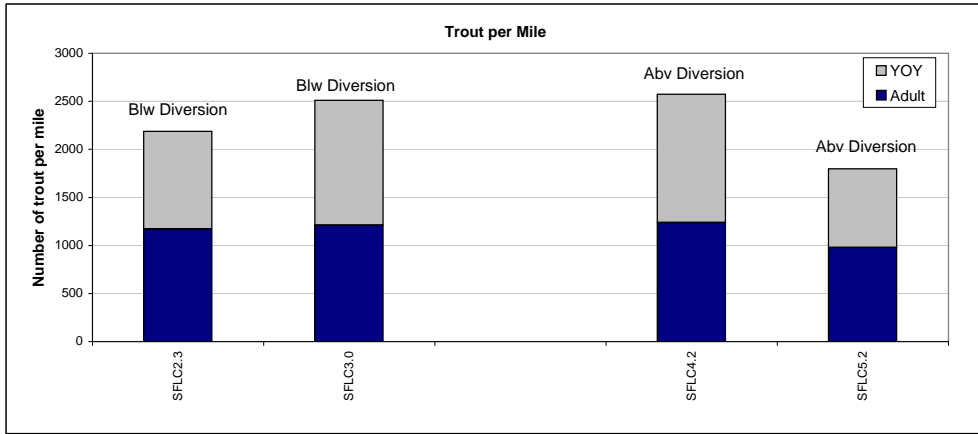
YOY: young-of-the-year

Figure 7.5-7b. The 2008 Density and Biomass of Trout Upstream and Downstream of Small Stream Diversions.



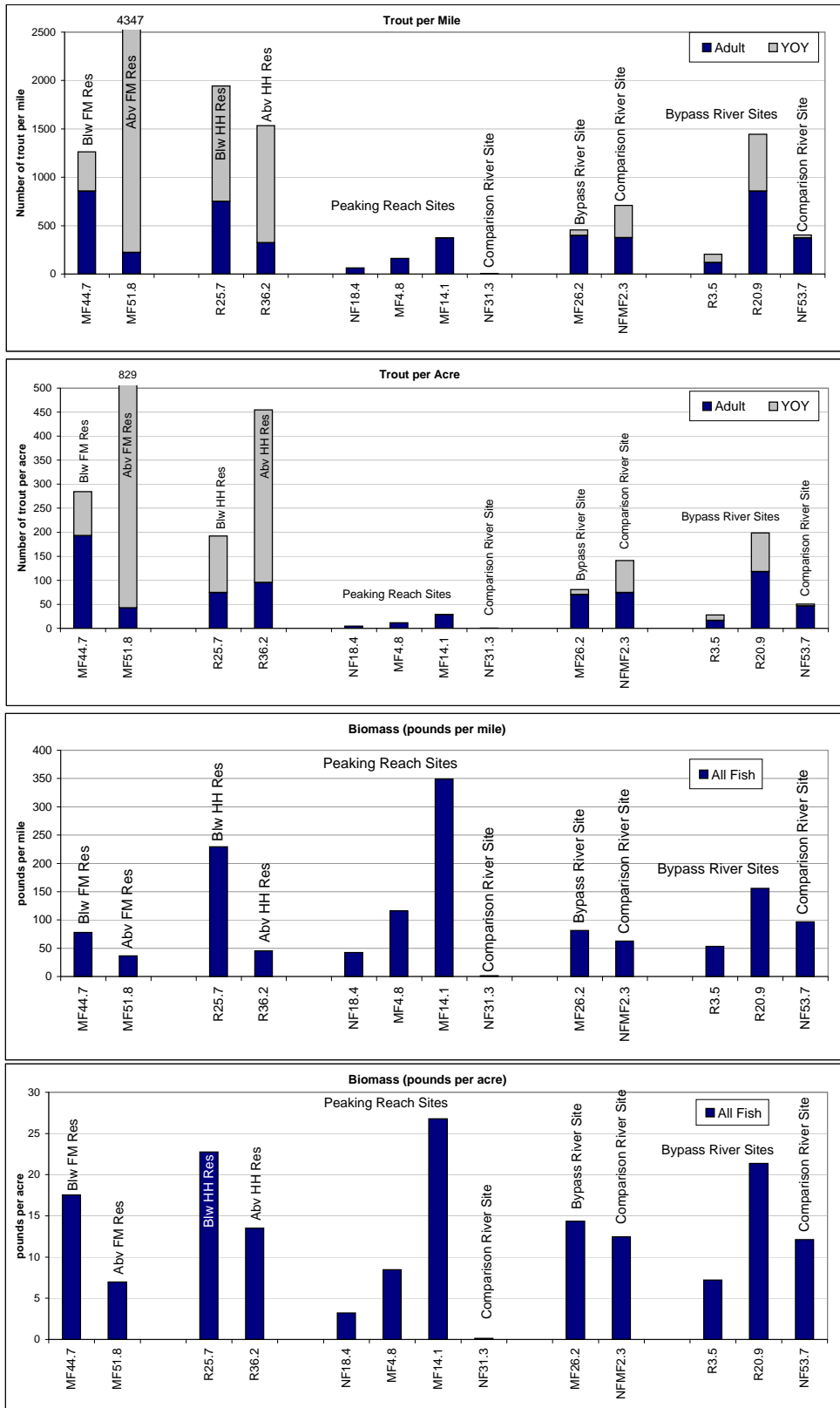
YOY: young-of-the-year

Figure 7.5-7c. The 2009 Density and Biomass of Trout Upstream and Downstream of Small Stream Diversions.



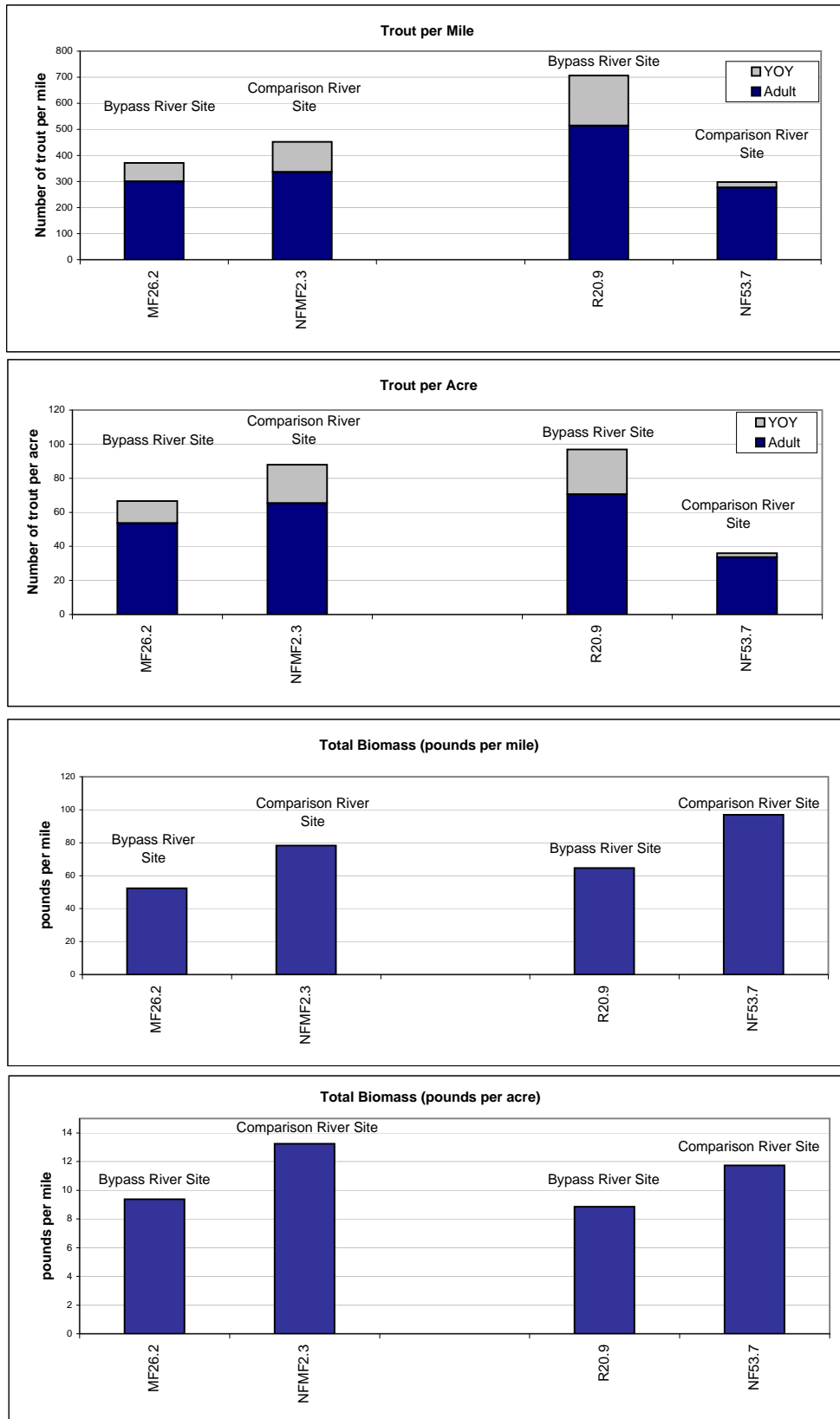
YOY: young-of-the-year

Figure 7.5-8a. 2007 Comparison of Trout Density and Biomass Between Study Sites and Potential Comparison Sites.



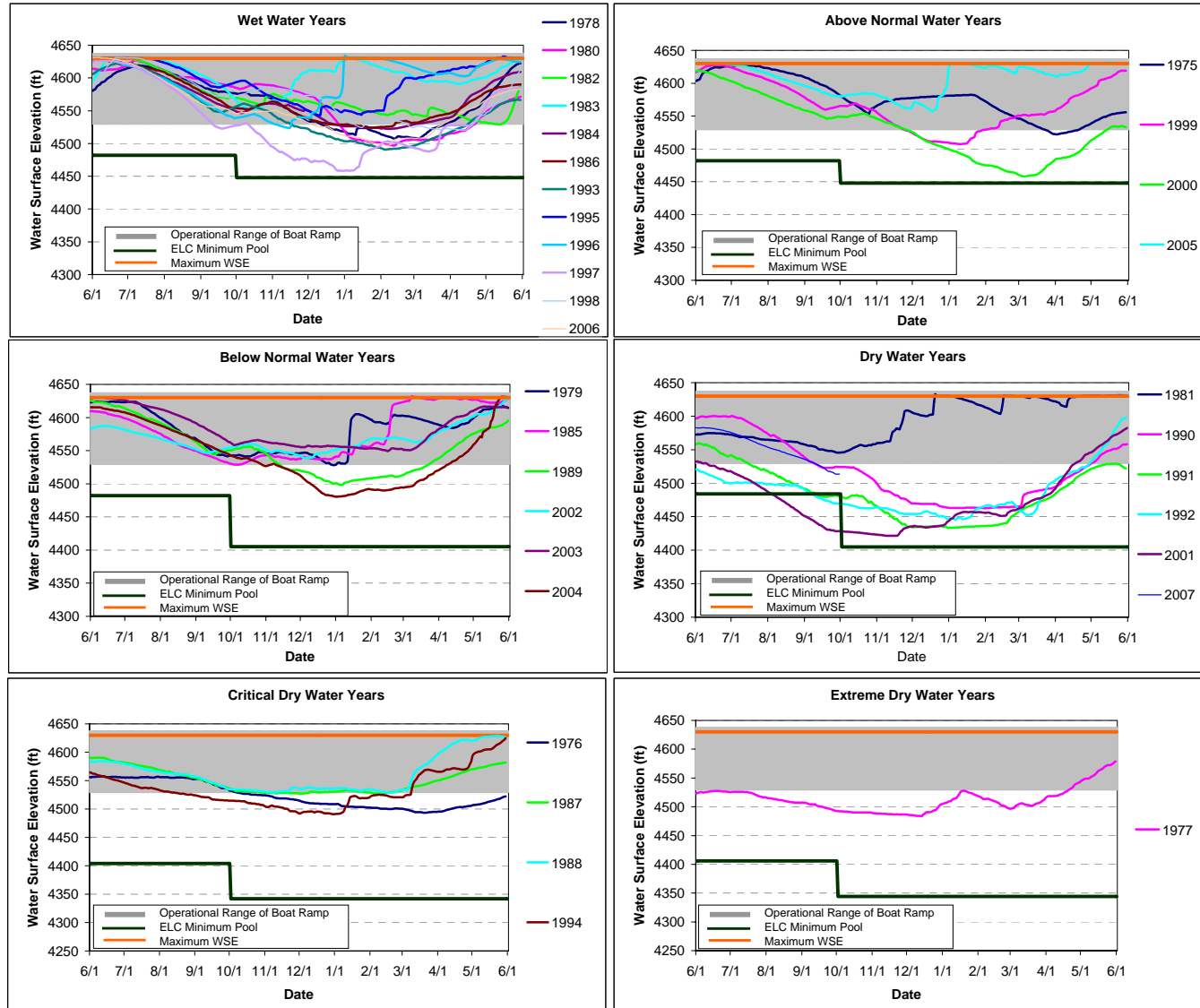
YOY: young-of-the-year

Figure 7.5-8b. 2008 Comparison of Trout Density and Biomass Between Study Sites and Potential Comparison Sites.



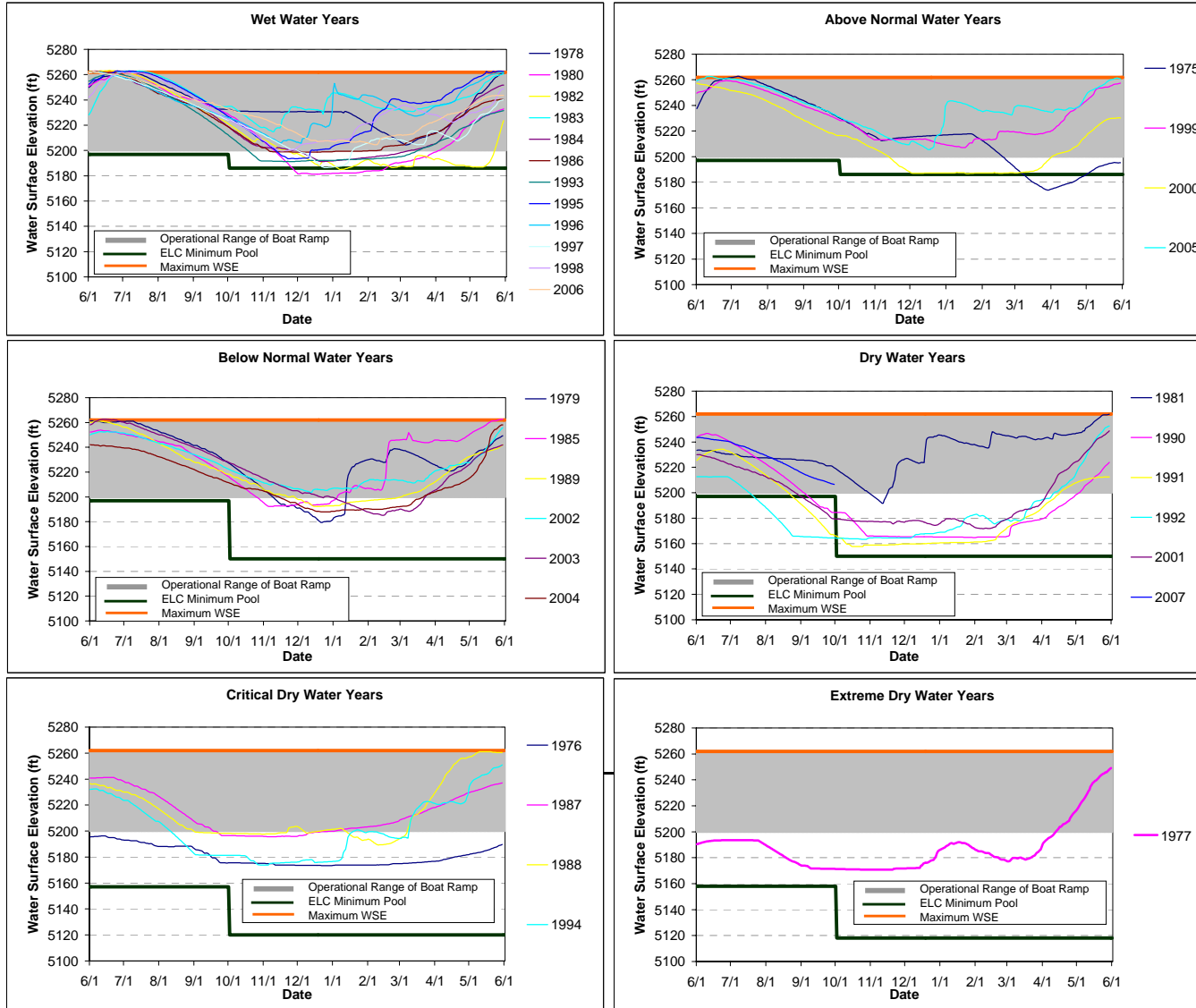
YOY: young-of-the-year

Figure 7.5-9a. Hell Hole Reservoir Water Surface Elevation in Relation to the Hell Hole Boat Ramp Operational Range and Minimum Pool Elevations by the Forecasted Water Year Type.



¹Plots are based on the Proposed Action water year type system (six water year types). The Existing FERC License three water year type system does not completely match. As a result, for example, some the Proposed Action dry water year types are plotted in the existing FERC License normal water year type classification.

Figure 7.5-9b. French Meadows Reservoir Water Surface Elevation in Relation to the French Meadows Boat Ramp Operational Range and Minimum Pool Elevations by the Forecasted Water Year Type.



*Plots are based on the Proposed Action water year type system (six water year types). The Existing FERC License three water year type system does not completely match. As a result, for example, some the Proposed Action dry water year types are plotted in the existing FERC License normal water year type classification.

Figure 7.5-10a. French Meadows Reservoir Water Temperature and Dissolved Oxygen Profiles at Site FM1 for all Years (2005–2008) and Sampling Months (June–October).

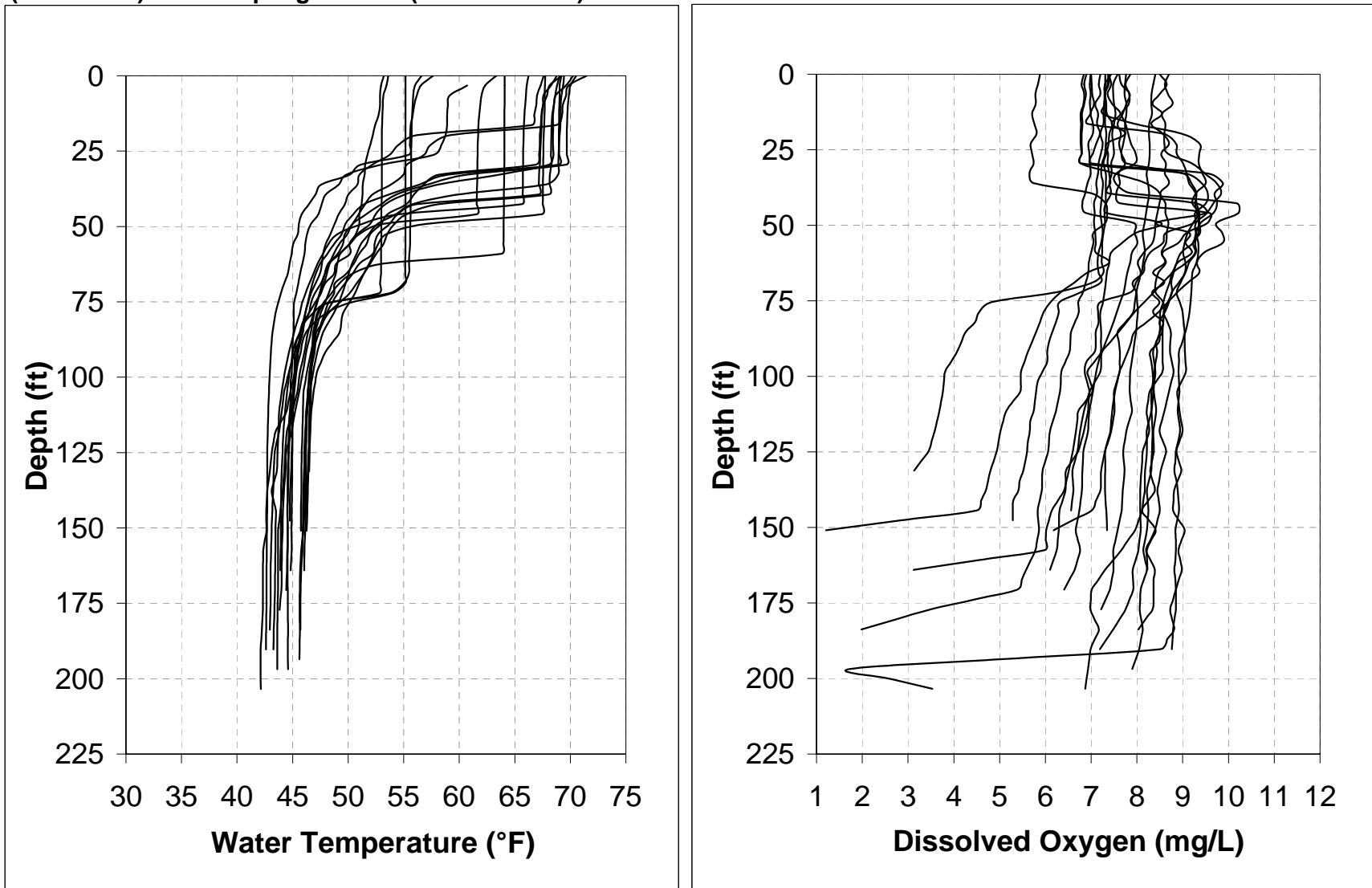


Figure 7.5-10b. Hell Hole Reservoir Water Temperature and Dissolved Oxygen Profiles at Site HH1 for all Years (2005–2008) and Sampling Months (June–October).

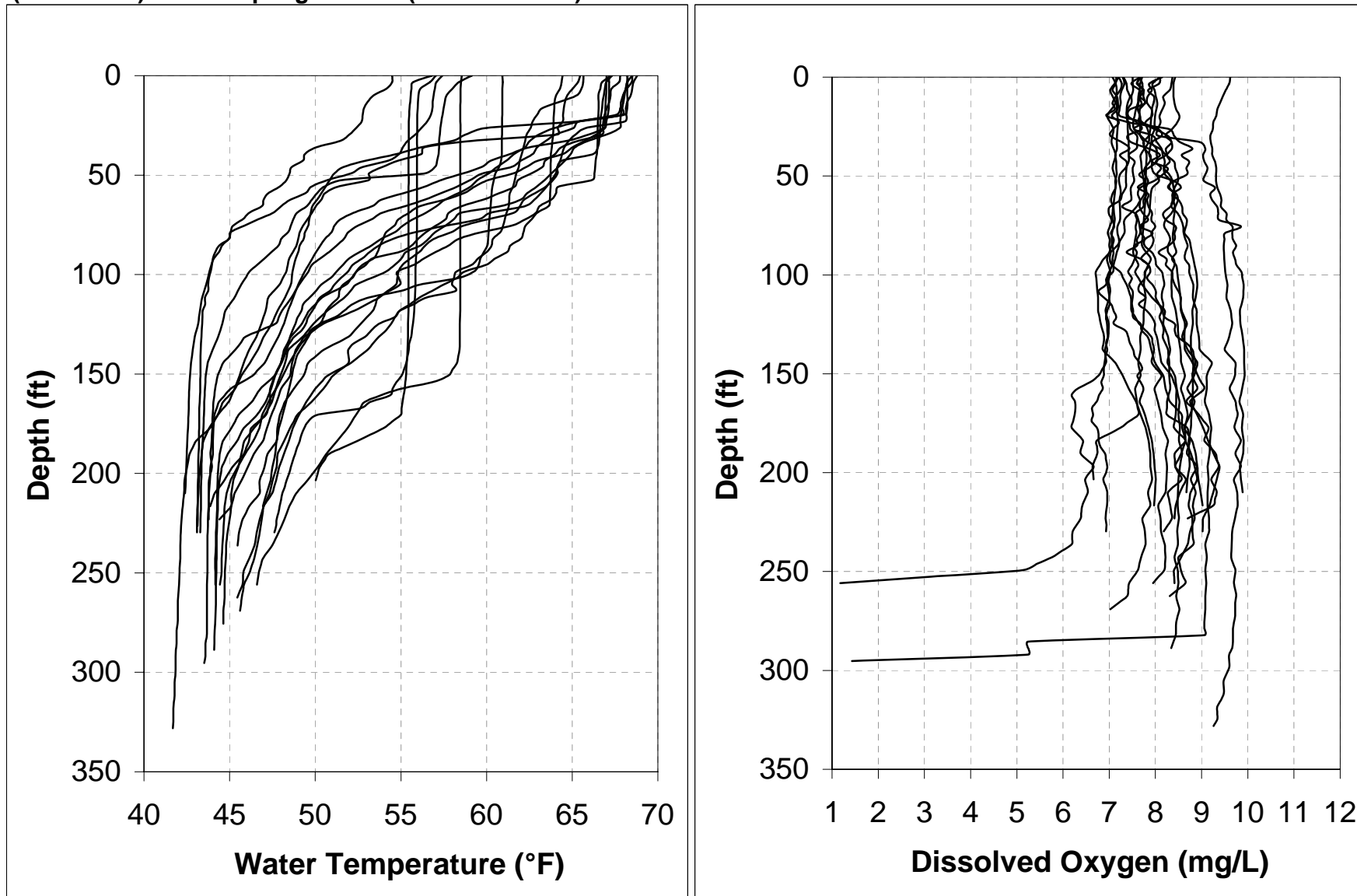


Figure 7.5-10c. Ralston Afterbay Water Temperature and Dissolved Oxygen Profiles at Site RA1 for all Years (2005–2008) and Sampling Months (June–October).

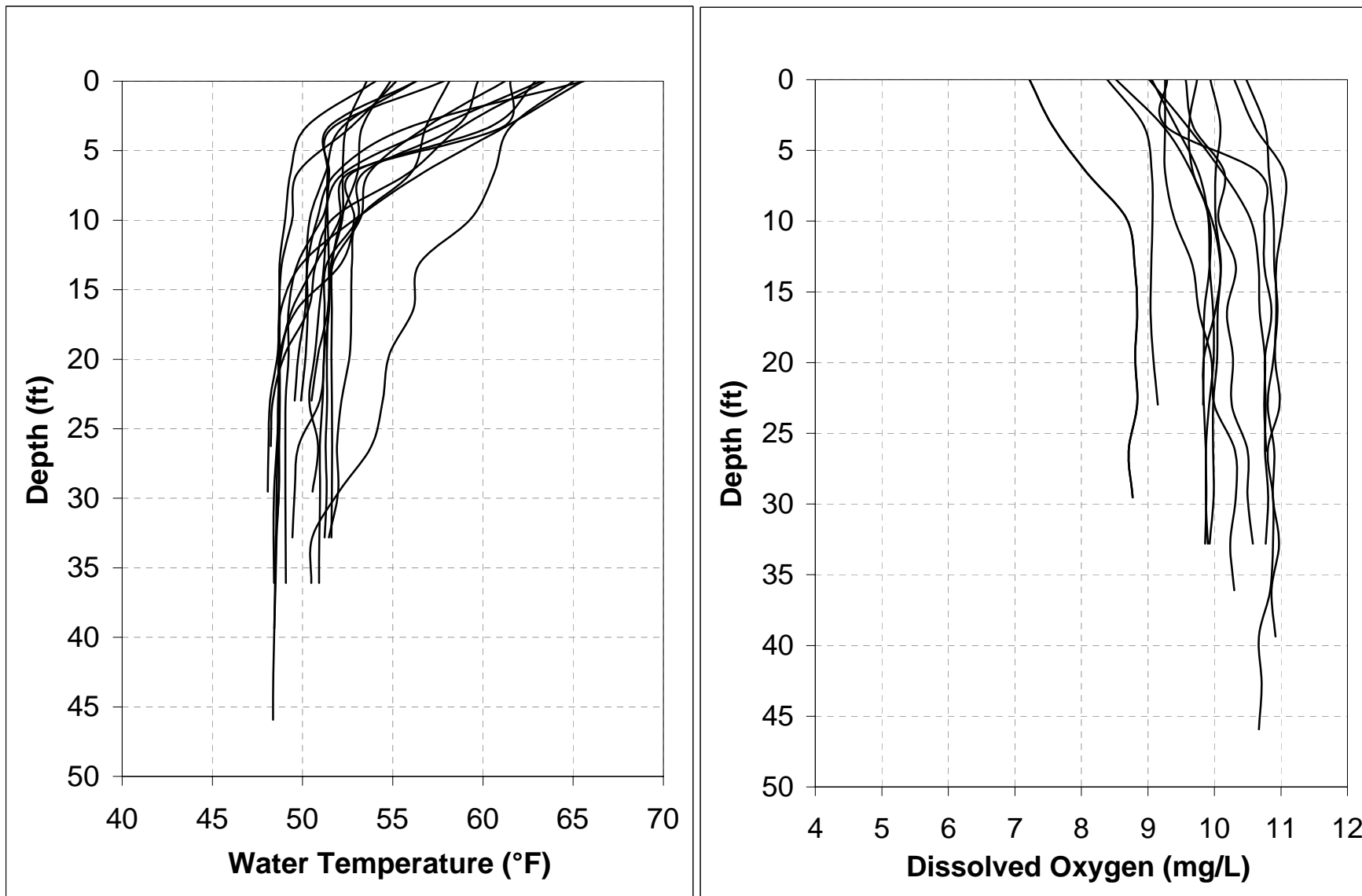
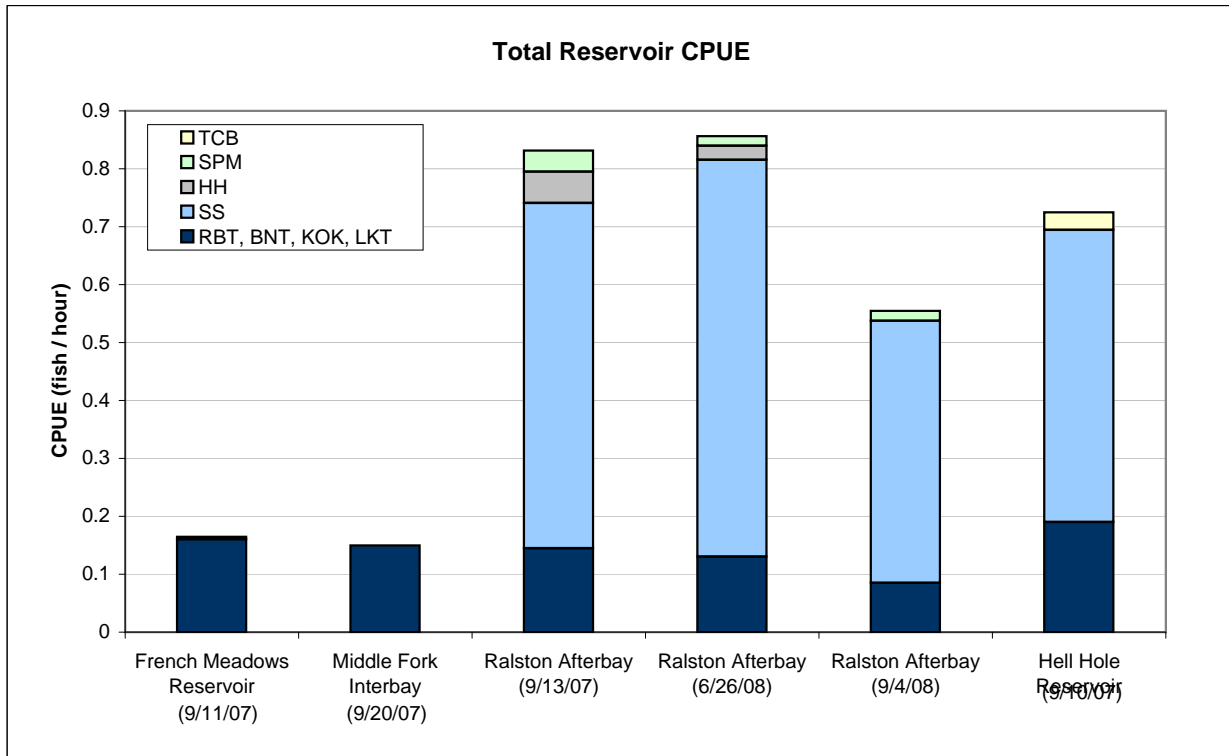


Figure 7.5-11. Gill Netting Catch per Unit Effort (CPUE) (Fish¹ per Hour) in Hell Hole Reservoir, French Meadows Reservoir, Middle Fork Interbay, and Ralston Afterbay.²



¹TCB = Tui Chub; SPM = Sacramento Pikeminnow; HH = Hardhead; SS = Sacramento Sucker, RBT = Rainbow Trout; BNT = Brown Trout; KOK = Kokanee Salmon; LKT = Lake Trout

²Study locations were altered on 9/4/08 for methylmercury fish tissue sampling efforts. Nets were not deployed at the bottom of the water column, fewer suckers were collected.

MAPS