Yuba Salmon Forum

Summary Habitat Analysis



Prepared for:

Yuba Salmon Forum Technical Working Group

Prepared by:

Craig Addley, PhD (Cardno ENTRIX), Katie Ross-Smith, PhD (Cardno ENTRIX), and Peter Graf (Cardno ENTRIX)

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1.0 INTRODUCTION

This report provides a summary assessment of potential anadromous spring-run Chinook salmon and steelhead habitat in the Yuba River watershed. The summary assessment was designed to provide the Yuba Salmon Forum (YSF) with habitat information that can be used to review potential options that warrant further investigation regarding introduction of Central Valley spring-run Chinook salmon and Central Valley steelhead into the North, Middle, and/or South Yuba rivers and/or portions of the Yuba River. The summary assessment includes a synthesis of data from various sources, including hydrology, water temperature, upstream migration barriers, and a quantification of migration, holding, spawning, incubation, rearing, and smolt emigration habitat.

The habitat assessment is primarily based on a four-year period (2008 – 2011) when empirical water temperature data (and hydrology) were available for the North, Middle, and South Yuba rivers and the Yuba River. The water year types ranged from dry to wet. For two years (2008 – 2009) of the four-year period, potential modified hydrology (modified instream flow requirements) and water temperature modeling data for the modified hydrology were available for the Middle and South Yuba rivers (PG&E and NID 2012). New Federal Energy Regulatory Commission (FERC) license conditions for these two rivers will likely result in modified (increased) flow requirements. Currently, temperature and modified hydrology modeling is being conducted in the lower watershed (Yuba River and North Yuba below New Bullards Bar Reservoir) as part of FERC relicensing. This modeling is not complete and is not included in this report.

The YSF is a collaborative effort of a diverse group of stakeholders that represent water and power purveyors, resource agencies and regulators, and non-governmental organizations (NGO)[1]. The purpose of the YSF is to identify, evaluate, recommend, and seek to achieve implementation of effective near-term and long-term actions to achieve viable anadromous salmonid populations in the Yuba River watershed that contribute to recovery goals, while also considering other beneficial uses of water resources and habitat values in neighboring watersheds, as part of Central Valley anadromous salmonid recovery actions.

2.0 STUDY AREA

The study area for the potential habitat summary analysis includes the following river reaches in the Yuba River watershed:

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[1] YSF stakeholders include: Yuba County Water Agency (YCWA); United States Department of Agriculture, Forest Service (USDA-FS); United States Department of Interior, Fish and Wildlife Service (USFWS); United States Department of Commerce, National Marine Fisheries Service (NMFS); United States Army Corps of Engineers (USACE); California Department of Fish and Wildlife (CDFW; formerly California Department of Fish and Game [CDFG]); California State Water Resources Control Board (SWRCB); Placer County Water Agency (PCWA); Pacific Gas & Electric Company (PG&E); and numerous NGOs.

- **North Yuba River**
    - Above New Bullards Bar Dam: Loves Falls to New Bullards Bar Reservoir High Water (RM 51.1 to 17.4)
    - Below New Bullards Bar Dam: New Bullards Bar Dam to the Confluence with the Middle Yuba River (RM 2.3 to 0.0)
- **Yuba River**
    - Above New Colgate Powerhouse: Confluence of North and Middle Yuba rivers to New Colgate Powerhouse (RM 39.7 to 33.9)
    - Below New Colgate Powerhouse: New Colgate Powerhouse to Englebright Lake High Water (RM 33.9 to 32.2)
    - Lower Yuba River: Englebright Dam to Feather River Confluence (RM 24.0 to 0.0)
- **Middle Yuba River**
    - Below the Total Upstream Fish Passage Barrier: Passage Barrier to Our House Dam (RM 35.1 to 12.5)
    - Below Our House Dam: Our House Dam to North and Middle Yuba River Confluence (RM 12.5 to 0.0)
- **South Yuba River**
    - Below the Total Upstream Fish Passage Barrier Water Fall: Passage Barrier to Englebright Lake Normal High Water Elevation (RM 34.9 to -0.4)
    - Below Englebright Reservoir: Englebright Reservoir Normal High Water Elevation to Confluence with the Yuba River (RM -0.4 to -0.1)

The study reaches, total length (miles) of each reach, upstream barrier locations, and the source of the river mile system are provided in Table 1 and Map 1. Two different river mile systems were generated for the Yuba River watershed as part of recent FERC hydroelectric relicensing proceedings. For this report, the river mile system from the Yuba-Bear Drum-Spaulding (YBDS) projects[2] was used for the South and Middle Yuba rivers. The river mile system used for the North Yuba River and the Yuba River was developed for the Yuba River Development Project (YRDP)[3].

3.0 OBJECTIVE

The objective of the spring-run Chinook salmon and steelhead potential habitat summary assessment is to evaluate life stage-specific habitat in the North, Middle, and

[2] Nevada Irrigation District's (NID) Yuba-Bear Hydroelectric Project (FERC Project No. 2266) and Pacific Gas and Electric Company's (PG&E) Drum-Spaulding Project (FERC Project No. 2310)

[3] Yuba County Water Agency's (YCWA) Yuba River Development Project (FERC Project No. 2246)

South Yuba rivers and the Yuba River under existing conditions and in the South and Middle Yuba rivers under different flow scenarios.

The spring-run Chinook salmon life stage-specific habitat objectives are as follows:

- **Upstream Fish Passage Barriers** – Identify the upstream migration barriers and determine the length of barrier-free channel within each river reach.
- **Water Temperature** – Quantify the length of river with suitable temperature for migration (trap/haul and volitional passage), holding, spawning, embryo incubation, juvenile rearing and downstream movement, and smolt emigration.
- **Holding** – Quantify the length of thermally suitable summer pool holding habitat and the number of holding pools.
- **Spawning** – Quantify the length of thermally suitable spawning habitat, amount of spawning gravel, and number of potential spawning redds.
- **Embryo Incubation** – Determine if thermally suitable embryo incubation habitat is a potential limiting factor.
- **Juvenile Rearing and Downstream Movement** – Quantify the length and area of thermally suitable juvenile rearing habitat.
- **Smolt Emigration** – Determine if thermally suitable smolt emigration habitat is a potential limiting factor.

Steelhead life stage-specific habitat objectives are fewer in number compared to those for spring-run Chinook salmon. Steelhead migration, holding, spawning and incubation all primarily occur during periods of cool/cold air and water temperatures and higher flows. As a result, fewer steelhead life stages are potentially limited by water temperature-related habitat in the Yuba River watershed, at least in relation to the primary limiting habitat factors, which are spawning habitat access and summer rearing habitat. The steelhead habitat objectives are as follows:

- **Upstream Fish Passage Barriers** – Identify the upstream migration barriers and determine the length of barrier-free channel within each river reach (main stem and tributary).
- **Juvenile Rearing and Downstream Movement** – Quantify the length and area of thermally suitable juvenile rearing habitat.

4.0 DATA SOURCES AND SIMPLIFYING ASSUMPTIONS

Numerous data sources were utilized to develop the life stage-specific physical habitat information for the different reaches, including the following:

- Yuba Salmon Forum studies
    - Fish Passage Study (HDR 2012)

  - Spawning Gravel Study (HDR 2011)
  - Rearing Habitat Study (Addley and Graf 2012a)
  - Holding Habitat Study (Addley and Graf 2012b)
  - Water Temperature Considerations for Yuba River Basin Anadromous Salmonid Reintroduction Evaluations (Bratovich et al. 2011)
- Upper Yuba River studies (CDWR 2007)
- FERC relicensing studies in the Yuba River watershed (recent and ongoing)
  - NID's Yuba-Bear Hydroelectric Project (PG&E and NID 2011; 2012)
  - PG&E's Drum-Spaulding Project (PG&E and NID 2011; 2012)
  - YCWA's Yuba River Development Project (YCWA 2011; 2013)
- Published studies and other data
  - Butte Creek Chinook Salmon Data (Ward et al. 2006)
  - Empirical water temperature data (e.g., South Yuba River Citizens League [SYRCL] and National Marine Fisheries Service [NMFS]).
  - Placer County Water Agency's (PCWA) Middle Fork American River Project (MFP) (FERC Project No. 2079)
  - Supplemental tributary barrier locations (unpublished; conducted by PCWA)
- River mile system data
  - Yuba-Bear Drum-Spaulding projects (provided by HDR|DTA)
  - Yuba River Development Project (provided by HDR|DTA)

The life stage/physical habitat data used from each data source are summarized by river reach in Table 2.

The YSF study methodologies were generally consistent with those used previously in the Upper Yuba River studies (CDWR 2007). This was done purposefully to enable comparison of habitat between river reaches and among studies in the Yuba River watershed. Nevertheless, it was necessary to use data from different data sources with slightly different methodologies (e.g., collected by different people with different approaches) or varying degrees of resolution. It was also necessary to simplify the potential habitat assessment to essential habitat elements or indexes of habitat in order to use the available habitat data effectively. The description of habitat assessment methods used for each life stage are provided below.

5.0 METHODS

5.1 HYDROLOGY

Existing hydrology data (2008 – 2011; dry to wet conditions) were used in the habitat assessment for all river reaches. In the Middle and South Yuba river reaches, modeled potential future and unimpaired hydrology were also included in the habitat assessment. These modeled data are presently only available for 2008 and 2009 (dry years). The modeled 2008 – 2009 dry year data provide a conservative estimate of the amount of habitat that would be available under the potential future and unimpaired hydrology (more habitat would be expected during wetter years).

The water year types for the 2008 – 2011 hydrology were determined using an exceedance analysis of the Yuba River near Smartville Gage (natural flow) (Department of Water Resources CDEC Station YRS) (1901 – 2011). In addition, 2008 – 2011 existing and/or potential future summer flows (July and August) in the North, Middle, and South Yuba rivers were compared to unimpaired hydrology (1976 – 2008) in these rivers using exceedance plots.

5.1.1 Existing 2008 – 2011 Hydrology

In all of the river reaches except one, the existing 2008 – 2011 hydrology was regulated by impoundments or water diversions during some portion of the year[4]. In the North Yuba River above New Bullards Bar Reservoir the hydrology was generally unregulated and the existing hydrology also represents the unimpaired hydrology. All existing hydrology was obtained from United States Geological Survey (USGS) gages (Table 3).

5.1.2 Modeled Potential Future and Unimpaired Hydrology (2008 – 2009)

For the Middle and South Yuba rivers, in addition to existing hydrology, the analysis included modeled potential future hydrology, modeled Base Case, and synthesized unimpaired hydrology. The 2008 unimpaired hydrology was developed as part of the YBDS relicensing studies (1976 – 2008 Relicensing Hydrology DVD) and the 2009 – 2011 unimpaired hydrology was based on regression with North Yuba River data (see Addley and Graf 2012a, Appendix A). The modeled potential future hydrology and Base Case hydrology scenarios were developed using the YBDS Operations model[5]. The modeled flow scenarios are as follows:

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[4] Flows under current operations of NID's Yuba-Bear Hydroelectric Project (FERC Project No. 2266), PG&E's Drum-Spaulding Project (FERC Project No. 2310), and YCWA's YRDP (FERC Project No. 2246).

[5] The model was developed using the United States Army Corp of Engineers – Hydrologic Engineering Center (HEC) Reservoir Simulation (ResSim) Version 3.0 program as a tool to evaluate impacts to project-affected water resources from potential modifications in Project operations and facility modifications during the relicensing process for the two projects.

- **Preliminary 4(e) Condition Flows.** USDA-FS Preliminary Section 4(e) conditions that were submitted by NID and PG&E in their respective Final License Applications[6] for the relicensing of the YBDS hydroelectric projects. Most Relicensing Participants agreed to these flows during collaborative relicensing meetings.

- **CFDG/FWN.** In addition to the "Preliminary 4(e) Condition Flows," the CDFW (formerly CDFG) and the Foothills Water Network (FWN – coalition of NGOs) proposed reservation of 2,500 acre-feet (AF) of water in the Middle Yuba River and 2,500 AF of water in the South Yuba River and subsequent release during the summer (June 15 to September 15) to maintain average daily water temperatures at 19°Celcius (C) or less upstream of Wolf Creek on the Middle Yuba River and upstream of Canyon Creek on the South Yuba River. This is approximately an additional 20 cubic feet per second (cfs) per day if the water was spread over a 2-month period.

- **NMFS.** Flows submitted by NMFS in their July 31, 2012 Preliminary Section 10(j) measures[7]. NMFS proposed flows also included provisions to meet 19°C temperature requirements on the Middle Yuba River upstream of the Plumbago Road crossing and on the South Yuba River upstream of Poorman Creek; however, only the flows were implemented in the habitat analysis (the 19°C temperature trigger was not included).

- **Base Case.** No-Action Alternative filed by NID and PG&E in their FERC license applications for the YBDS projects. The scenario includes the existing FERC license minimum instream flows and reservoir elevations. The Base Case includes a number of assumptions (e.g., water deliveries to NID and PCWA based on 2001 – 2009 averages; retirement of Alta Powerhouse Unit 2; re-operation of Dutch Flat No. 1 and No. 2; PG&E's winter/spring operating plan; and reservoir bathymetry as performed during the relicensing studies).

5.2 WATER TEMPERATURE

5.2.1 Seasonal Life Stage Periodicity and Temperature Criteria for Adult Spring-Run Chinook Salmon and Steelhead

The YSF Technical Working Group (TWG) performed an extensive literature review and developed species- and life stage-specific water temperature criteria for the purposes of

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[6] NID filed its License Application with FERC on April 15, 2011 and an amended License Application on June 18, 2012. PG&E filed its License Application on April 12, 2011 and an amended License Application on June 18, 2012. All filings are available in the FERC eLibrary.

[7] Comments, Motion to Intervene, Reservation of Federal Power Act Fishway Prescription Authority, and Preliminary Protection, Mitigation, and Enhancement Measures for the Yuba-Bear Hydroelectric Project (P-2266) and the Drum-Spaulding Hydroelectric Project (P-2310). (Jul. 31, 2012), eLibrary No. 20120731-5212.

comparing various introduction alternatives (Bratovich et al. 2011). The water temperature criteria were primarily derived from studies that used average daily temperature or steady temperatures to identify biological thresholds. The TWG's intent was to identify biologically important threshold temperature criteria and the two biological water temperature thresholds identified for evaluating introduction were as follows:

- **Upper Optimum Temperature (UO).** The highest temperature below which growth, reproduction, and/or behavior are not negatively affected by temperature.

- **Upper Tolerable Temperature (UT).** The highest temperature that fish can survive in indefinitely, without experiencing substantial detrimental effects to physiological and biological functions such that survival occurs, but growth and reproduction success are reduced below optimal.

The maximum weekly average temperature (MWAT) was the metric that was determined to be most appropriate for evaluating the temperature criteria. Other temperature metrics were evaluated (see Section 5.2.2 for additional discussion). The temperature criteria and life stage periodicity for spring-run Chinook salmon and steelhead are provided in Table 4. The life stage periodicity was developed from previous studies and ongoing monitoring in the Lower Yuba River (Bratovich et al. 2011).

For spring-run Chinook salmon holding habitat, two UT temperatures were identified. One based on the literature review ($UT_{General\ Lit}$) (65°F) (Bratovich et al. 2011) and one based on evaluating the temperature in Butte Creek (UT_{Butte}) (66°F) in years when significant temperature-related holding mortality of spring-run Chinook salmon did not occur (e.g., Ward et al. 2006). The Butte Creek water temperature data (2001 – 2007) that were used to determine the Butte Creek UT temperature limit (UT_{Butte}) for spring-run Chinook salmon are shown in Appendix A Figure 1.

5.2.2 Water Temperature Analyses

All comparisons of the miles of suitable habitat available for different life stages (and temperature-dependent physical life stage habitats) relied on water temperature data collected at discrete gaging stations or modeled at discrete locations along the river reaches. The data sources for the empirical temperature data are summarized in Table 5 (by reach, temperature logger location, river mile source, and date). In addition to the measured water temperature data, modeled water temperature data of potential higher instream flow releases (Section 5.1.2) were analyzed for the Middle and South Yuba rivers (2008 and 2009 only). The temperature modeling was developed as part of the YBDS relicensing (PG&E and NID 2012).

For the habitat analyses, the empirical and modeled water temperatures were linearly interpolated between the discrete measured/modeled locations. In a few instances where there were gaps/errors in the empirical water temperature gage data, "patches" were made to the water temperature data using correlation with nearby water temperature gages. Addley and Graf (2012a and 2012b) describe in detail the temperature interpolations and water temperature issues and the associated analyses to develop the water temperature data “patches” in the North, Middle, and South Yuba rivers. Appendix B Figure 1 shows the data patches that were developed for the Lower Yuba River.

The water temperature modeling in the Middle Yuba River possibly overestimates water temperature in the upper portion of the river. This possibility is based on one empirical temperature logger that the YBDS temperature model did not calibrate to accurately (over-predicted measured temperature). As a result there is a level of uncertainty in the upper Middle Yuba River temperature modeling. An “adjusted” Middle Yuba River water temperature data set was developed to compensate for the possible overestimation. The approach for the adjustment is shown in Figure 1. The habitat assessment summaries present results of analyses using both of the water temperature data sets. This creates a “band” of uncertainty in the habitat results. The level of uncertainty cannot be reduced until further data collection/modeling clarifies the inconsistency.

MWAT was the temperature index used to determine if the temperature criteria were exceeded. MWAT is a metric used by the California Regional Water Quality Control Board (RWQCB). MWAT was calculated as the annual maximum of the 7-day running average of the mean daily water temperature. Other temperature metrics could be used to evaluate the temperature criteria as discussed in Bratovich et al. (2011).

The Environmental Protection Agency (EPA) (2003) recommends different salmonid temperature criteria than those identified in Section 5.2.1 and a different temperature metric, the 7-day average of the daily maximum (7DADM). The combination of the EPA temperature criteria and 7DADM metric is a more conservative temperature analysis (i.e., indicates that colder water is required by salmonids) than the temperature criteria in Section 5.2.1 and the MWAT temperature metric approach. An analysis was conducted to determine the sensitivity of the habitat calculations to the temperature criteria and metrics used. Specifically, the temperature criteria in Section 5.2 and MWAT metric were compared to the EPA criteria and 7DADM temperature metric. The analysis compared the results for the North Yuba River (Loves Falls to New Bullards Bar Reservoir High Water Mark, RM 51.1 to RM 17.4) using the available water temperature data sets (2008 – 2011).

5.3 HABITAT SUMMARY TABLES

Four habitat summary tables were developed to summarize and compare the length / area of suitable spring-run Chinook salmon and steelhead habitats for each river reach and life stage (Section 3.0). The tables included existing hydrology (2008 – 2011) (all reaches) and modeled hydrology (2008 – 2009) (Middle and South Yuba River reaches) as follows:

- Spring-run Chinook Salmon – Existing Conditions.
- Spring-run Chinook Salmon – Middle Yuba River Existing Conditions and Modeled Hydrology Scenarios.
- Spring-run Chinook Salmon – South Yuba River Existing Conditions and Modeled Hydrology Scenarios.
- Steelhead – Existing Conditions all River Reaches and Modeled Hydrology Scenarios (South and Middle Yuba rivers).

Brief descriptions of the habitat summary methods for each of the life stages / physical habitat features for spring-run Chinook salmon and steelhead are summarized in Table 6. A detailed description of the habitat summary methods for each life stage/ physical habitat feature is provided below.

5.3.1 Upstream Fish Passage Barriers

The locations (river mile) of the downstream-most natural total barriers to upstream spring-run Chinook salmon and steelhead immigration were identified in the main channel rivers. The large dams (Englebright, Our House, and New Bullards Bar) were categorized as man-made barriers, but are still considered full barriers to anadromous salmonid immigration.

Natural barriers in the Middle and South Yuba rivers were identified from the CDWR (2007) report, which used the criteria developed by Powers and Orsborn (1985) and estimates of whether or not barriers were low-flow (< approximately 100 – 200 cfs) and/or high-flow barriers (> approximately 100 – 200 cfs). Only the CDWR (2007) total barriers (both a low- and high-flow barrier) were used in the habitat summary assessment. It is important to note, however, that CDWR (2007) identified two low-flow barriers in the Middle Yuba River and three low-flow barriers in the South Yuba River downstream of the total barriers that should receive additional evaluation as potential total or seasonally-total Chinook salmon/steelhead immigration barriers.

In the North Yuba River above New Bullards Bar Reservoir, Loves Falls has typically been assumed to be the upstream migration barrier and was assumed to be the upstream migration barrier in this habitat assessment. Based on a helicopter flight over the site there are several falls in the Loves Falls area (narrow rocky gorge that appear to be full barriers); nevertheless, additional on-the-ground assessment should occur at the site.

Tributary barriers were determined from HDR (2012) and PG&E and NID (2011), a helicopter over-flight, and two site-specific investigations of potential barriers in Canyon Creek on the South Yuba River and Lavezzolla Creek on the North Yuba River. Many of the tributaries were investigated only near their mouth (first 0.5 miles of stream) and additional surveys are needed to further determine the absence/presence of barriers in many of the tributaries.

5.3.2 Adult Migration

Adult spring-run Chinook salmon immigration occurs from April through August and requires cool water temperatures (Table 4) within a barrier-free river. Late spring and summer water temperature was a potential migration limiting factor. Migration for steelhead occurs during August through March and was not assumed to be a limiting factor during the fall/winter/spring portion of the migration period due to cool water temperatures and higher flows and therefore, was not evaluated.

One option being investigated for the introduction of spring-run Chinook salmon in the upper Yuba rivers is to trap salmon and haul them around existing barriers and unsuitable habitat. Another alternative option is volitional passage into the Middle and South Yuba rivers via a fish ladder at Englebright Dam or removal of Englebright Dam.

Trap and Haul

The date when summer water temperatures exceeded the temperature criteria for adult spring-run Chinook salmon upstream migration (Table 4) was determined at potential trap and haul drop off locations (Table 7). On the North Yuba River, water temperature was assessed at the Hwy 49 Crossing (RM 23.5). On the Middle Yuba River, temperature was evaluated at the Above Our House Dam data logger location (RM 12.7). On the South Yuba River, temperature was assessed near Edwards Crossing (at the Humbug Creek confluence temperature model node and data logger location – RM 19.6) and near Washington (at the Poorman Creek confluence temperature model node and data logger – RM 28.1).

Volitional

The dates when summer water temperature exceeded the temperature criteria for adult spring-run Chinook salmon migration (Table 4) was assessed upstream of Englebright Dam (Table 7). Water temperatures were evaluated on the Middle and South Yuba rivers above the Yuba River confluence; on the North Yuba River above the Middle Yuba River confluence; and on the Yuba River above the Feather River confluence, above Englebright Dam, and above the New Colgate Powerhouse.

5.3.3 Adult Holding

Adult spring-run Chinook salmon holding habitat (April to August) was analyzed as a habitat limiting factor due to the potential for high water temperatures, relative to the holding temperature criteria, in July through August (Table 4). Steelhead holding habitat (August to March), was assumed not to be a limiting factor during the fall – spring portion of the migration/holding period due to cool water temperatures and, therefore, was not evaluated.

The analysis of the miles of suitable Chinook salmon holding habitat and the number of holding pools is briefly described below (additional information is available in Addley and Graf [2012b]).

Length of Holding Habitat

The maximum extent (length) of Chinook salmon summer holding habitat was determined based on the availability of suitable water temperatures (MWAT) for adult holding, UO and UT temperature criteria (Table 4 and Section 5.2), within the accessible main channel (i.e., below upstream migration barriers). The miles of adult holding habitat for existing conditions was evaluated for 2008 – 2011 on the North, Middle, and South Yuba rivers and the Yuba River and the miles of Chinook salmon adult holding habitat for different flow scenarios (Section 5.1.2) was evaluated for 2008 – 2009 on the South and Middle Yuba rivers.

Number of Holding Pools

Holding pool data (e.g., location and suitability ranking) from various studies (Table 2) were evaluated to determine the total number of holding pools within the thermally suitable, barrier-free reaches. Depending on data availability, pool habitat was included as follows:

- **North Yuba River:** Two categories of pools; 1) pools with a maximum pool depth ≥ 10 feet and with cover[8]; and 2) holding pools 4 feet - <10 feet deep or pools ≥ 10 feet deep without cover.

- **Middle, South, and Upper Yuba Rivers:** Pools with a maximum pool depth ≥ 10 feet and with cover.

- **Lower Yuba River:** Pools with a maximum pool depth ≥ 10 feet and area of 100 ft^2 (no evaluation of cover).

5.3.4 Adult Spawning

Spring-run Chinook salmon spawning (September to November 15; Table 4) suitable spawning habitat length (miles), amount of spawning gravel (ft^2 x 1000), and potential number of spawning redds were evaluated for each reach. Steelhead spawning (January through April 15; Table 4) was not assumed to be limiting due to cool temperature during the time period and, therefore, was not evaluated.

Length of Adult Spawning Habitat

The length of adult spring-run Chinook salmon spawning habitat was evaluated using two approaches. The first approach used the length of summer holding habitat combined with empirical studies of downstream movement distances immediately prior to spawning (Ward et al. 2006 and Hockersmith et al. 1994). The second method was based solely on suitable water temperatures in late September (at the beginning of spawning). The two approaches are described below.

[8] Cover included bedrock ledges, boulders, bubble curtain and/or surface turbulence.

Based on Holding Habitat

The spring-run Chinook salmon holding and spawning locations in Butte Creek (Ward et al. 2006) and in Yakima River (Washington State) (Hockersmith et al. 1994) were used to develop a relationship between the locations where fish held in July and August and where spawning occurred in the fall. The data from these studies indicate that holding salmon possibly would move about 2.2 miles downstream after holding to find spawning gravel. Using this approach to determine the amount of spawning habitat, the length (miles) of spawning habitat was calculated as the sum of the holding habitat (miles) plus 2.2 miles downstream (or the total length of the reach, whichever was less).

Hockersmith et al. (1994) found that 80% of tracked Chinook salmon (75 fish total) moved 2.5 miles or less from holding locations to spawning locations and that the weighted average total movement was 2.2 miles. Ninety percent of the tracked Chinook salmon moved upstream (see Figure 25 in Hockersmith et al. 1994). In the Yakima River fish could move both upstream and downstream from their holding locations in contrast to fish in Butte Creek, see below.

Butte Creek spawning and holding data were similarly analyzed. The observed holding and spawning locations were compared (Ward et al. 2006). The number of Chinook salmon at observed spawning locations was shifted by approximately 2.2 miles downstream compared with the number of Chinook salmon observed at the holding locations (Appendix A Figure 2). Butte Creek fish hold at the top of the river reach and the only direction for spawning movement is downstream.

Based on Temperature

The median MWAT during the last two weeks of September was also used as a secondary estimate of the miles of suitable spawning habitat. The last two weeks of September were selected for the analyses because many of the empirical and modeling water temperature data sets did not extend beyond the end of September. The available water temperature data indicate that temperatures throughout all the river reaches cool relatively quickly by October (in a downstream direction) and temperature at the beginning of spawning (e.g., September) likely is not the primary factor limiting the length of spawning habitat (September to November 15) (note: however, in the Lower Yuba River, where temperatures are not limiting early in the spawning period, a substantial amount of spawning does occur during the month of September).

Amount of Spawning Gravel

Spawning gravel data (e.g., amount and locations) from CDWR (2007) and HDR (2011) were used to determine the amount of spawning gravel (ft^2 x 1000) within the thermally suitable river reaches of spawning habitat (i.e., holding habitat plus 2.2 miles downstream). The amount of spawning gravel was not quantified for the secondary length of spawning habitat approach that was based on end of September water temperature (see Length of Spawning Habitat above).

For the South, Middle, and North Yuba rivers, the amount of spawning gravel data were only a relative index of the amount of spawning gravel. Spawning gravel data were only available for the tailouts of deeper pools that provided holding habitat suitable for spawning fish[9] and the amount of spawning gravel in the tailouts only roughly included depth and velocity suitability. Gravels in other habitats that may be suitable for spawning were not available or assessed (note: these spawning gravel data should not be used for fish population modeling or they should be used very cautiously).

For the Lower Yuba River, the amount of spawning gravel was determined from the YRDP instream flow study, full river reach 2D modeling. The instream flow study included all gravels within the reach with suitable spawning depths and velocities (YCWA 2013). These spawning gravel data could be considered a census (as opposed to a relative index as was used for the Upper Yuba River).

Number of Spawning Redds

An estimate of the number of spring-run Chinook salmon spawning redds within the thermally suitable river reaches was calculated using the amount of spawning gravel and the average redd size from Butte Creek, Battle Creek, and Clear Creek empirical data (94 ft^2 / redd). The data were provided by CDFW (S. Hoobler, pers comm.) (2/20/13). The number of redds was calculated by dividing the amount of spawning gravel by the redd size. The number of redds within a reach, however, can vary depending on a number of factors, including the size of gravel and fish densities. Also, because the number of spawning redds is based on spawning gravels in wetted pool tailouts in the South, Middle, and North Yuba rivers, the numbers of redds should be viewed as a conservative index. To provide an approximate range for the potential number of redds, the number of spawning redds was also calculated using the minimum redd size (from Butte Creek – 29 ft^2/ redd) and the maximum redd size (from Clear Creek – 101 ft^2/ redd) from the empirical data sets.

5.3.5 Embryo Incubation

Water temperatures between September and May were evaluated for the potential to be a limiting factor for either spring-run Chinook salmon or steelhead embryo incubation (Table 4).

5.3.6 Juvenile Rearing Habitat and Downstream Movement

Summer (e.g., July and August) was the time period when rearing habitat was most likely limited due to the combination of high water temperatures and low base flows for

[9] Note that CDWR (2007) only included deep pool tailout gravels for Chinook salmon, but included other gravel areas for steelhead.

both stream-type[10] juvenile spring-run Chinook salmon (remain in the stream their first summer) and juvenile steelhead (remain in the river for at least one summer and out-migrate as age 1+, 2+, or 3+ fish) (note: other time periods could limit rearing habitat if extreme high- or low-flows/temperatures occur). The length (miles) of rearing habitat and the amount (ft^2) of juvenile rearing habitat was calculated as described below (additional details on the analyses are provided in Addley and Graf [2012a]).

Length of Juvenile Rearing Habitat

Main stem river length (miles) of rearing habitat was evaluated based on the availability of suitable water temperatures (MWAT) (Table 4) during the summer (July, August) within the accessible main channel (below upstream migration barriers). Rearing habitat was evaluated for existing conditions (2008 – 2011) in all river reaches and for each of the different flow scenarios in the South and Middle Yuba rivers (Section 5.1.2) (2008 – 2009).

The length of potential tributary steelhead juvenile habitat was assessed to the extent possible based on the locations of the first total barriers on tributaries to the North, Middle, and South Yuba rivers that were identified and mapped: HDR (2012) and PG&E and NID (2011); a helicopter over-flight by PCWA (2011); and two site-specific investigations of potential barriers in Canyon Creek on the South Yuba River and Lavezzolla Creek on the North Yuba River system.

Amount of Juvenile Rearing Habitat

Physical Habitat Simulation (PHABSIM) analysis was used to determine the amount (area, ft^2) of rearing habitat as a function of the summer discharge. On the Middle and South Yuba rivers, PHABSIM weighted usable area (WUA) studies developed during the YBDS relicensing were used for the analysis. For the North Yuba River above New Bullards Bar Reservoir, a PHABSIM study had not been conducted; therefore, a relationship between WUA and wetted stream width was developed based on PHABSIM studies from a number of nearby rivers. This relationship was then applied to the North Yuba River using empirical wetted stream width data collected on the North Yuba River (refer to Addley and Graf [2012a] for additional details on this approach). WUA curves for rainbow trout juveniles were used for this analysis for both juvenile spring-run Chinook salmon and steelhead (Chinook salmon were not modeled in the YBDS studies). The suitability criteria for juvenile rainbow trout are representative of juvenile steelhead suitability criteria and are a reasonable surrogate for juvenile spring-run Chinook salmon suitability criteria. For the Yuba River, PHABSIM WUA studies

[10] Juvenile spring-run Chinook salmon would likely exhibit a range of rearing strategies, with fish remaining in the system for up to one year. Juvenile spring-run Chinook salmon could emigrate in their first spring as fry (ocean type) or over-summer and emigrate in the fall/winter/spring as smolts (river type) (CDWR 2007; Campos and Massa 2010). The rearing analysis time period in this study is not applicable to juvenile Chinook salmon that emigrate in their first spring.

were available from the YRDP relicensing for both juvenile spring-run Chinook salmon and steelhead (YCWA 2013).

For each river reach, the WUA relationship for July and August average flows was multiplied by the length of habitable river, based on water temperature and barriers, to estimate the total rearing habitat area available each summer for existing conditions (2008 – 2011) and for the different flow scenarios in the South and Middle Yuba rivers (Section 5.1.2) (2008 – 2009).

5.3.7 Smolt Emigration

Smolt emigration (November to May 15) (Table 4) for spring-run Chinook salmon and steelhead requires suitable water temperatures, adequate transport flows, and barrier-free passage. The suitability of water temperatures for smolt emigration was evaluated in each reach.

6.0 RESULTS

6.1 HYDROLOGY

The 2008 – 2011 hydrology used in the habitat summary assessment represented a range of different water year types from dry to wet: 2008 (dry); 2009 (below normal); 2010 (below normal); and 2011 (wet) (Figure 2). The 2009 below normal water year was relatively “dry” and the 2010 below normal water year was relatively “wet.”

The existing July/August average monthly flows for 2008 – 2011 in the North Yuba (above New Bullards Bar Reservoir), Middle Yuba, and South Yuba rivers were generally representative of the range of flows that occurred during a longer period of record (1976 – 2008). The 2008 and 2009 summers were characterized by relatively lower stream flow (approximately <80% exceedance) and the 2010 and 2011 summers were characterized by relatively higher stream flow (approximately <30% exceedance) in the portions of the rivers where natural hydrology was dominant (North Yuba River and the downstream half of the Middle and South Yuba rivers) (Figures 3, 4a and 4b, 5a and b).

The hydrology analysis also provides natural versus modified hydrology insight (context) for the 2008 – 2011 habitat analysis. The North Yuba River above New Bullards Bar Reservoir consists predominately of unimpaired natural flows (Figure 3). In the Middle and South Yuba rivers there are significant headwater water storage and diversion facilities/operations. The Middle Yuba River Preliminary 4(e) Conditions flows that were used in the analysis were generally similar to both the existing and unimpaired flows for July/August (Figures 4a and 4b). The other modeled flows, CDFG/FWN and NMFS, were substantially higher during the summer than existing, unimpaired, or the Preliminary 4(e) Condition flows. In the South Yuba River, modeled July/August Preliminary 4(e) Condition flows were generally substantially higher than both unimpaired and existing flows (Figures 5a and 5b) and the CDFG/FWN and NMFS flows were the highest of all the flows. The hydrology data are discussed further in Addley and Graf (2012a; 2012b).

6.2 WATER TEMPERATURE

Existing MWAT water temperatures in the North, Middle, and South Yuba rivers and the Yuba River (2008 – 2011) are shown in Maps 2a-2d. The temperature maps show that cold water summer temperatures suitable for various salmonid life stages (Table 4) (e.g., <68°F) exist primarily in the upstream portions of the North, Middle, and South Yuba rivers and in the lower portion of the Yuba River below Englebright Dam. The amount of cold water increases in the North, Middle, and South Yuba rivers with increasingly wetter water year types (i.e., from dry 2008 to wet 2011). The amount of cold water habitat below Englebright Dam remains generally consistent with water year type and encompasses the entire 24 miles of river below Englebright Dam.

The amount of cold water in the upstream rivers (below the upstream total fish passage barriers) is typically greatest in the North Yuba River and least in the South Yuba River. Additional temperature results for existing and modeled hydrology are provided in the various life stage-specific habitat discussions below.

A sensitivity analysis of the EPA temperature criteria and 7DADM metric for the North Yuba River is presented in Appendix C. The EPA criteria are significantly more conservative (i.e., identify colder water) than the temperature criteria and MWAT metric used in this report. Based on this analysis, the EPA criteria / 7DADM temperature metric approach identifies that there is no suitable 61°F 7DADM core salmonid juvenile rearing or adult holding habitat in the North Yuba River in 2010 (the specific year analyzed). In comparison, the temperature criteria / MWAT temperature metric approach in this report identifies greater than 20 miles of habitat. In general, the EPA criteria / 7DADM temperature metric approach would identify little, if any, salmonid habitat in the upper Yuba River system, even in the wetter water year types.

6.3 HABITAT SUMMARY TABLES

The habitat assessment summary based on existing conditions and modeled scenarios for each of the life stages are show in the following tables:

- Spring-run Chinook Salmon – Existing Conditions (Table 8)
- Spring-run Chinook Salmon – Middle Yuba River Existing Conditions and Modeled Scenarios (Table 9)
- Spring-run Chinook Salmon – South Yuba River Existing Conditions and Modeled Scenarios (Table 10)
- Steelhead – Existing Conditions all River Reaches and Modeled Scenarios (South and Middle Yuba rivers) (Table 11).

Overall, the largest amount of habitat for spring-run Chinook salmon and steelhead was in the Lower Yuba River followed in decreasing amounts by the North Yuba River, Middle Yuba River, the combined reaches above Englebright and below New Bullards Bar, and the least amount of habitat was in the South Yuba River. Additional details for the habitat summary results are provided for each life stage below.

6.3.1 Upstream Fish Passage Barriers

The only barrier-free portion of main stem river that is accessible to volitional upstream passage in the Yuba River system was the 24 miles of the Lower Yuba River below Englebright Dam (Chinook salmon and steelhead). If fish were placed above the dams/reservoirs (Englebright, New Bullards Bar, Our House), the length of barrier-free river in the North, Middle, and South Yuba rivers, was 33.7, 22.2, and 34.9 miles, respectively. The lengths of lesser amounts of barrier-free habitat in other river reaches and the locations of the barriers in all reaches are shown in Table 1 (and Tables 8 – 11) and Map 1. Additional information on barriers (main stem and tributary) is available in CDWR (2007) and HDR (2012).

The largest amount of steelhead tributary habitat to the main stem river reaches that is barrier-free exists in the North Yuba River watershed above New Bullards Bar Reservoir and is approximately 22^{+} miles. Less tributary habitat exists in the Middle (approximately 2.5^{+}) and South Yuba rivers (approximately 6.5^{+}). Additional field survey work is required to identify the amount of habitat in a number of tributaries. Table 12 and Map 3 show the locations of tributary barriers and the tributaries that need additional survey work.

6.3.2 Adult Migration

The dates when temperatures would be too warm for upstream migration at potential spring-run Chinook salmon trap and haul release locations in the North, Middle, and South Yuba rivers (Table 7) typically were in mid-June and early July depending on the river reach and water year type (Tables 8 – 10). Appendix D shows time series plots of the available temperature data at trap and haul release locations.

The dates when spring-run Chinook salmon volitional upstream migration could occur into river reaches above Englebright Reservoir (e.g., Middle and South Yuba Rivers, Yuba River above New Colgate Powerhouse), if fish were able to get above Englebright Reservoir (e.g., fish ladder), were typically prior to mid-May through June (Tables 8 – 10). At some locations/years temperature data were not available early enough in the year to determine the date. Appendix D shows time series plots of the available temperature data at volitional passage locations.

Large temperature differences between cold water releases at the base of Englebright Dam / New Colgate Powerhouse and warm water in the rivers upstream of Englebright Reservoir / New Colgate Powerhouse in the late spring and early summer would likely make volitional passage into the Middle and South Yuba rivers difficult. Fish may behaviorally remain in the downstream colder water and not migrate further upstream into warmer waters. This issue is illustrated in Appendix B Figure 2, which shows water temperatures at locations within the Yuba River and the spring-run Chinook salmon migration temperature criteria (64 and 68°F). If warmer water was released from New Colgate Powerhouse / Englebright Reservoir, volitional passage could potentially be modified, but likely at the expense of cold water habitat in the Lower Yuba River.

6.3.3 Adult Holding

Length of Holding Habitat

The greatest length of spring-run Chinook salmon holding habitat was in the Lower Yuba River (24 miles all years) and the next largest lengths of habitat were in the North Yuba River (5.4 – 33.7 miles, 2008 – 2011) and Middle Yuba River (5 – 10.1 miles, 2008 – 2011) based on the 65°F criteria and existing conditions (Figure 6, Table 8, Appendix B Maps 1, 5, 6, and 7). The length of holding habitat in the Middle Yuba River could increase several miles depending on the future hydrology scenario (Figure 6, Table 9, Figure 4a-b). All other reaches had lesser amounts of holding habitat (Figure 6, Tables 8 – 10, Appendix E Maps).

The length of spring-run Chinook salmon holding habitat through the summer months was a primary limiting factor for Chinook salmon habitat. The length of holding habitat also determined the number of holding pools available and the length / amount of spawning habitat (see Section 6.3.4) and was the same length of habitat as the juvenile rearing for over-summering juveniles (Section 6.3.6) (the required temperatures for holding and rearing were the same).

Number of Holding Pools

The relative number of holding pools in the different river reaches generally was consistent with the length of holding habitat (more habitat length equals more pools; see above); the only deviations from this were the relatively low number of $\geq$10 ft deep holding pools (5 total) in the upper portion of the North Yuba River in the drier years (2008 and 2009) and the low number of holding pools in the upper South Yuba River (3 total) under the modeled flow scenarios (Tables 8 – 10, Appendix E Maps).

6.3.4 Adult Spawning

Length of Adult Spawning Habitat Based on Holding Habitat

The length of spring-run Chinook spawning habitat was similar to the holding habitat results with the Lower Yuba, North Yuba, and Middle Yuba rivers providing the most habitat, respectively (Figure 7, Tables 8 – 10). This is expected based on the approach of calculating spawning habitat by adding 2.2 miles to summer holding habitat to represent fall downstream movement for spawning.

Length of Adult Spawning Habitat Based on Temperature

The length of spawning habitat based on the water temperature during the last two weeks of September provided roughly similar results (Tables 8 – 10) to the holding habitat approach used to calculate spawning habitat (above). Fall temperatures dropped relatively rapidly on all of the reaches (Figure 8) and it does not appear that fall temperature would limit the amount of spawning habitat. Rather, the length of spawning habitat would be most likely limited by the upstream locations where spring-run Chinook salmon held during the summer and by behavioral downstream movement of holding Chinook salmon when temperatures in the river begin to cool to ≤ 58°F.

Amount of Spawning Gravel

The amount of spawning gravel was greatest (by a very large amount) in the Lower Yuba River, followed by the North and Middle Yuba rivers. The amounts of spawning gravel in the North and Middle Yuba rivers were similar in drier years (2008 and 2009), with the North Yuba River having significantly more spawning gravel in the wetter years (2010, 2011) (Tables 8 – 10). Under the modeled flow scenarios the amount of spawning gravel in the Middle Yuba River in 2008 and 2009 was increased above the levels in the North Yuba.

The amount of spawning gravel in all of the river reaches upstream of Englebright Reservoir was based on the gravel in the tailouts of deep water holding pools (within the length of river with holding-based spawning habitat [see above]). As such, it is only a relative index of spawning gravel and should not be used for population modeling (it excludes spawning gravels that would be used in other habitat types). It also does not reflect the amount of gravel with suitable depths and velocities.

The amount of spawning in the Lower Yuba River (downstream of Englebright Reservoir) was based on the amount of spawning gravel with suitable depths and velocities throughout the Lower Yuba River, in all habitat types.

Number of Spawning Redds

The number of potential spawning redds was largest (by a very large number) in the Lower Yuba River, followed by the North and Middle Yuba rivers (Tables 8 – 10, Appendix F Figure 1). Other reaches had very low numbers of potential redds. The same precautions should be used in interpreting the redd data as discussed above for the amount of spawning gravel. The number of redds was based on dividing the amount of spawning gravel by the estimated area per redd (94 ft^2/ redd). Appendix G Tables 1a and 1b contain a redd sensitivity analysis showing the number of redds based on using the minimum, average, and maximum area / redd from Butte Creek, Battle Creek, and Clear Creek (Sean Hoobler [CDFW]).

6.3.5 Embryo Incubation

Embryo incubation (water temperature, gravel quality) was not limiting (Table 8 – 10). The available temperature data indicates that temperatures are lower than the 58°F temperature threshold required for incubation after September (e.g., Figure 8). Also, CDWR (2007) and HDR (2011) indicate that gravel permeability is relatively high.

6.3.6 Juvenile Rearing Habitat and Downstream Movement

The length and amount (area) of juvenile rearing habitat was calculated for both Chinook salmon and steelhead.

Length of Juvenile Rearing Habitat

Chinook Salmon

The greatest temperature-based length of spring-run Chinook salmon rearing habitat was in the Lower Yuba River (24 miles all years) and the next largest lengths of habitat were in the North Yuba River (5.4 – 33.7 miles, 2008 – 2011) and Middle Yuba River (5 – 10.1 miles, 2008 – 2011) based on the UT 65°F criteria and existing conditions (Figure 9, Table 8, Appendix B Maps 1, 5, 6, and 7). The length of rearing habitat in the Middle Yuba River could increase several miles depending on the future hydrology scenario (Figure 9, Table 9, Figure 4a-b). All other reaches had lesser amounts of holding habitat (Figure 9, Tables 8 – 10, Appendix H Maps).

For the Middle and South Yuba rivers, longitudinal MWAT water temperature plots (2008 – 2009) that show the length of Chinook salmon rearing habitat gain and approximate river mile locations between Base Case Flows and the other flow scenarios are provided in Appendix I.

Steelhead

Because the steelhead juvenile rearing temperature, UT 68°F, was greater than the Chinook holding / juvenile rearing temperature (UT 65°F), there is more steelhead main stem river rearing habitat than juvenile Chinook salmon habitat. The greatest length of steelhead rearing habitat was in the Lower Yuba River (24 miles all years) and the next largest lengths of habitat were in the North Yuba (16.5 – 33.7 miles, 2008 – 2011) and Middle Yuba rivers (7.6 – 17.4 miles, 2008 – 2011) based on the UT 68°F criteria and existing conditions (Figure 10, Table 11, Appendix H Maps). The length of rearing habitat in the Middle Yuba River could increase several miles depending on the future hydrology scenario (Figure 10, Table 11, Figure 4a-b). All other reaches had lesser amounts of rearing habitat (Figure 10, Table 11, Appendix H Maps).

For the Middle and South Yuba rivers, longitudinal MWAT water temperature plots (2008 – 2009) that show the length of steelhead rearing habitat gain and approximate river mile locations between Base Case Flows and the other flow scenarios are provided in Appendix I.

Amount of Juvenile Rearing Habitat

The amount of rearing habitat area incorporates the temperature-based length of river suitable for habitat, the flow, and the WUA. The amount of summer flow in the river reaches had a relatively large effect on the amount of juvenile Chinook salmon and steelhead rearing habitat.

Chinook Salmon

The greatest amount of juvenile Chinook salmon rearing habitat was in the Lower Yuba River (approximately 10,000,000 ft^2 all years) and the next largest amounts of habitat were in the North Yuba River (568,000 – 3,384,000 ft^2, 2008 – 2011) and Middle Yuba River (251,000 – 668,000 ft^2, 2008 – 2011) based on the UT 65°F criteria and existing conditions (Appendix F Figure 2, Table 8). The amount of rearing habitat in the Middle Yuba River could increase substantially depending on the future hydrology scenario (Appendix F Figure 2, Table 9). All other reaches had lesser amounts of holding habitat (Appendix F Figure 2, Tables 8 – 10).

In part, because the North Yuba River had higher summer flows (Appendix J Table 1), the amount of rearing habitat was several times greater than the amount of habitat in the Middle Yuba River (existing conditions). This was the case even though the length of habitat in dry years (2008 and 2009) was similar.

Steelhead

The amount of juvenile steelhead rearing habitat followed the same relative pattern between river reaches as the juvenile Chinook salmon rearing habitat (Lower Yuba River > North Yuba River > above Englebright, below New Bullards Bar combined reaches > South Yuba River). However, there was more steelhead rearing habitat in several of the reaches because the length of habitat was greater due to the UT 68°F steelhead versus UT 65°F Chinook salmon temperature criteria (Tables 8 – 10).

6.3.7 Smolt Emigration

Smolt emigration habitat (October to May 15) was not limiting. For example, Figure 8 shows empirical water temperatures for 2008 – 2011 in the North, Middle, and South Yuba rivers from late April/early May through approximately the end of September. Although limited temperature data are available for the winter and early spring, water temperatures are always below the temperature criteria for smolt emigration by early October and were still within the thermally suitable range when temperature data collection resumed in late April / early May.

7.0 SUMMARY

The greatest amount of habitat for both spring-run Chinook Salmon and steelhead was in the Lower Yuba River (much greater), followed by the North Yuba River and the Middle Yuba River, followed by lesser amounts of habitat in other reaches. The relative amount of habitat for Chinook salmon and steelhead varied by river reach and by water year (drier versus wetter year) and hydrology scenario (Tables 8 – 10). For spring-run Chinook salmon, adult holding appeared to be one of the main limiting factors. The other life stages were generally either related to the amount of holding habitat (e.g., spawning habitat calculated based on holding habitat) or of similar magnitude (juvenile rearing). The amount of steelhead rearing habitat was the primary limiting factor for steelhead. The amount of steelhead rearing habitat was greater than the amount of Chinook salmon habitat in the main stem rivers due to the higher steelhead temperature criteria (UT 68°F versus UT 65°F).

- **Yuba River below Englebright.** There was consistently 24 miles (Englebright Dam to the Feather River-Yuba River confluence) of habitat for both species and for all life stages (holding, spawning, and rearing) and for all water year types (drier and wetter years). There was a particularly large amount of spawning gravel and spawning habitat.

- **North Yuba River.** A little over 5 miles of spring-run Chinook salmon habitat (e.g., holding and spawning habitat) existed in the dry years and 21.8 – 33.7 miles of suitable habitat length existed in the wetter years (UT temperature criteria). Steelhead rearing habitat in the North Yuba River was greater than the amount of Chinook salmon rearing habitat. The North Yuba River also had the largest amount of accessible tributary habitat for steelhead compared to the other river reaches.

- **Middle Yuba River.** The length of spring-run Chinook salmon habitat (e.g., holding and spawning habitat) ranged from about 5 miles in dry years to 7.6 – 12.3 miles in wetter years under existing conditions (UT temperature criteria). Under the modeled flow regimes for the drier years (2008 and 2009), the lengths of suitable habitat for different life stages increased under the Preliminary 4(e) Condition flows and was even higher under the CDFG/FWN and NMFS flow regimes. In wetter years no modeling data were available (2009 and 2010), but more habitat would be expected.

- **Other Reaches.** The combined upper Yuba River and North Yuba River reaches above Englebright Reservoir and below New Bullards Bar Dam provided small amounts of habitat under existing conditions due to temperature above New Colgate Powerhouse and hydropeaking below New Colgate Powerhouse. Also, some of the reaches have very low gravel availability.

- **South Yuba River.** No habitat to minimal spring-run Chinook salmon habitat (e.g., holding and spawning habitat) existed under dry year flow conditions, with small increases in habitat (0.8 – 3 miles in total habitat length, depending on life stage) in wetter years (UT temperature criteria). In drier years under higher-flow regimes (2008 and 2009), the length of suitable holding and rearing habitats increased a small amount (up to about 2 miles). In wetter years no modeling data were available (2010, 2011), but more habitat would be expected.

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TABLES

Table 1. Yuba River Watershed Reaches, River Miles, and River Mile Source.

River Reaches	River Miles				Description
	Total Length	Mile	Source[1]		
			YCWA	YBDS	
North Yuba River					
Above New Bullards Bar Res	33.7				
Top		51.1	●		Loves Falls (total barrier)
Bottom		17.4	●		New Bullards Bar Reservoir High Water
Below New Bullards Bar Res	2.3				
Top		2.3	●		New Bullards Bar Dam
Bottom		0.0	●		Confluence w/ Middle Yuba River
Yuba River					
Above New Colgate Powerhouse	5.8				
Top		39.7	●		North and Middle Yuba River Confluence
Bottom		33.9	●		New Colgate Powerhouse
Below New Colgate Powerhouse	1.7				
Top		33.9	●		New Colgate Powerhouse
Bottom		32.2	●		Englebright Lake High Water
Englebright Lake	8.2				
Top		32.2	●		Englebright Lake High Water
Bottom		24.0	●		Englebright Dam
Lower Yuba River	24.0				
Top		24.0	●		Englebright Dam
Bottom		0.0	●		Feather and Yuba River Confluence
Middle Yuba River					
Middle Yuba	35.1 (22.6)				
Top		35.1		●	Water Fall (total barrier)
Bottom A		12.5		●	Our House Dam (fish barrier)
Bottom B		0.0		●	North and Middle Yuba River Confluence
South Yuba River					
South Yuba	36.0 (35.3)				
Top		34.9		●	Water Fall (total barrier)
Bottom A		-0.4		●	Englebright Lake High Water (Kentucky Ravine)
Bottom B		-1.1		●	Confluence w/ Yuba River

[1] Source for river mile data. River mile data are available from the Yuba-Bear Drum-Spaulding relicensing studies and the YCWA relicensing studies.

Table 2. Data Sources for the Habitat Summary.

Data Source	North Yuba River	Middle Yuba River	South Yuba River	North Yuba River below New Bullards Bar	Yuba River above Englebright Reservoir		Lower Yuba River - Englebright Dam to Feather River	Tributaries	General Information
					Yuba River above New Colgate Powerhouse	Yuba River from New Colgate Powerhouse to Englebright Reservoir			
Yuba Watershed Data Sources									
Upper Yuba River Studies[1]		B, SG, HP	B, SG, HP		B, SG, HP	B, SG, HP			
Yuba Salmon Forum Studies									
Water Temperature Study	TD	TD	TD	TD	TD	TD			
Fish Barriers Study	B	B	B	B				B	
Spawning Gravel Study	SG								
Rearing Habitat Study	RH	RH	RH						
Holding Habitat Study	HP								
Water Temperature Considerations for Yuba River Basin Anadromous Salmonid Reintroduction Evaluations	TC	TC	TC	TC	TC	TC	TC		
Yuba-Bear Drum-Spaulding Relicensing Studies		TD, TM, B, RH	TD, TM, B, RH						
YCWA Relicensing Studies				TD, RH, HP, B, SG	TD, RH, HP, B, SG	TD, RH, HP, B, SG	TD, RH, HP, B, SG		
SYRCL Data	TD								
NMFS Data	TD								
PCWA Helicopter Surveys	B, RH	B, RH	B, RH					B, RH	
Data Sources for Other Regional Information									
PCWA MFP Relicensing Studies									RH
Butte Creek									TC; Spawning Movement

Key for Lifestage/Physical Habitat Feature:
Barriers (B)
Empirical Temperature Data (TD)
Temperature Modeling (TM)
Temperature Criteria (TC)
Spawning Gravels (SG)
Holding Pools (HP)
Rearing Habitat (RH)

Abbreviations
SYRCL: South Yuba River Citizens League
NMFS: National Marine Fisheries Service

[1] Other data were available, but were not specifically used for the development of the habitat matrices.

Table 3. USGS Gage Locations and Data Sources Used to Develop July and August Average Monthly Flows and Exceedance Curves for the Habitat Summary.

River/Gage Location[1]	Flow Scenario	Data Source 2008-2011
Upper North Yuba River		
Below Goodyears Bar	Existing/Unimpaired	Below Goodyears Bar (USGS Gage 11413000)
Middle Yuba River		
Below Milton Diversion Dam	Modeled Unimpaired	YBDS Hydrology DVD
	Existing	Middle Yuba River below Milton Diversion Dam (USGS Gage 11408550)
	Modeled	AG 080211 Model Run
Above Our House Dam	Modeled Unimpaired	YBDS Hydrology DVD
	Existing	USGS Gages 11408870 [Lohman Ridge Tunnel near Camptonville CA] + 11408880 [Middle Yuba River below Our House Dam]
	Modeled	AG 080211 Model Run
South Yuba River		
Lang's Crossing	Modeled Unimpaired	YBDS Hydrology DVD
	Existing	Lang's Crossing (USGS Gage 11414250)
	Modeled	AG 080211 Model Run
Jones Bar	Modeled Unimpaired	YBDS Hydrology DVD
	Existing	Jones Bar (USGS Gage 11417500)
	Modeled	AG 080211 Model Run
North Yuba River below New Bullards Bar		
Below New Bullards Bar	Existing	Minimum releases from New Bullards Bar Dam
Yuba River above New Colgate Powerhouse		
Above New Colgate Powerhouse	Existing	Minimum Releases from Our House Log Cabin + New Bullards Bar Dam
Yuba River below New Colgate Powerhouse		
Below New Colgate Powerhouse	Existing	Not estimated[2]
Lower Yuba River below Englebright Dam		
Smartville	Existing	Yuba River near Smartsville (USGS Gage 11418000)[3]
Marysville	Existing	Yuba River near Marysville (USGS Gage 11421000)

[1] Modeled (including unimpaired) data are only available for 2008 and 2009.

[2] Under existing conditions, peaking flows within reach can vary substantially from very low to high flows in very short time periods, with multiple cycles per day.

[3] USGS Gage data unavailable for October 2011 at time of analyses. Used CDEC (California Data Exchange Center) Yuba River near Smartville (YRS) flow data for October 2011.

Table 4. Temperature Criteria and Periodocity for Evaluation of the Introduction of Spring-run Chinook Salmon (top) and Steelhead (bottom) in the Upper Yuba Watershed.

Spring-run Chinook Salmon Lifestage	Upper Optimum (°F)[2]	Upper Tolerance (°F)[2]	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Adult Migration	64	68							■	■	■	■	■	■	■	■	■	■								
Adult Holding	61	65							■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
Spawning	56	58																	■	■	■	■	■			
Embryo Incubation	56	58	■	■	■	■													■	■	■	■	■	■	■	■
Juv. Rearing & Downstream Mvmnt.	61	65	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Smolt Emigration	63	68	■	■	■	■	■	■	■	■											■	■	■	■	■	■

Steelhead Lifestage	Upper Optimum (°F)[2]	Upper Tolerance (°F)[2]	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Adult Migration	64	68	■	■	■	■	■	■									■	■	■	■	■	■	■	■	■	■
Adult Holding	61	65	■	■	■	■	■	■									■	■	■	■	■	■	■	■	■	■
Spawning	54	57	■	■	■	■	■	■	■	■																
Embryo Incubation	54	57	■	■	■	■	■	■	■	■	■	■														
Juv. Rearing & Downstream Mvmnt.	65	68	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Smolt Emigration	52	55	■	■	■	■	■	■	■												■	■	■	■	■	■

[1] See Bratovich et al. (2011).
[2] The values represent the maximum weekly average temperature (MWAT).

Table 5. Locations of Water Temperature Loggers on the South Yuba, Middle Yuba, North Yuba, and Lower Yuba Rivers Used for the Spring-run Chinook Salmon and Steelhead Habitat Summary (2008-2011).

Gage Location Description	Temperature Logger ID and RM (Agency Maintaining Gage)	Temperature Loggers and River Miles Used for Habitat Summaries	River Mile System Source		Temperature Logger Location		Dates of Empirical Temperature Data by Source (2008-2011)						Notes
			YB DS Project	YCWA Project	Lat or Northing[1]	Long or Easting[1]	PG&E/NID YBDS[2]	YCWA YRDP[3]	Yuba Salmon Forum[4] YCWA	Yuba Salmon Forum[4] NMFS	Yuba Salmon Forum[4] SYRCL	HDR[5]	
North Yuba River													
NYR above Sierra City	NYR-52.1 (YCWA)	52.1		●	39.59218	-120.6112			10/2/09-10/20/11				
NYR below Haypress Creek	NYR-50.1 (NMFS)	50.1		●	39.568233	-120.615933				7/14/10-12/13/11			**Data gap:** 7/4/11-8/10/11
NYR near China Flat	NYR-42.6 (YCWA)			●	39.57002	-120.7376			10/2/09-10/20/11				
NYR below Union Flat	NYR-41.7 (NMFS)	41.7		●	39.561767	-120.74785				7/14/10-12/13/11			**Data gap:** 7/4/11-8/8/11
NYR above Downieville	NYR-38.5 (NMFS)	38.5		●	39.555717	-120.793883				7/13/10-10/5/10			
NYR below Downieville	NYR-36.1 (NMFS)	36.1		●	39.559183	-120.832217				7/14/10-12/13/11			
NYR above Goodyears Bar	NYR-33.7 (NMFS)	33.7		●	39.5471	-120.862283				7/14/10-12/13/11			
NYR above Goodyears Bar	NYR-32.7 (YCWA)			●	39.54303	-120.8791			10/2/09-10/19/11				
NYR at Goodyears Bar	NYR32.3 (NMFS)	32.3		●	39.540333	-120.886283				7/14/10-12/13/11			**Data gap:** 7/7/11-8/10/11
NYR below Goodyears Bar	NYR-31 (NMFS)	31		●	39.54125	-120.905117				7/14/10-12/13/11			
Below Convict Flat	NYR-27.2 (NMFS)	27.2		●	39.520417	-120.956183				7/12/10-10/12/10			
NYR at Rocky Rest	NYR-25.7 (NMFS)	25.7		●	39.513033	-120.976167				7/14/10-7/6/11			
NYR at Indian Valley	NYR-24.2 (NMFS)	24.2		●	39.518867	-120.998583				7/14/10-12/13/11	5/21/09-9/30/09		
NYR at Hwy49 Bridge	NYR-23.5 (NMFS)	23.5		●	39.51635	-121.01185				7/13/10-10/8/10	6/6/08-9/30/08		
NYR at Hwy49 Bridge	NYR-23.4 (YCWA)			●	39.51637	-121.0127			10/2/09-10/19/11				
NYR below Indian Creek	NYR-22.4 (NMFS)	22.4		●	39.5056	-121.024217				7/13/10-10/8/10			
NYR below Cherokee Creek	NYR-21.3 (NMFS)	21.3		●	39.514167	-121.037117				7/14/10-12/13/11			
NYR at Kelly Bar	NYR-20.1 (NMFS/YCWA)	20.1		●	39.522033	-121.0524			7/12/10-10/21/11	7/12/10-10/21/11			**Data gap:** 10/12/2010-early July 2011
NYR below Canyon Creek	NYR-19.9 (NMFS)	19.9		●	39.522417	-121.057767				7/12/10-10/12/10			
NYR at 'NYS' Gage	NYR-17.7 (YCWA)			●	39 31.422	-121 05.459			1/1/09-6/12/11				Logger plots at the same river mile as the 'Upstream of New Bullards Bar Reservoir' logger. RM 17.7 - New Bullards Bar High-water Mark
NYR above Slate Creek	NYR-17.6 (YCWA)	17.6		●	39.52552	-121.0915			10/7/09-9/15/11				**Data gap:** 7/6/10-10/12/10
NYR below Slate Creek	NYR-17.5	17.5		●	39.52555	-121.0942			8/22/10-9/15/11				**Data gap:** 7/6/10-10/12/10
Upstream of New Bullards Bar Reservoir	T65/ NYR 16.0 (YCWA)			●	39.523728	-121.090972		1/1/08-8/11/10					**Logger is located at different river mile than indicated in YCWA study plan table.** Logger plots at the same river mile as the 'NYR at NYS Gage'. Data not used in analysis.
At Low Flow Releases from New Bullards Bar Dam	T70/NYR-2.3 (YCWA)	2.3		●	39.392348	-121.141584		7/18/08-11/3/10	7/18/08-6/1/11				
Upstream of Middle Yuba River	NYR-0.1 (YCWA) T80/NYR 0.0 (YCWA)	0.1		●	39.368694	-121.136793		8/19/08-12/18/08 3/28/09-11/9/10	8/19/08-9/6/11				
Middle Yuba River													
MYR below Milton Diversion Dam	WT08/RM44.4 (PG&E/NID and HDR)	44.4	●		706904	4377488	6/3/08-10/10/08 6/12/09-10/15/09					7/11/10-8/21/10	**Inconsistent UTM River Mile with Temp Logger ID RM.** Logger is located at different river mile than indicated in YB DS water temperature report table.
MYR above East Fork Creek	WT07/RM34.6 (PG&E/NID and HDR)	38.1 (see note)	●		698955	4375845	7/1/08-10/7/08 6/11/09-9/22/09					7/14/10-8/16/10	Per Beth Lawson, logger is located at RM 38.1, not at RM34.6.
MYR above Wolf Creek	WT04/RM26.9 (PG&E/NID and HDR) MYR-26.9 (YCWA)	26.9	●		688857	4367781	6/3/08-10/21/08 5/15/09-10/12/09		7/7/11-10/20/11			7/15/10-8/21/10	
MYR above Kanaka Creek	WT02/RM17.5 (PG&E/NID) MYR-17.5 (YCWA)	16.5 (see note)	●		677071	4365376	5/13/08-10/21/08 5/15/09-10/13/09		7/7/11-10/20/11			7/14/10-8/15/10	**Typo in Water Temp Tech Memo Table.** Per Randy Olden (HDR, email 2/8/13), "the MYR above Kanaka Creek had a river mile in the tech memo table of 17.5. This was likely a typo as the UTM coordinates placed the logger location at river mile 16.5".
MYR above Our House Diversion Impoundment	WT01/RM12.8 (PG&E/NID)	12.8	●		672684	4364578	5/13/08-10/21/08 5/14/09-10/13/09						
Upstream of Our House Diversion Dam Impoundment	T10/MYR-12.2 (YCWA)	12.7[6]	●		39.41302	-120.9946		3/28/09-10/18/11					**YBDS and YCWA YRDP River Mile Differences.** The corresponding YCWA RM for this location is RM 12.2.
MYR below Our House Dam	T30/MYR-11.9 (YCWA)	12.4[7]	●					10/24/08-10/31/11					**YBDS and YCWA YRDP River Mile Differences.** The corresponding YCWA RM for this location is RM 11.9.
MYR above NYR Confluence	T90/RM0.0 (PG&E/NID and YCWA) MYR-0.1 (YCWA)	0.1	●		39 22.118	-120 08.139		8/19/08-12/18/08 3/28/09-10/31/11					
South Yuba River													
South Yuba River below Spaulding Main Dam	WT26/RM40.8 (PG&E/NID and HDR)	40.8	●		702878	4355373	7/3/08-10.21/08 4/1/09-10/13/09					7/10/10-8/17/10	**UTM Error at this Location.** Lat/Long in YB DS table is not on the river. Coordinates that correspond to RM40.8 are at Spaulding Powerhouse No. 2 release downstream of the dam (702878, 4355373).
South Yuba River above Jordan Creek	WT25/RM40.3 (PG&E/NID)	40.3	●		702179	4355046	6/4/08-10/8/08 5/12/09-10/13/09						
SYR above Langs Crossing		40.1	●		701996	4354816						7/14/10-8/10/10	
South Yuba River above Canyon Creek	WT22/RM32.5 (PG&E/NID and HDR)	32.5	●		693956	4359014	5/14/08-10/15/08 4/1/09-10/12/09					7/16/10-8/10/10	
South Yuba River above Poorman Creek	WT20/RM28.1 (PG&E/NID and HDR) SYR-28.1 (YCWA)	28.1 (see note)	●		688516	4358331	5/14/08-10/15/08 5/2/09-10/11/09		8/9/11-10/17/11 (data issues; data not used)			7/14/10-8/10/10	**Quad Map Error at this Location.** The quad map in the YBDS report incorrectly shows the RM of the Poorman Ck confluence (RM28.1). Based on aerials, the confluence is at RM27.9.UTM coordinates show logger at RM 27.9.

Table 5. Locations of Water Temperature Loggers on the South Yuba, Middle Yuba, North Yuba, and Lower Yuba Rivers Used for the Spring-run Chinook Salmon and Steelhead Habitat Summary (2008-2011).

Gage Location Description	Temperature Logger ID and RM (Agency Maintaining Gage)	Temperature Loggers and River Miles Used for Habitat Summaries	River Mile System Source: YB DS Project	River Mile System Source: YCWA Project	Temperature Logger Location: Lat or Northing[1]	Temperature Logger Location: Long or Easting[1]	Dates of Empirical Temperature Data by Source (2008-2011): PG&E/NID YBDS[2]	YCWA YRDP[3]	Yuba Salmon Forum[4]: YCWA	Yuba Salmon Forum[4]: NMFS	Yuba Salmon Forum[4]: SYRCL	HDR[5]	Notes
South Yuba River above Humbug Creek	WT18/RM19.6	19.6	•		678382	4356343	5/13/08-10/7/09 5/14/09-10/11/09					7/14/10-8/10/10	
SYR above Spring Creek	SYR-14.9 (PG&E/NID and HDR)		•		673365	4355611			8/8/11-10/18/11				
SYR above Rock Creek	SYR-10.1 (YCWA)		•		668195	4353202			7/7/11-10/12/11				**Inconsistent UTM River Mile with Temp Logger ID RM.** Logger is located at different river mile than indicated in YBDS water temperature report table.
South Yuba River above Rush Creek/ Jones Bar	WT14/RM6.2 (PG&E/NID) Jones Bar/SYR-6.2 (YCWA)	6.2	•		663480	4350925	5/15/08-10/17/08 4/15/09-10/12/09	5/16/08-6/1/11					
South Yuba River above Englebright Reservoir/ SYR at Bridgeport	WT11/RM0.1 (PG&E/NID and HDR) SYR-0.1 (YCWA)	0.1 (see note)	•		655873	4350818	5/15/08-10/17/08 4/1/09-10/13/09		7/14/11-10/18/11			7/15/10-8/10/10	**Note:** Logger is 1.08 miles upstream from the the Yuba River confluence. **Data gap:** 6/18/08 - 7/7/08
Lower Yuba River													
Downstream of Confluence of North Yuba River and Middle Yuba River	T100/YR-39.7 (YCWA)	39.7		•	39.367839	-121.136655		8/19/08-12/18/08 3/28/09-9/6/11					
Upstream of New Colgate Powerhouse	T110/YR-34.1 (YCWA)	34.1		•	39.330602	-121.187675		8/19/08-12/18/08 3/28/09-9/6/11					
Downstream of New Colgate Powerhouse	T130/YR-33.8 (YCWA)	33.8		•	39.33026	-121.193169		8/19/08-12/18/08 3/28/09-9/6/11					
Downstream of Dobbins Creek	T150/YR-33.6 (YCWA)	33.6		•	39.328398	-121.196162		3/28/09-9/6/11					
Downstream of Narrows #2 Powerhouse at Smartville	T170/YR 23.6 (YCWA)	23.6		•	39.235799	-121.272688		4/15/09-2/14/11					
Downstream of Deer Creek	T180/YR 22.7 (YCWA)	22.7		•	39.230047	-121.285165		11/8/08-2/14/11					
Downstream of Dry Creek	T190/YR13.3 (YCWA)	13.3		•	39.219611	-121.415128		11/8/08-3/9/09					
At USACE's Daguerre Point Dam Fish Ladder	T210/ YR 11.4 (YCWA)	11.4		•	39.208009	-121.443116		11/18/08-11/14/10					
At Walnut Avenue (Near Western Extent of Yuba Goldfields)	T220/YR 8.1 (YCWA)	8.1		•	39.18822	-121.495307		8/28/08-2/7/11					
At Marysville Gage	Marysville/YR 6 (YCWA)			•	39.176164	-121.524386		1/1/08-4/1/11					
Upstream of Simpson Lane (Between Yuba Goldfields and Marysville)	T230/YR 4.8 (YCWA)	4.8		•	39.165328	-121.54135		8/28/08-2/7/11					Loggers are installed in an area that becomes a backwater a lower flows.
At Marysville	T240/YR 0.7 (YCWA)	0.7		•	39.13451	-121.59072		8/21/08-3/2/11					

[1] Unless indicated, coordinates listed in this table are provided in coordinate system used in the source table.
[2] Yuba-Bear Drum-Spaulding projects (Aug 2010 Water Temperature Technical Memo, Table 2.1-1)
[3] Yuba County Water Agency Yuba River Development Project Revised Water Temperature Study Plan Table 5.3.1-1
[4] Yuba Salmon Forum Studies Water Temperature Reports and updates (2011 and 2012).
[5] Data provided by HDR to Cardno ENTRIX
[6] RM 12.2 in the YCWA and YSF studies using the YCWA Project river mile line work.
[7] RM 11.9 in the YCWA and YSF studies using the YCWA Project river mile line work.

Table 6. Habitat Summary Methods Description.

Life Stage or Physical Habitat Feature	Description
Upstream Fish Passage Barriers	
Length of Barrier-free River	The length of barrier-free habitat downstream of the most downstream total barrier to upstream migration.
Spring-Run Chinook Salmon	
Adult Migration (Apr – Aug)	
Trap and Haul	Date when summer water temperatures exceeded temperature criteria for adult migration at specified locations considered for trap and haul.
Volitional	Date when summer water temperatures exceeded temperature criteria for adult migration at main tributary confluences and facilities upstream of Englebright Dam.
Adult Holding (Apr – Aug)	
Adult Holding	Length of thermally suitable and accessible summer holding habitat within the accessible channel.
Holding Pools	Total number of suitable holding pools within thermally-suitable barrier-free reaches.
Adult Spawning (Sept – Nov 15)	
Adult Spawning	Length of thermally suitable adult spawning habitat within the accessible channel.
Spawning Gravels	Amount of spawning gravel within adult spawning habitat.
Spawning Redds	Estimated number of spawning redds within adult spawning habitat.
Embryo Incubation (Sept – Feb)	
Embryo Incubation	Length of thermally suitable habitat for embryo incubation.
Juvenile Rearing and Downstream Movement (Year-round)	
Juvenile Rearing and Downstream Movement	Length of thermally suitable habitat within the accessible channel.
Juvenile Rearing and Downstream Movement (Year-round) (continued)	
Rearing Habitat	Amount (area) of rearing habitat within juvenile rearing habitat reach.
Smolt Emigration (Oct – May 15)	
Smolt Emigration	Length of thermally suitable habitat for smolt emigration.

Table 6. Habitat Summary Methods Description (continued).

Life Stage or Physical Habitat Feature	Description
Steelhead	
Juvenile Rearing and Downstream Movement (Year-round)	
Juvenile Rearing and Downstream Movement	Length of thermally suitable habitat within the accessible channel.
Rearing Habitat	Amount (area) of rearing habitat within juvenile rearing habitat reach.
Tributary Rearing Habitat	Length of available habitat.

Table 7. Locations Evaluated for Trap and Haul and Volitional Adult Migration Timing Limitations Based on Temperature (April - August) in the Upper Yuba Watershed.

Location for Temperature Analysis			River Mile System Source[1]	
River Reach	**Location**	**Temperature Logger and River Mile**	**YB DS Project**	**YCWA Project**
Trap and Haul				
North Yuba River above New Bullards Bar	Hwy 49 Crossing	NYR at Hwy49 Bridge (RM 23.4)		•
Middle Yuba River	Above Our House Diversion Dam	Upstream of Our House Diversion Dam Impoundment (RM12.7)	•	
South Yuba River	Edwards Crossing	South Yuba River above Poorman Creek (RM 28.1)	•	
	Washington	South Yuba River above Humbug Creek (RM 19.6)	•	
Volitional Passage				
Middle Yuba River	MYR above Yuba River confluence	MYR above NYR Confluence (RM 0.05)	•	
South Yuba River	SYR above Yuba River confluence	South Yuba River above Englebright Reservoir/ SYR at Bridgeport 0.1 (this is 1.08 mi. upstream from Yuba River confluence)	•	
Yuba River above New Colgate Powerhouse	Yuba River above New Colgate Powerhouse	Upstream of New Colgate Powerhouse (RM 34.1)		•
Yuba River from New Colgate Powerhouse to Englebright Reservoir	Yuba River above Englebright Dam	Downstream of Dobbins Creek (RM 33.6)		•
Lower Yuba River - Englebright Dam to Feather River	Yuba River above Feather River confluence	Downstream of Narrows #2 Powerhouse at Smartville (RM 23.6)		•

[1] Source for river mile data. River mile data are available from the Yuba-Bear Drum-Spaulding relicensing studies and the YCWA relicensing studies.

Table 8. Spring-Run Chinook Salmon Habitat Summary – Existing Conditions.

Life Stage[1] or Physical Habitat Feature	Temperature Criteria[2]		River Reach and Year																											
			North Yuba River above New Bullards Bar Reservoir				Middle Yuba River				South Yuba River				North Yuba River below New Bullards Bar Dam				Yuba River above New Colgate Powerhouse				Yuba River from New Colgate Powerhouse to Englebright Reservoir				Lower Yuba River below Englebright Dam to Feather River			
			2008	2009	2010	2011	2008	2009	2010	2011	2008	2009	2010	2011	2008	2009	2010	2011	2008	2009	2010	2011	2008	2009	2010	2011	2008	2009	2010	2011
Upstream Fish Passage Barriers																														
Length of Barrier-free River (miles)			33.7 (Loves Falls)				35.1[3] (22.2 miles above Our House Diversion				34.9				2.3				5.8				1.7				24			
Adult Migration (Apr – Aug)																														
Trap and Haul																														
Location			Hwy 49 Crossing (RM 23.5)				Above Our House Diversion Dam (RM 12.7)				Edwards Crossing (top) (RM 19.6) or Washington (bottom) (RM 28.1)																			
Trap and Haul (date when temperature exceeds temperature criteria)	UO	64°F	25-Jun	26-Jun	12-Jul	NL	11-Jun	16-Jun	NA	16-Jul	6-Jun 10-Jun	15-Jun 17-Jun	NA NA	NA NA																
	UT	68°F	4-Jul	16-Jul	NL	NL	22-Jun	24-Jun	NA	22-Jul	14-Jun 19-Jun	21-Jun 24-Jun	NA NA	NA NA																
Volitional																														
Location							At Middle Yuba River above Yuba River Confluence				At South Yuba River above Englebright High Water Mark				At North Yuba River above Middle Yuba River Confluence				At Yuba River Above New Colgate Powerhouse (RM 34.1)				at Yuba River above Englebright Dam (RM 24.0)				at Yuba River above Feather River Confluence (RM 0.7)			
Volitional (date when temperature exceeds temperature criteria)	UO	64°F					NA	16-May	12-Jun	30-Jun	NA	27-May	NA	NA	NA	17-May	15-Jun	NA	NA	15-May	4-Jun	6-Jul	NL	NL	NL	NL	NL	NL	NL	NL
	UT	68°F					NA	26-May	22-Jun	3-Jul	NA	14-Jun	NA	18-Jul	NA	17-Jun	24-Jun	NA	NA	24-May	20-Jun	8-Jul	NL	NL	NL	NL	NL	NL	NL	NL
Adult Holding (Apr – Aug)																														
Length of Holding Habitat (miles)	UO	61°F	0	0	4.4	21.2	1.1	1.5	2.4	3.5	0	0	0	0	0.6	0.8	0.9	1	0	0	0	0	1.7	1.7	1.7	1.7	15.7	15.8	16.3	15.9
	$UT_{General\ lit}$	65°F	5.5	5.4	21.8	33.7	5.3	5	7.6	10.1	0	0	0	0.8	1	1.2	1.3	1.4	0	0	0	0	1.7	1.7	1.7	1.7	24	24	24	24
	$UT_{Butte\ Creek}$	66°F	9.2	9	23.3	33.7	6.3	5.9	9.2	12.6	0	0	0	1.3	1.1	1.3	1.4	1.5	0	0	0	0	1.7	1.7	1.7	1.7	24	24	24	24
No. of Holding Pools ≥ 10' deep w/cover (Holding Pools 4' - <10' deep or deeper w/o cover)[4]	UO	61°F	0 (0)	0 (0)	3 (24)	25 (96)	3	6	13	15	0	0	0	0	L[7]	L[7]	L[7]	L[7]	0	0	0	0	L[8]	L[8]	L[8]	L[8]	69[10]	69[10]	89[10]	85[10]
	$UT_{General\ lit}$	65°F	5 (28)	5 (28)	25 (99)	53 (152)	15	15	15	17	0	0	0	3	L[7]	L[7]	L[7]	L[7]	0	0	0	0	L[8]	L[8]	L[8]	L[8]	115[10]	115[10]	115[10]	115[10]
	$UT_{Butte\ Creek}$	66°F	6 (41)	6 (40)	32 (105)	53 (152)	15	15	15	17	0	0	0	3	L[7]	L[7]	L[7]	L[7]	0	0	0	0	L[8]	L[8]	L[8]	L[8]	144[10]	144[10]	144[10]	144[10]
Adult Spawning (Sept – Nov 15)[11]																														
Length of Adult Spawning Habitat (Hold + 2.2 mi Downstream) (miles)	UO	61°F	0	0	6.6	23.4	3.3	3.7	4.6	5.7	0	0	0	0	2.3	2.3	2.3	2.3	0	0	0	0	1.7	1.7	1.7	1.7	17.9	18	18.5	18.1
	$UT_{General\ lit}$	65°F	7.7	7.6	24	33.7	7.5	7.2	9.8	12.3	0	0	0	3	2.3	2.3	2.3	2.3	0	0	0	0	1.7	1.7	1.7	1.7	24	24	24	24
	$UT_{Butte\ Creek}$	66°F	11.4	11.2	25.5	33.7	8.5	8.1	11.4	14.8	0	0	0	3.5	2.3	2.3	2.3	2.3	0	0	0	0	1.7	1.7	1.7	1.7	24	24	24	24
Amount of Spawning Gravel (doesn't include depth and velocity suitability except for the Lower Yuba River) (area ft^2 x 1000)	UO	61°F	0	0	12	195	4	5	5	10	0	0	0	0	L	L	L	L	L	L	L	L	6	6	6	6	6,646	6,704	6,821	6,745
	$UT_{General\ lit}$	65°F	17	17	197	316	19	18	25	42	0	0	0	4	L	L	L	L	L	L	L	L	6	6	6	6	7,597	7,656	7,692	7,672
	$UT_{Butte\ Creek}$	66°F	29	29	202	316	22	21	36	57	0	0	0	5	L	L	L	L	L	L	L	L	6	6	6	6	7,597	7,656	7,692	7,672
No. of Spawning Redds (# redds @ 94ft^2/redd)[6]	UO	61°F	0	0	129	2,069	44	51	55	110	0	0	0	0	L	L	L	L	L	L	L	L	59	59	59	59	70,707	71,316	72,567	71,752
	$UT_{General\ lit}$	65°F	183	179	2,094	3,358	206	190	264	451	0	0	0	40	L	L	L	L	L	L	L	L	59	59	59	59	80,818	81,442	81,833	81,613
	$UT_{Butte\ Creek}$	66°F	305	304	2,153	3,358	238	224	379	606	0	0	0	48	L	L	L	L	L	L	L	L	59	59	59	59	80,818	81,442	81,833	81,613
Length of Adult Spawning Habitat Based on Sept 15-30 Temperature[5] (miles)	UO	56°F	11.6	1.5	19.9	17.8	5.6	2.7	NA	NA	0	0	NA	NA	1.2	1.1	1.2	1.1	0	0	0	0	1.7	1.7	1.7	1.7	3.7	4	3.4	3.7
	UT	58°F	20.6	10.4	28.7	23.9	9	5.5	NA	NA	0.6	0	NA	NA	1.6	1.3	1.6	1.3	0	0	0	0	1.7	1.7	1.7	1.7	9.5	8.7	9.3	11.1
Embryo Incubation (Sept – Feb)																														
Embryo Incubation	UO	56°F	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL
	UT	58°F	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL
Juvenile Rearing and Downstream Movement (Year – round)																														
Length of Juvenile Rearing & Downstream Movement (miles)	UO	61°F	0	0	4.4	21.2	1.1	1.5	2.4	3.5	0	0	0	0	0.6	0.8	0.9	1	0	0	0	0	1.7	1.7	1.7	1.7	15.7	15.8	16.3	15.9
	UT	65°F	5.5	5.4	21.8	33.7	5.3	5	7.6	10.1	0	0	0	0.8	1	1.2	1.3	1.4	0	0	0	0	1.7	1.7	1.7	1.7	24	24	24	24
Amount of Rearing Habitat (area ft^2 x 1000)	UO	61°F	0	0	416	1,936	52	93	154	211	0	0	0	0	38.5[9]	51.3[9]	57.8[9]	64.2[9]	0	0	0	0	L[8]	L[8]	L[8]	L[8]	6,893	6,468	6,404	6,139
	UT	65°F	593	568	2,373	3,384	251	310	499	667	0	0	0	88	64.2[9]	77[9]	83.4[9]	89.8[9]	0	0	0	0	L[8]	L[8]	L[8]	L[8]	10,913	10,039	9,626	9,542
Smolt Emigration (Oct - May 15)																														
Smolt Emigration	UO	63°F	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL
	UT	68°F	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL

Legend/Abbreviations: NA - No data available; NL - Temperature not a limiting factor during this time period; L - Limiting based on low gravel availability.

Volitional passage or Trap and Haul not applicable at this location.

[1] See Table 4 for lifestage periodicity tables.

[2] UO = Upper Optimum, UT = Upper Tolerable. $UT_{General\ Lit}$: Derived from a general literature review, including empirical temperature data from Butte Creek. $UT_{Butte\ Creek}$: Derived from a specific analysis of the average MWAT in years when there was not obvious summer holding mortality temperature observed at Butte Creek due to temperature.

[3] Assuming passage at Our House Diversion Dam.

[4] Data for holding pools less than 10'deep were only available in the North Yuba River.

[5] Calculated independent of holding habitat. Miles calculated in the table by using the median MWAT the last two weeks of September (note: many of the empirical and modeling data sets do not extend beyond September).

[6] The number of redds was estimated using 94 ft^2/redd. Also see Redd Sensitivity Analysis Appendix.

[7] Relatively low flows occur within this reach.

[8] This is a peaking reach with fluctuating high and low flows.

[9] Assumed minimum instream flow release during July and August (5 cfs).

[10] Pools evaluated based on depth only. Includes pools ≥ 100 feet square.

[11] Temperature criteria are holding temperature criteria.

Table 9. Spring-Run Chinook Salmon Habitat Summary – Middle Yuba River Existing Conditions and Modeled Scenarios.

Life Stage[1] or Physical Habitat Feature	Temperature Criteria[2]		Flow Scenarios[9]																							
			Existing Conditions				Preliminary 4(e) Conditions				CDFG / FWN				NMFS				Unimpaired				Modeled Base Case			
			2008	2009	2010	2011	2008	2009	2010	2011	2008	2009	2010	2011	2008	2009	2010	2011	2008	2009	2010	2011	2008	2009	2010	2011
Upstream Fish Passage Barriers																										
Length of Barrier-free River (miles)			35.1[3] (22.2 miles above Our House Diversion Dam)																							
Adult Migration (Apr – Aug)																										
Trap and Haul																										
Location			Above Our House Diversion Dam (RM 12.7)																							
Trap and Haul (date when temperature exceeds temperature criteria)	UO	64°F	11-Jun	16-Jun	NA	NA	9-Jun	12-Jun			9-Jun	12-Jun			14-Jun	17-Jun			11-Jun	16-Jun			9-Jun	9-Jun		
	UT	68°F	22-Jun	24-Jun	NA	NA	16-Jun	20-Jun			16-Jun	20-Jun			25-Jun	25-Jun			22-Jun	24-Jun			14-Jun	17-Jun		
Volitional																										
Location			At Middle Yuba River above Confluence																							
Volitional (date when temperature exceeds temperature criteria)	UO	64°F	NA	16-May	12-Jun	30-Jun	NA	NA			NA	NA			NA	NA			NA	16-May			NA	NA		
	UT	68°F	NA	26-May	22-Jun	3-Jul	NA	NA			NA	NA			NA	NA			NA	26-May			NA	NA		
Adult Holding (Apr – Aug)																										
Length of Holding Habitat (miles)	UO	61°F	1.1	1.5	2.4	3.5	0 (2.7)[4]	0 (2.6)[4]			1.6 (4.5)[4]	1.5 (4.9)[4]			4.1 (6.7)[4]	2.8 (5.8)[4]			1.1	1.5			0	0		
	UT General lit	65°F	5.3	5	7.6	10.1	4.4 (6.8)[4]	3.4 (6.1)[4]			6.7 (8.2)[4]	6.6 (8.2)[4]			9.8 (11.3)[4]	7.9 (8.9)[4]			5.3	5			2.6	1.9		
	UT Butte Creek	66°F	6.3	5.9	9.2	12.6	5.6 (7.8)[4]	4.5 (7.0)[4]			7.9 (9.1)[4]	7.9 (8.4)[4]			11.4 (12.9)[4]	9.8 (10.6)[4]			6.3	5.9			3.8	3.1		
No. of Holding Pools ≥ 10' deep w/cover[5]	UO	61°F	3	6	13	15	0 (13)	0 (13)			6 (15)	6 (15)			15 (15)	14 (15)			3	6			0	0		
	UT General lit	65°F	15	15	15	17	15 (15)	15 (15)			15 (15)	15 (15)			17 (17)	15 (15)			15	15			13	7		
	UT Butte Creek	66°F	15	15	15	17	15 (15)	15 (15)			15 (15)	15 (15)			17 (17)	17 (17)			15	15			15	15		
Adult Spawning (Sept – Nov 15)[8]																										
Length of Adult Spawning (Hold + 2.2 mi Downstream)(miles)	UO	61°F	3.3	3.7	4.6	5.7	0 (4.9)[4]	0 (4.8)[4]			3.8 (6.7)[4]	3.7 (6.1)[4]			6.3 (8.9)[4]	5 (8.0)[4]			3.3	3.7			0	0		
	UT General lit	65°F	7.5	7.2	9.8	12.3	6.6 (9.0)[4]	5.6 (8.3)[4]			8.9 (10.4)[4]	8.8 (10.4)[4]			12 (13.5)[4]	10.1 (11.1)[4]			7.5	7.2			4.8	3.1		
	UT Butte Creek	66°F	8.5	8.1	11.4	14.8	7.8 (10.0)[4]	6.7 (9.2)[4]			10.1 (11.3)[4]	10.1 (10.6)[4]			13.6 (15.1)[4]	12 (12.8)[4]			8.5	8.1			6	5.3		
Amount of Spawning Gravel (doesn't include depth and velocity suitability) (area ft^2 x 1000)	UO	61°F	4	5	5	10	0 (7)[4]	0 (6)[4]			5 (17)[4]	5 (18)[4]			11 (23)[4]	8 (21)[4]			4	5			0	0		
	UT General lit	65°F	19	18	25	42	16 (23)[4]	9 (22)[4]			23 (29)[4]	23 (29)[4]			42 (51)[4]	28 (33)[4]			19	18			6	5		
	UT Butte Creek	66°F	22	21	36	57	20 (27)[4]	17 (23)[4]			28 (34)[4]	28 (30)[4]			51 (57)[4]	42 (48)[4]			22	21			11	8		
No. of Spawning Redds (# redds @ 94ft^2/redd)[7]	UO	61°F	44	50	55	110	0 (73)[4]	0 (64)[4]			52 (179)[4]	50 (190)[4]			118 (240)[4]	83 (221)[4]			44	51			0	0		
	UT General lit	65°F	206	190	264	451	174 (240)[4]	100 (237)[4]			240 (312)[4]	240 (312)[4]			442 (539)[4]	297 (347)[4]			206	190			64	54		
	UT Butte Creek	66°F	238	224	379	606	213 (290)[4]	179 (240)[4]			297 (358)[4]	297 (315)[4]			541 (611)[4]	442 (506)[4]			238	224			112	86		
Length of Adult Spawning Based on Sept 15-30 Temperature[6] (miles)	UO	56°F	5.6	2.7	NA	NA	4.3	0			4.3	0			9.7	0			5.6	2.7			6	0.5		
	UT	58°F	9	5.5	NA	NA	11.8	2.4			11.8	2.4			17.9	5.7			9	5.5			12.2	4		
Embryo Incubation (Sept – Feb)																										
Embryo Incubation	UO	56°F	NL	NL	NL	NL	NL	NL			NL	NL			NL	NL			NL	NL			NL	NL		
	UT	58°F	NL	NL	NL	NL	NL	NL			NL	NL			NL	NL			NL	NL			NL	NL		
Juvenile Rearing and Downstream Movement (Year – round)																										
Length of Juvenile Rearing & Downstream Movement (miles)	UO	61°F	1.1	1.5	2.4	3.5	0 (2.7)[4]	0 (2.6)[4]			1.6 (4.5)[4]	1.5 (4.9)[4]			4.1 (6.7)[4]	2.8 (5.8)[4]			1.1	1.5			0	0		
	UT	65°F	5.3	5	7.6	10.1	4.4 (6.8)[4]	3.4 (6.1)[4]			6.7 (8.2)[4]	6.6 (8.2)[4]			9.8 (11.3)[4]	7.9 (8.9)[4]			5.3	5			2.6	1.9		
Amount of Rearing Habitat (area ft^2 x 1000) (Adjusted Middle Yuba Model Temperature)	UO	61°F	52	93	157	211	0 (157)[4]	0 (151)[4]			93 (261)[4]	87 (284)[4]			284 (464)[4]	194 (402)[4]			52	93			0	0		
	UT	65°F	251	310	499	667	255 (394)[4]	197 (354)[4]			389 (476)[4]	383 (476)[4]			741 (903)[4]	547 (644)[4]			251	310			129	94		
Smolt Emigration (Oct-May 15)																										
Smolt Emigration	UO	63°F	NL	NL	NL	NL	NL	NL			NL	NL			NL	NL			NL	NL			NL	NL		
	UT	68°F	NL	NL	NL	NL	NL	NL			NL	NL			NL	NL			NL	NL			NL	NL		

Legend/Abbreviations: NA - No data available; NL - Temperature not a limiting factor during this time period.

Volitional passage or Trap and Haul not applicable at this location.

[1] See Table 4 for lifestage periodicity tables.
[2] UO = Upper Optimum, UT = Upper Tolerable. UTGeneral Lit: Derived from a general literature review, including empirical temperature data from Butte Creek. UTButte Creek: Derived from a specific analysis of the average MWAT in years when there was not obvious summer holding mortality temperature observed at Butte Creek due to temperature.
[3] Assuming passage at Our House Diversion Dam.
[4] Adjusted Middle Yuba Model Temperature. This was an attempt to compensate for the slight overestimate of temperature by the model in the upper reach.
[5] Data for holding pools less than 10'deep were only available in the North Yuba River.
[6] Calculated independent of holding habitat. Miles calculated in the table by using the median MWAT the last two weeks of September (note: many of the empirical and modeling data sets do not exte
[7] The number of redds was estimated using 94 ft^2/redd. Also see Redd Sensitivity Analysis Appendix.
[8] Temperature criteria are holding temperature criteria.
[9] Existing Conditions = empirical data; Modeled Base Case = from model developed fo

Table 10. Spring-Run Chinook Salmon Habitat Summary – South Yuba River Existing Conditions and Modeled Scenarios

Life Stage[1] or Physical Habitat Feature	Temperature Criteria[2]		Flow Scenarios[7]																								
			Existing Conditions				Preliminary 4(e) Conditions				CDFG / FWN				NMFS				Unimpaired				Modeled Base Case			
			2008	2009	2010	2011	2008	2009	2010	2011	2008	2009	2010	2011	2008	2009	2010	2011	2008	2009	2010	2011	2008	2009	2010	2011
Upstream Fish Passage Barriers																											
Length of Barrier-free River (miles)			34.9																								
Adult Migration (Apr – Aug)																											
Trap and Haul																											
Location			Edwards Crossing (top) (RM 19.6) or Washington (bottom) (RM 28.1)																								
Trap and Haul (date when temperature exceeds temperature criteria)	UO	64°F	6-Jun	15-Jun	NA	NA	6-Jun	15-Jun			6-Jun	15-Jun			11-Jun	21-Jun			6-Jun	15-Jun			< 1-Jun	25-Jun		
			10-Jun	17-Jun	NA	NA	10-Jun	19-Jun			10-Jun	19-Jun			30-Jun	28-Jun			10-Jun	17-Jun			< 1-Jun	26-Jun		
	UT	68°F	14-Jun	21-Jun	NA	NA	11-Jun	22-Jun			11-Jun	22-Jun			1-Jul	29-Jun			14-Jun	21-Jun			< 1-Jun	27-Jun		
			19-Jun	24-Jun	NA	NA	29-Jun	27-Jun			29-Jun	27-Jun			13-Aug	17-Jul			19-Jun	24-Jun			8-Jun	28-Jun		
Volitional																											
Location			At South Yuba River above Confluence																								
Volitional (date when temperature exceeds temperature criteria)	UO	64°F	NA	27-May	NA	NA	< 1-Jun	10-Jun			< 1-Jun	10-Jun			4-Jun	13-Jun			NA	27-May			< 1-Jun	< 1-Jun		
	UT	68°F	NA	14-Jun	NA	18-Jul	7-Jun	15-Jun			7-Jun	15-Jun			10-Jun	20-Jun			NA	14-Jun			< 1-Jun	24-Jun		
Adult Holding (Apr – Aug)																											
Length of Holding Habitat (miles)	UO	61°F	0	0	0	0	0	0			0	0			0	0			0	0			0	0		
	UT$_{\text{General lit}}$	65°F	0	0	0	0.8	0.2	0			1.1	1.3			2.2	1.9			0	0			0	0		
	UT$_{\text{Butte Creek}}$	66°F	0	0	0	1.3	1.1	0.8			2.1	2.1			2.9	2.2			0	0			0	0		
No. of Holding Pools ≥ 10' deep w/cover (Adjusted Middle Yuba Model Temperature)[3]	UO	61°F	0	0	0	0	0	0			0	0			0	0			0	0			0	0		
	UT$_{\text{General lit}}$	65°F	0	0	0	3	3	0			3	3			3	3			0	0			0	0		
	UT$_{\text{Butte Creek}}$	66°F	0	0	0	3	3	3			3	3			4	3			0	0			0	0		
Adult Spawning (Sept – Nov 15)[6]																											
Length of Adult Spawning (Hold + 2.2 mi Downstream) (miles)	UO	61°F	0	0	0	0	0	0			0	0			0	0			0	0			0	0		
	UT$_{\text{General lit}}$	65°F	0	0	0	3	2.4	0			3.3	3.5			4.4	4.1			0	0			0	0		
	UT$_{\text{Butte Creek}}$	66°F	0	0	0	3.5	3.3	3			4.3	4.3			5.1	4.4			0	0			0	0		
Amount of Spawning Gravel (doesn't include depth and velocity suitability) (area ft2 x 1000)	UO	61°F	0	0	0	0	0	0			0	0			0	0			0	0			0	0		
	UT$_{\text{General lit}}$	65°F	0	0	0	4	3	0			4	5			7	5			0	0			0	0		
	UT$_{\text{Butte Creek}}$	66°F	0	0	0	5	4	4			6	6			10	7			0	0			0	0		
No. of Spawning Redds (# redds @ 94ft^2/redd)[5]	UO	61°F	0	0	0	0	0	0			0	0			0	0			0	0			0	0		
	UT$_{\text{General lit}}$	65°F	0	0	0	40	36	0			46	48			75	52			0	0			0	0		
	UT$_{\text{Butte Creek}}$	66°F	0	0	0	48	46	40			66	66			105	75			0	0			0	0		
Length of Adult Spawning Based on Sept 15-30 Temperature[4] (miles)	UO	56°F	0	0	NA	NA	0	0			0	0			0	0			0	0			0	0		
	UT	58°F	0.6	0	NA	NA	0	0			0	0			0	0			0.6	0			0	0		
Embryo Incubation (Sept – Feb)																											
Embryo Incubation	UO	56°F	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL
	UT	58°F	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL
Juvenile Rearing and Downstream Movement (Year – round)																											
Length of Juvenile Rearing & Downstream Movement (miles)	UO	61°F	0	0	0	0	0	0			0	0			0	0			0	0			0	0		
	UT	65°F	0	0	0	0.8	0.2	0			1.1	1.3			2.2	1.9			0	0			0	0		
Amount of Rearing Habitat (area ft^2 x 1000)	UO	61°F	0	0	0	0	0	0			0	0			0	0			0	0			0	0		
	UT	65°F	0	0	0	88	25	0			136	161			266	230			0	0			0	0		
Smolt Emigration (Oct-May 15)																											
Smolt Emigration	UO	63°F	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL
	UT	68°F	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL	NL

Legend/Abbreviations: NA - No data available; NL - Temperature not a limiting factor during this time period.

Volitional passage or Trap and Haul not applicable at this location.

[1] See Table 4 for lifestage periodicity tables.

[2] UO = Upper Optimum, UT = Upper Tolerable. UTGeneral Lit: Derived from a general literature review, including empirical temperature data from Butte Creek. UTButte Creek: Derived from a specific analysis of the average MWAT in years when there was not obvious summer holding mortality temperature observed at Butte Creek due to temperature.

[3] Data for holding pools less than 10'deep were only available in the North Yuba River.

[4] Calculated independent of holding habitat. Miles calculated in the table by using the median MWAT the last two weeks of September (note: many of the empirical and modeling data sets do not extend beyond September).

[5] The number of redds was estimated using 94 ft^2/redd. Also see Redd Sensitivity Analysis Appendix.

[6] Temperature criteria are holding temperature criteria.

[7] Existing Conditions = empirical data; Modeled Base Case = from model developed for YBDS relicensing

Table 11. Steelhead Habitat Summary under Existing Conditions for All Reaches (top), Middle and South Yuba Rivers under Existing Conditions and Modeled Flow Scenarios (bottom).

Existing Conditions - All Reaches

Life Stage[1] or Physical Habitat Feature	Temperature Criteria[2]		River Reach and Year																											
			North Yuba River above New Bullards Bar Reservoir				Middle Yuba River				South Yuba River				North Yuba River below New Bullards Bar Dam				Yuba River above New Colgate Powerhouse				Yuba River from New Colgate Powerhouse to Englebright Reservoir				Lower Yuba River below Englebright Dam to Feather River			
			2008	2009	2010	2011	2008	2009	2010	2011	2008	2009	2010	2011	2008	2009	2010	2011	2008	2009	2010	2011	2008	2009	2010	2011	2008	2009	2010	2011
Upstream Fish Passage Barriers																														
Length of Barrier-free River (miles)			33.7				35.1[3] (22.2 miles above Our House Diversion				34.9				2.3				5.8				1.7				24			
Juvenile Rearing and Downstream Movement (Year–round)																														
Length of Juvenile Rearing & Downstream Movement (miles)	UO	65°F	5.5	5.4	21.8	33.7	5.3	5	7.6	10.1	0	0	0	0.8	1	1.2	1.3	1.4	0	0	0	0	1.7	1.7	1.7	1.7	24	24	24	24
	UT	68°F	16.6	16.5	31	33.7	8.5	7.6	13.1	17.4	0.3	0.1	0.3	2.3	1.3	1.4	1.6	1.7	0	0	0	0	1.7	1.7	1.7	1.7	24	24	24	24
Rearing Habitat (area ft^2 x 1000)	UO	65°F	593	568	2,373	3,384	251	310	507	668	0	0	0	87	64.2	77	83.4	89.8	0	0	0	0	L[5]	L[5]	L[5]	L[5]	11,357	10,472	9,926	9,664
	UT	68°F	1,894	1,829	3,626	3,384	411	471	1066	1333	25	9	33	251	83.4	89.8	102.7	109.1	0	0	0	0	L[5]	L[5]	L[5]	L[5]	11,357	10,472	9,926	9,664

Middle and South Yuba Rivers Existing Conditions and Modeled Scenarios

Life Stage[1] or Physical Habitat Feature	Temperature Criteria[2]		Flow Scenarios																							
			Existing Conditions				Preliminary 4(e) Conditions				CDFG / FWN				NMFS				Unimpaired				Modeled Base Case			
			2008	2009	2010	2011	2008	2009	2010	2011	2008	2009	2010	2011	2008	2009	2010	2011	2008	2009	2010	2011	2008	2009	2010	2011
Middle Yuba River																										
Upstream Fish Passage Barriers																										
Length of Barrier-free River (miles)			35.1[3] (22.2 miles above Our House Diversion Dam)																							
Juvenile Rearing and Downstream Movement (Year – round)																										
Length of Juvenile Rearing & Downstream Movement (miles)	UO	65°F	5.3	5	7.6	10.1	4.4 (6.8)[4]	3.4 (6.1)[4]			6.7 (8.2)[4]	6.6 (8.2)[4]			9.8 (11.3)[4]	7.9 (8.9)[4]			5.3	5			2.6	1.9		
	UT	68°F	8.5	7.6	13.1	17.4	8.8 (10.4)[4]	6.9 (8.5)[4]			10.8 (12.3)[4]	10.8 (11.5)[4]			14.7 (16.3)[4]	13.2 (14.0)[4]			8.5	7.6			6.2	5.4		
Amount of Rearing Habitat (area ft^2 x 1000) (Adjusted Middle Yuba Model Temperature)	UO	65°F	251	310	507	668	255 (394)[4]	197 (354)[4]			389 (476)[4]	383 (476)[4]			741 (903)[4]	547 (644)[4]			251	310			129	94		
	UT	68°F	411	471	1066	1333	529 (671)[4]	400 (502)[4]			707 (840)[4]	707 (769)[4]			1270 (1443)[4]	1108 (1195)[4]			411	471			306	267		
South Yuba River																										
Upstream Fish Passage Barriers																										
Length of Barrier-free River (miles)			34.9																							
Juvenile Rearing and Downstream Movement (Year – round)																										
Length of Juvenile Rearing & Downstream Movement (miles)	UO	65°F	0	0	0	0.8	0.2	0			1.1	1.3			2.2	1.9			0	0			0	0		
	UT	68°F	0.3	0.1	0.3	2.3	2.9	2.2			3.7	3.2			5.7	3.6			0.3	0.1			0	0		
Amount of Rearing Habitat (area ft^2 x 1000) (Adjusted Middle Yuba Model Temperature)	UO	65°F	0	0	0	87	25	0			136	161			266	230			0	0			0	0		
	UT	68°F	25	9	33	251	351	273			372	190			636	360			25	9			0	0		

Legend/Abbreviations: NA - No data available; L - Limiting based on low gravel availability.

[1] See Table 4 for lifestage periodicity tables.
[2] UO = Upper Optimum, UT = Upper Tolerable.
[3] Assuming passage at Our House Dam.
[4] Adjusted Middle Yuba Model Temperatures. This was an attempt to compensate for the slight over-estimate of water temperature by the model in the upper reach.
[5] This is a peaking reach with fluctuating high and low flows.

Table 12. Potential Barrier-free Steelhead Tributary Habitat in North, Middle, and South Yuba Rivers.

Tributary	Approximate RM Location on Main Stem River	Potential Barrier-free Tributary Habitat (miles)	Surveyed and Method	Additional Data Needed
North Yuba River				
Haypress Creek	50.1	1.3	Helicopter and foot survey ≤ 0.5 miles at mouth	Foot surveys
Hackmans Ravine	49.2	<0.2	Foot survey ≤ 0.5 miles at mouth	
Negro Canyon	43.9	<0.1	Foot survey ≤ 0.5 miles at mouth	
Ladies Creek/Little Ladies	43.5	0.3	Helicopter	Foot surveys
Jim Crow Creek	39.4	0.9	Helicopter and foot survey ≤ 0.5 miles at mouth	Foot surveys
San Juan Canyon Creek	0.3	0.3	Helicopter and foot survey ≤ 0.5 miles at mouth	Foot surveys
Downie River	36.3	6.5	Helicopter and foot survey ≤ 0.5 miles at mouth	Foot surveys
Pauley Creek	0.8	<0.2	Helicopter and foot survey ≤ 0.5 miles at mouth	
Lavezzola Creek	1.8	<0.2	Helicopter and foot survey ≤ 0.5 miles at mouth	
Slug Creek	35.8	<0.1	Foot survey ≤ 0.5 miles at mouth	
Woodruff Creek	32.2	0.9	Helicopter and foot survey ≤ 0.5 miles at mouth	Foot surveys
Rock Creek	0.2	<0.4	Foot survey ≤ 0.5 miles at mouth	Foot surveys
Goodyears Creek	32.0	3.0	Helicopter and foot survey ≤ 0.5 miles at mouth	Foot surveys
Humbug Creek	25.2	<0.2	Foot survey ≤ 0.5 miles at mouth	
Fiddle Creek	24.3	<0.6	Helicopter and foot survey ≤ 0.5 miles at mouth	
Indian Creek	22.4	0.7	Helicopter and foot survey ≤ 0.5 miles at mouth	Foot surveys
Cherokee Creek	21.5	<0.3	Foot survey ≤ 0.5 miles at mouth	
Canyon Creek (NYR)	20.1	1.7	Helicopter and foot survey ≤ 0.5 miles at mouth	Foot surveys
Slate Creek	17.6	4.3	Helicopter and foot survey ≤ 0.5 miles at mouth	Foot surveys
Total		**Approximately 22.1**		
Middle Yuba River				
East Fork Creek	34.6	0.3	Helicopter and foot survey ≤ 0.5 miles at mouth	Foot surveys
Bear Creek	32.4	<0.1	Foot survey ≤ 0.5 miles at mouth	Foot surveys
Wolf Creek	27.0	<0.8	Helicopter and foot survey ≤ 0.5 miles at mouth	Foot surveys
Bloody Run	18.5	<0.3	Foot survey ≤ 0.5 miles at mouth	Foot surveys
Kanaka Creek	16.5	<0.4	Helicopter and foot survey ≤ 0.5 miles at mouth	Foot surveys
Indian Creek	14.7	no data	not surveyed	Foot surveys
Grizzly Creek	9.3	no data	not surveyed	Foot surveys
Oregon Creek	4.7	0.6	Helicopter and foot survey ≤ 0.5 miles at mouth	
Total		**Approximately 2.5***		
South Yuba River				
Diamond Creek	33.2	no data	not surveyed	Foot surveys
Canyon Creek (SYR)	32.4	<1.2	Helicopter and foot survey	
Scotchman Creek	30.4	no data	not surveyed	Foot surveys
Washington Creek	28.4	no data	not surveyed	Foot surveys
Poorman Creek	28.1	4.3	Helicopter and foot survey ≤ 0.5 miles at mouth	Foot surveys
Jefferson Creek	27.4	<0.2	Foot survey ≤ 0.5 miles at mouth	Foot surveys
Fish Creek	25.4	<0.1	Foot survey ≤ 0.5 miles at mouth	
Missouri Canyon	22.8	>0.5	Foot survey ≤ 0.5 miles at mouth	Foot surveys
Humbug Creek	19.5	<0.1	Foot survey ≤ 0.5 miles at mouth	Foot surveys
Kenebec Creek	16.2	no data	not surveyed	Foot surveys
Spring Creek	14.9	<0.1	Foot survey ≤ 0.5 miles at mouth	
Rock Creek	9.9	no data	not surveyed	Foot surveys
Shady Creek	5.0	no data	not surveyed	Temperatures potentially too warm; Foot surveys
Total		**Approximately 6.5***		

* Additional miles of potential tributary habitat may exist in the tributaries with "no data."

FIGURES

Figure 1. Approach for Adjusting Potential Over-Estimation of Modeled Water Temperatures in the Middle Yuba River.

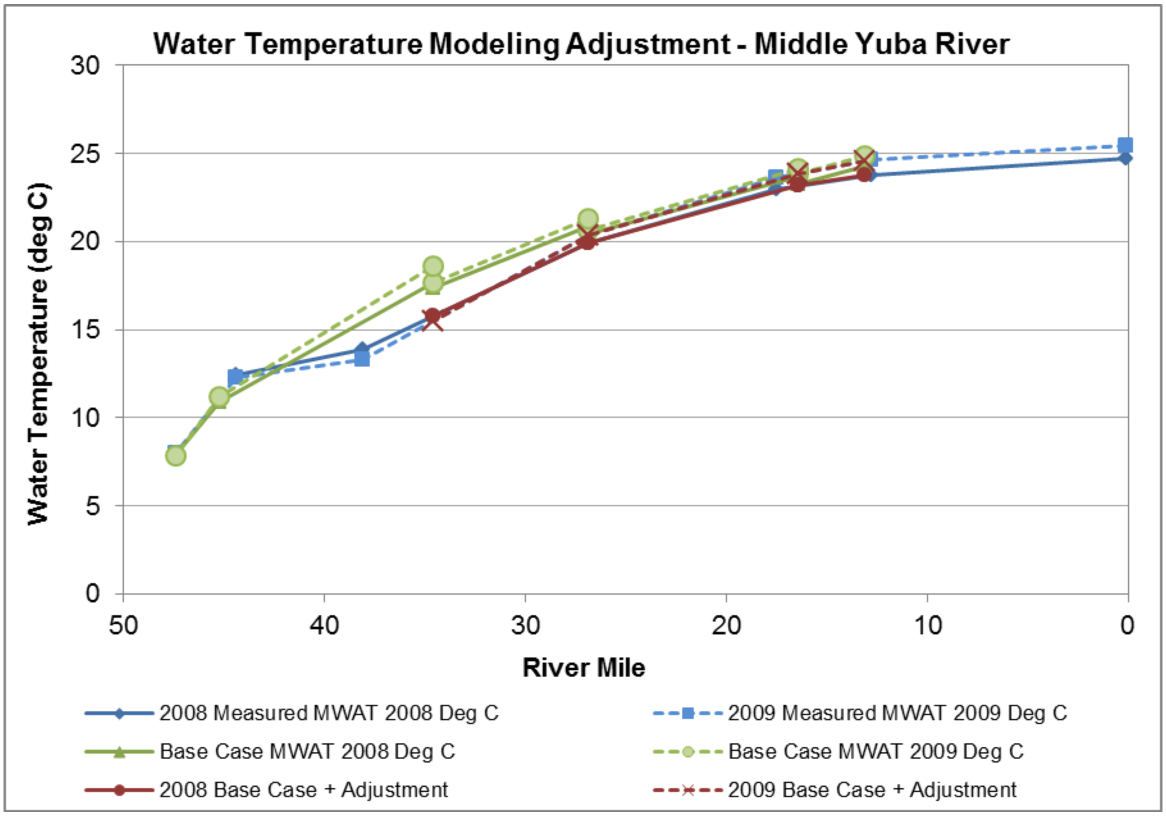


Figure 2. Water Year Index using Yuba River at Smartville Unimpaired Annual Runoff (DWR CDEC Station YRS). Water Year Types are Those Used for the YBDS Relicensing.

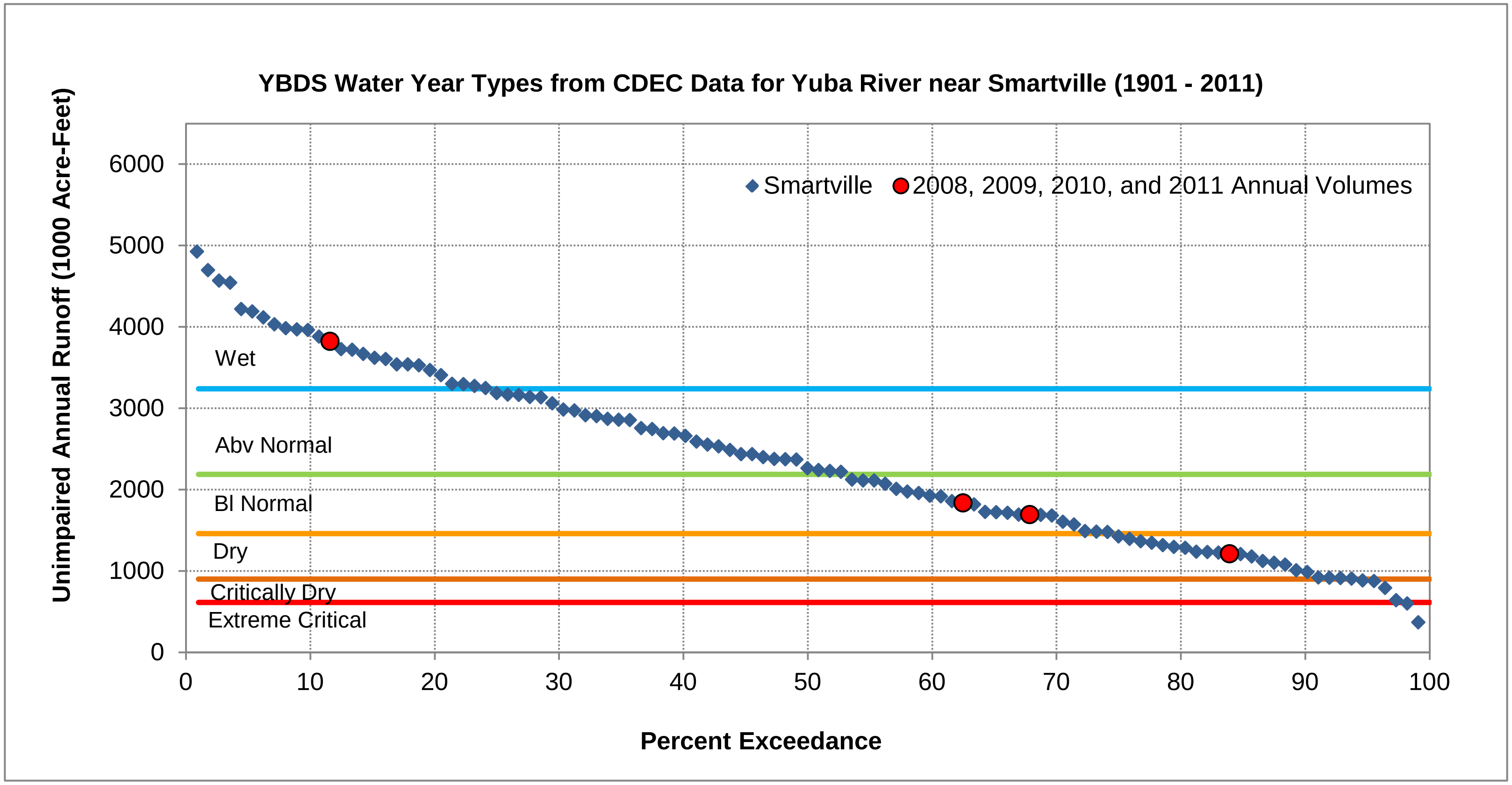
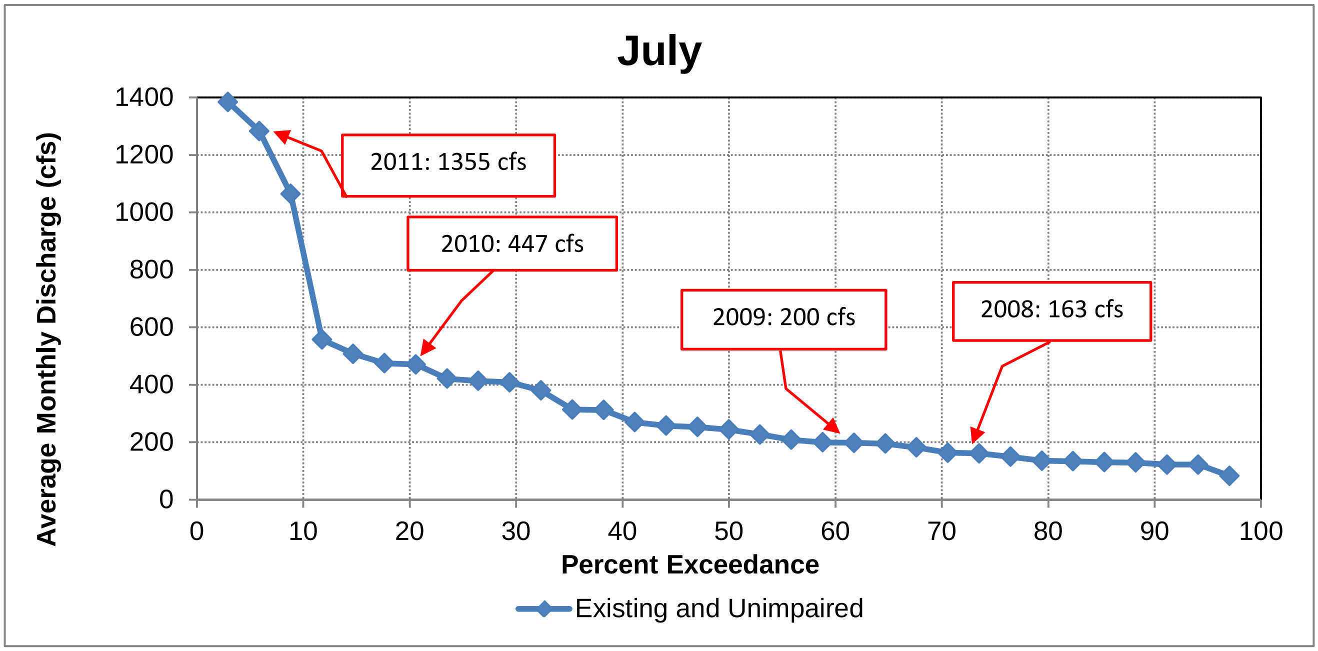
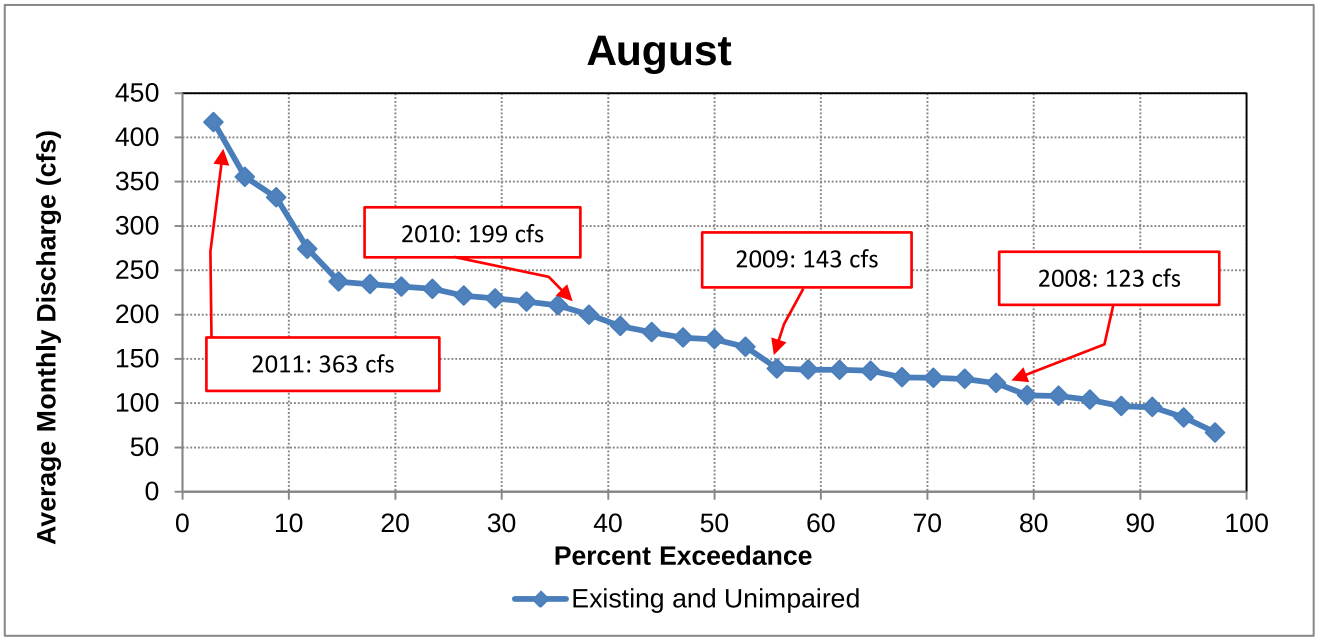


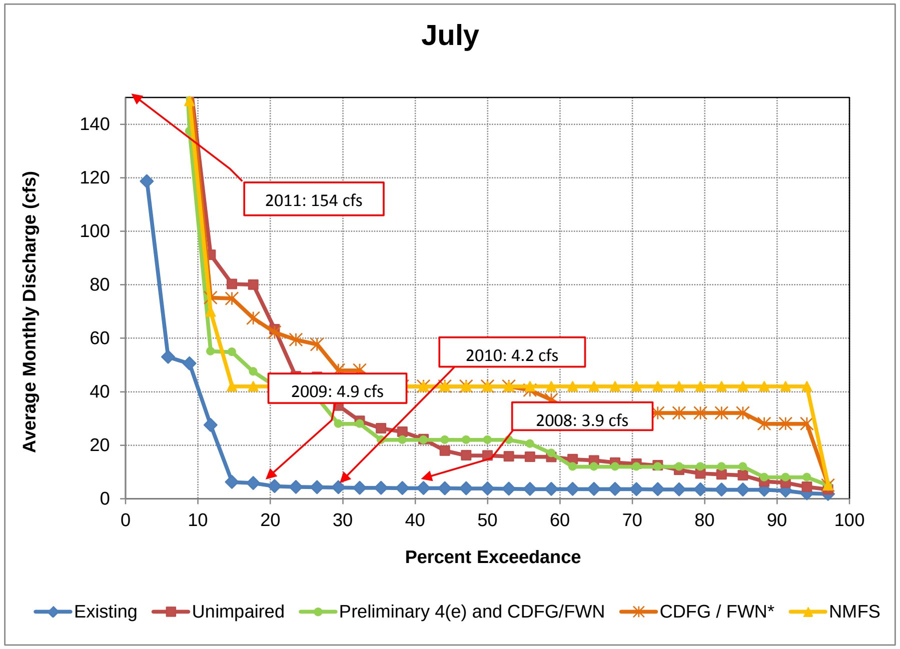
Figure 3. North Yuba River (1975-2008) Average July (top) and August (bottom) Monthly Flow Percent Exceedance at Goodyears Bar (USGS Gage 11413000).

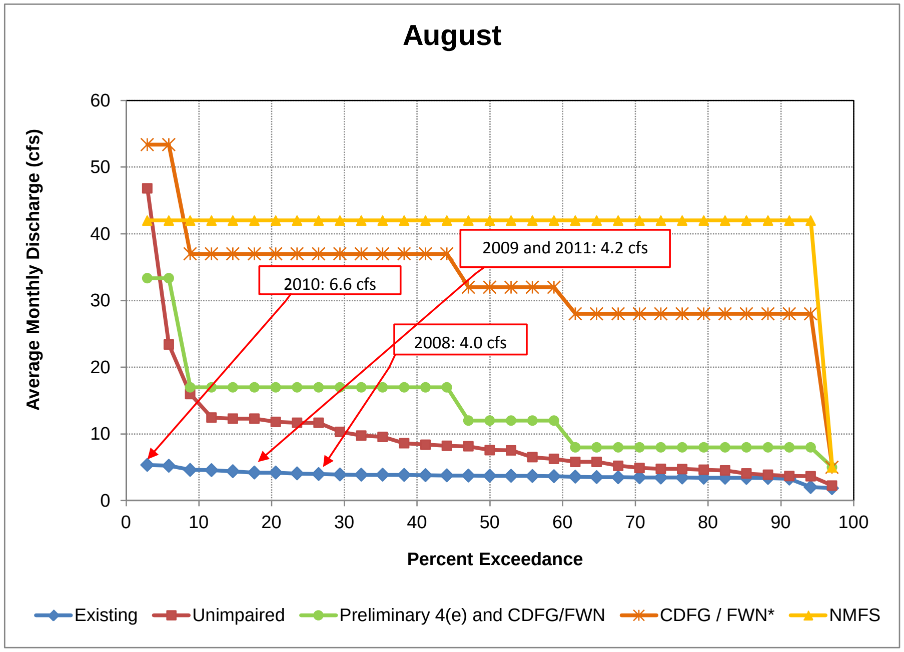




Note: Scale of vertical axis varies.

Figure 4a. Middle Yuba River (1975-2008) Average July (left) and August (right) Monthly Flow Percent Exceedance below Milton Diversion Dam for Existing, Unimpaired (USGS Gage 11408550), Preliminary 4(e) and CDFG/FWN, CDFG/FWN, and NMFS Flow Scenarios.

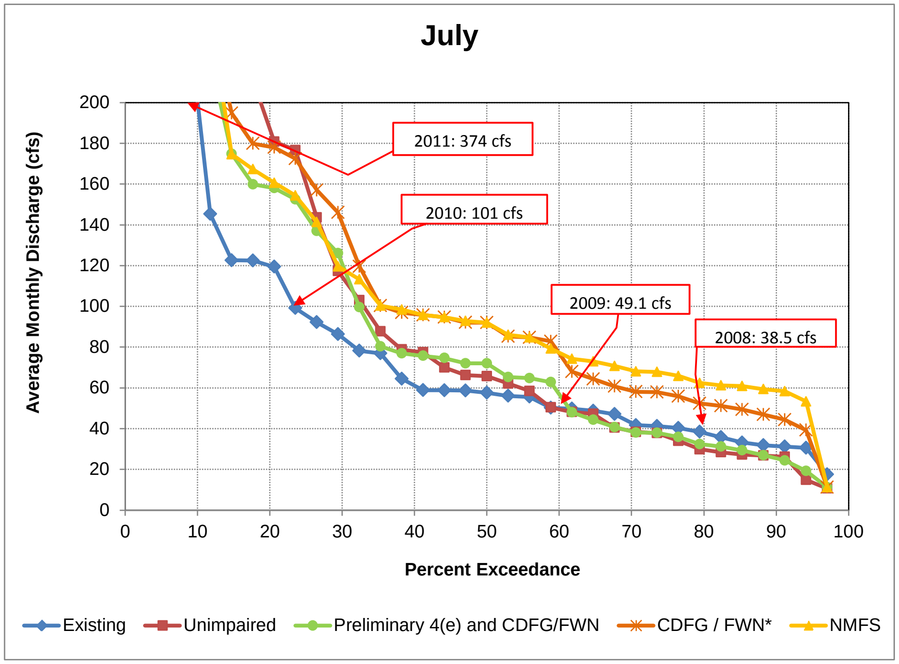


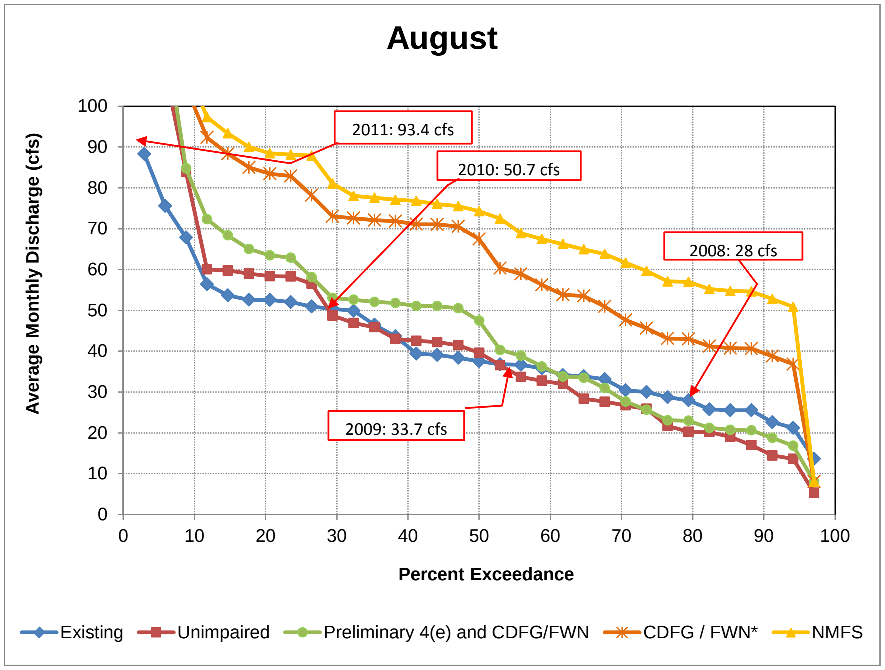


Note: Scale of vertical axis varies.

*Assumes 2500 cfs block flow will be distributed throughout July and August in all water years, except 1977.

Figure 4b. Middle Yuba River (1975-2008) Average July (left) and August (right) Monthly Flow Percent Exceedance above Our House Dam for Existing, Unimpaired (USGS Gage 11408870 + 11408880), Preliminary 4(e) and CDFG/FWN, CDFG/FWN, and NMFS Flow Scenarios.

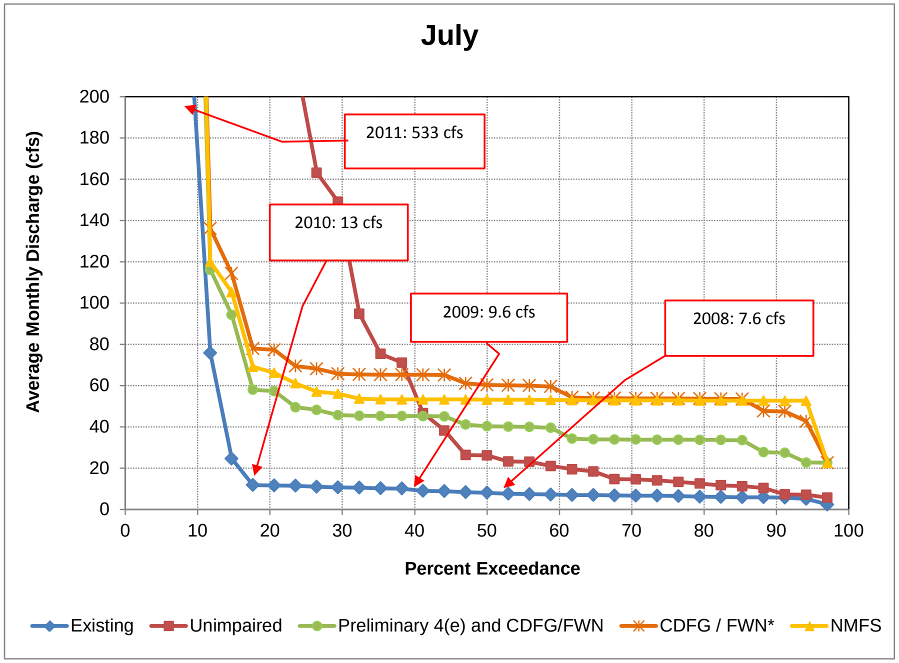


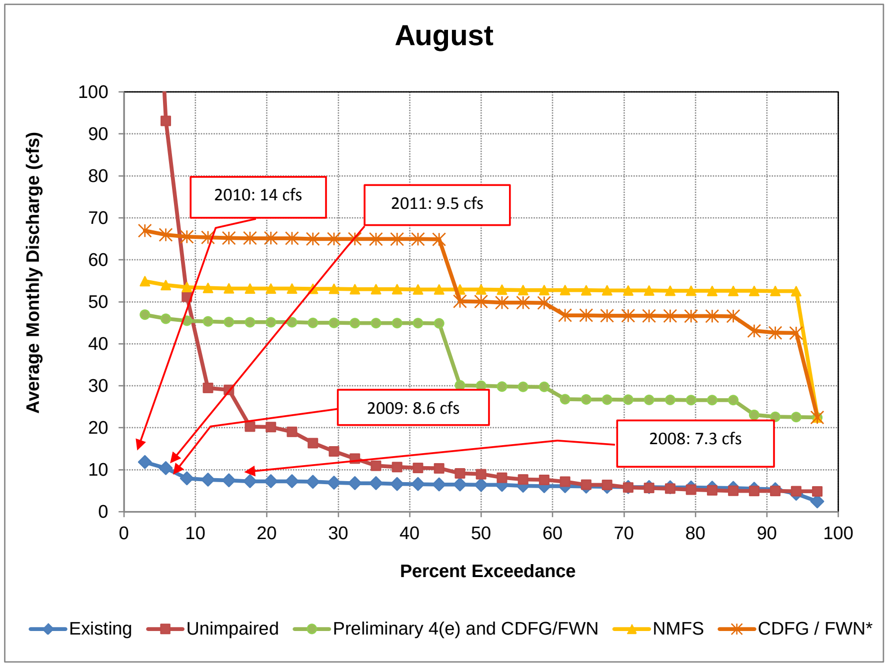


Note: Scale of vertical axis varies.

*Assumes 2500 cfs block flow will be distributed throughout July and August in all water years, except 1977.

Figure 5a. South Yuba River (1975-2008) Average July (left) and August (right) Monthly Flow Percent Exceedance at Lang's Crossing for Existing, Unimpaired (USGS Gage 11414250), Preliminary 4(e) and CDFG/FWN, CDFG/FWN, and NMFS Flow Scenarios.

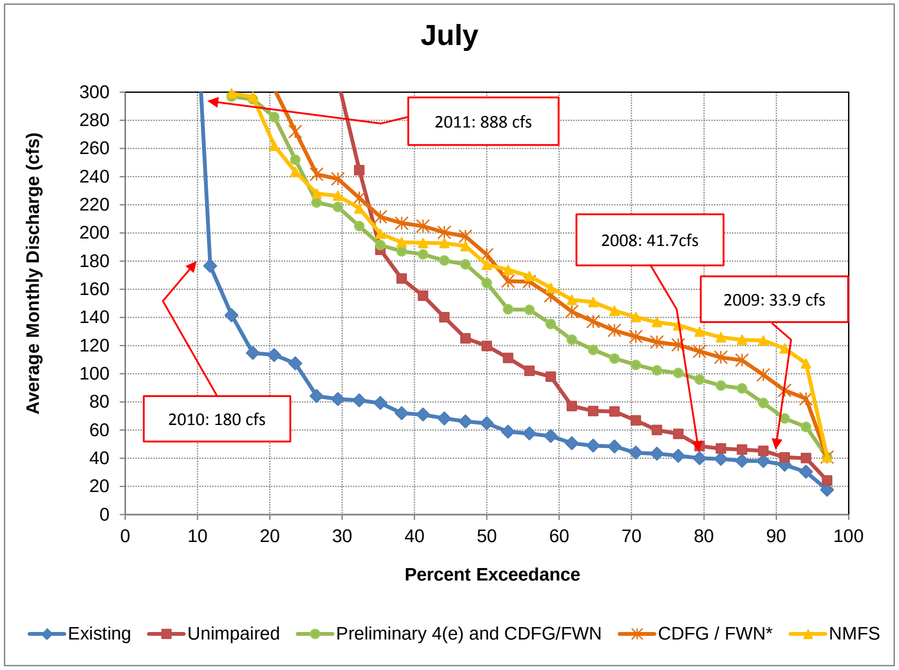


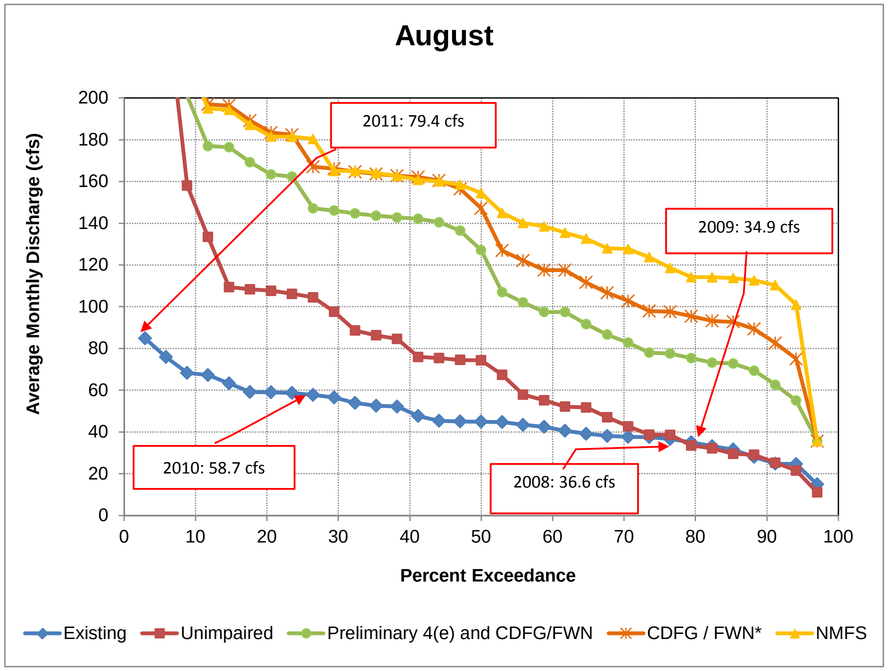


Note: Scale of vertical axis varies.

*Assumes 2500 cfs block flow will be distributed throughout July and August in all water years, except 1977.

Figure 5b. South Yuba River (1975-2008) Average July (left) and August (right) Monthly Flow Percent Exceedance at Jones Bar for Existing, Unimpaired (USGS Gage 11417500), Preliminary 4(e) and CDFG/FWN, CDFG/FWN, and NMFS Flow Scenarios.





Note: Scale of vertical axis varies.

*Assumes 2500 cfs block flow will be distributed throughout July and August in all water years, except 1977.

Figure 6. Comparison of the Miles of Adult Holding Habitat (2008-2011) for Each Holding Temperature Criterion on the North, Middle, and South Yuba Rivers and the Yuba River under Existing Conditions (a) and on the Middle Yuba River (b) and South Yuba River (c) under the Different Flow Scenarios.

(a) Existing Conditions

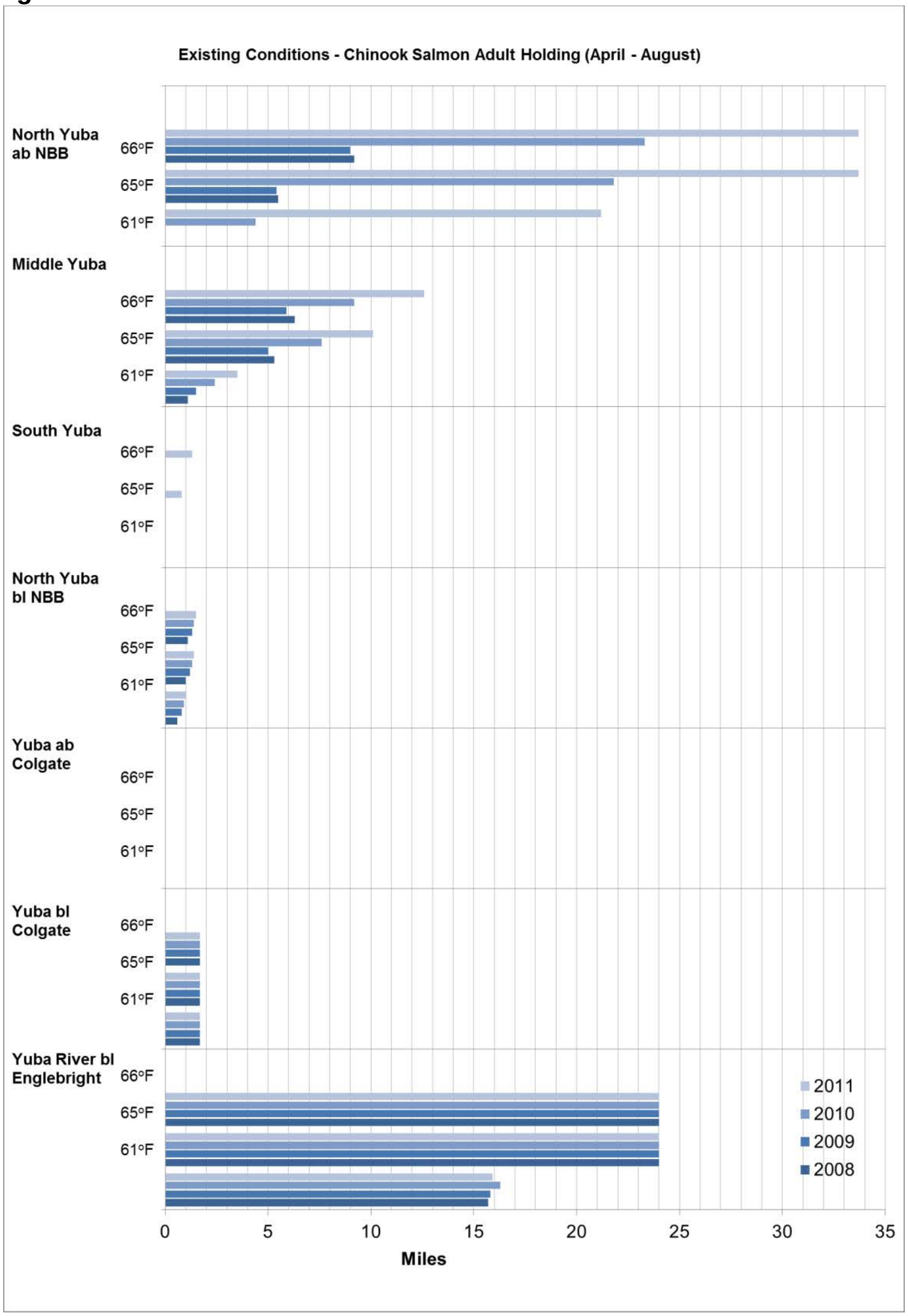


Figure 6. Comparison of the Miles of Adult Holding Habitat (2008-2011) for Each Holding Temperature Criterion on the North, Middle, and South Yuba Rivers and the Yuba River under Existing Conditions (a) and on the Middle Yuba River (b) and South Yuba River (c) under the Different Flow Scenarios (continued).

(b) Middle Yuba River

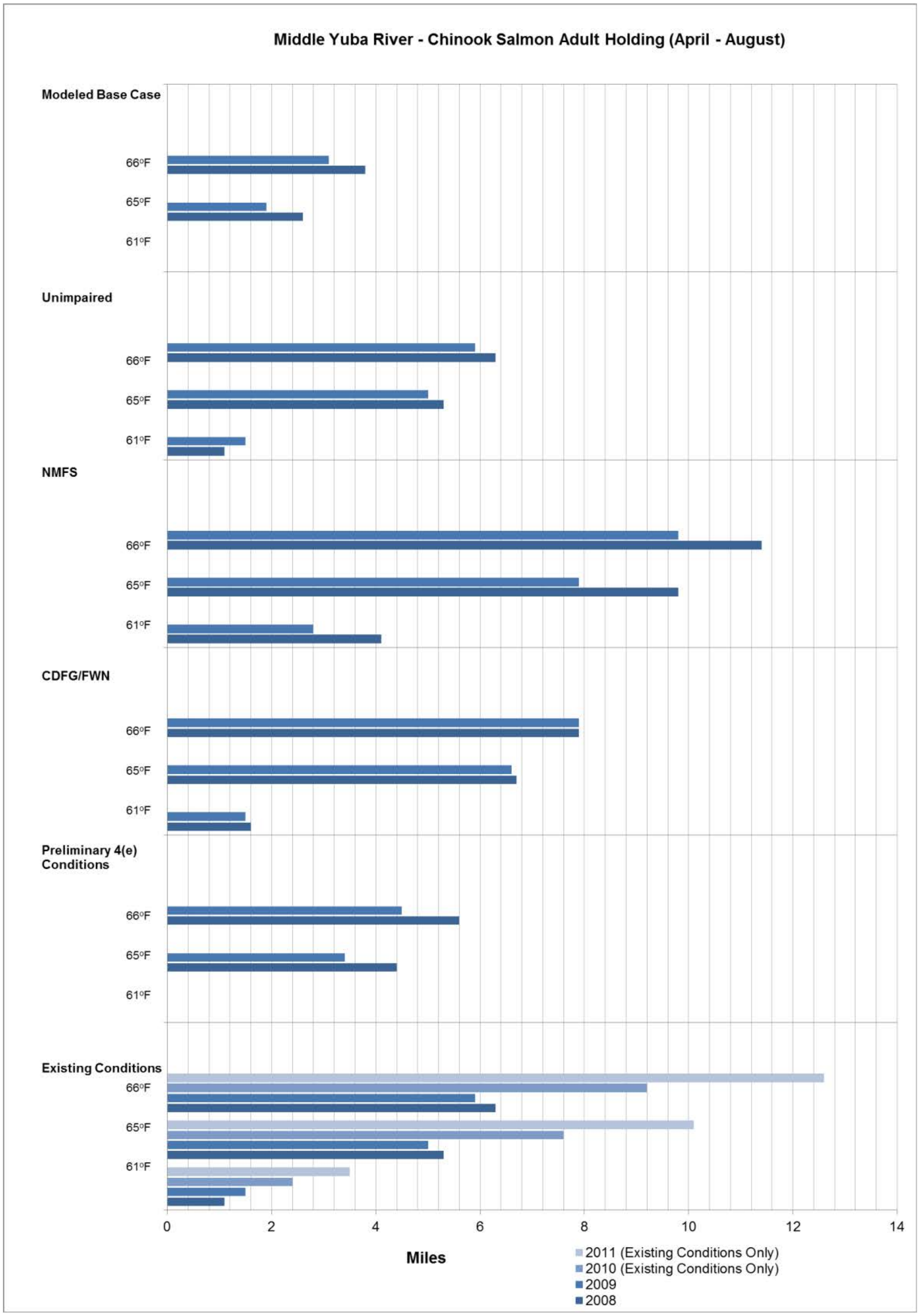


Figure 6. Comparison of the Miles of Adult Holding Habitat (2008-2011) for Each Holding Temperature Criterion on the North, Middle, and South Yuba Rivers and the Yuba River under Existing Conditions (a) and on the Middle Yuba River (b) and South Yuba River (c) under the Different Flow Scenarios (continued).

(c) South Yuba River

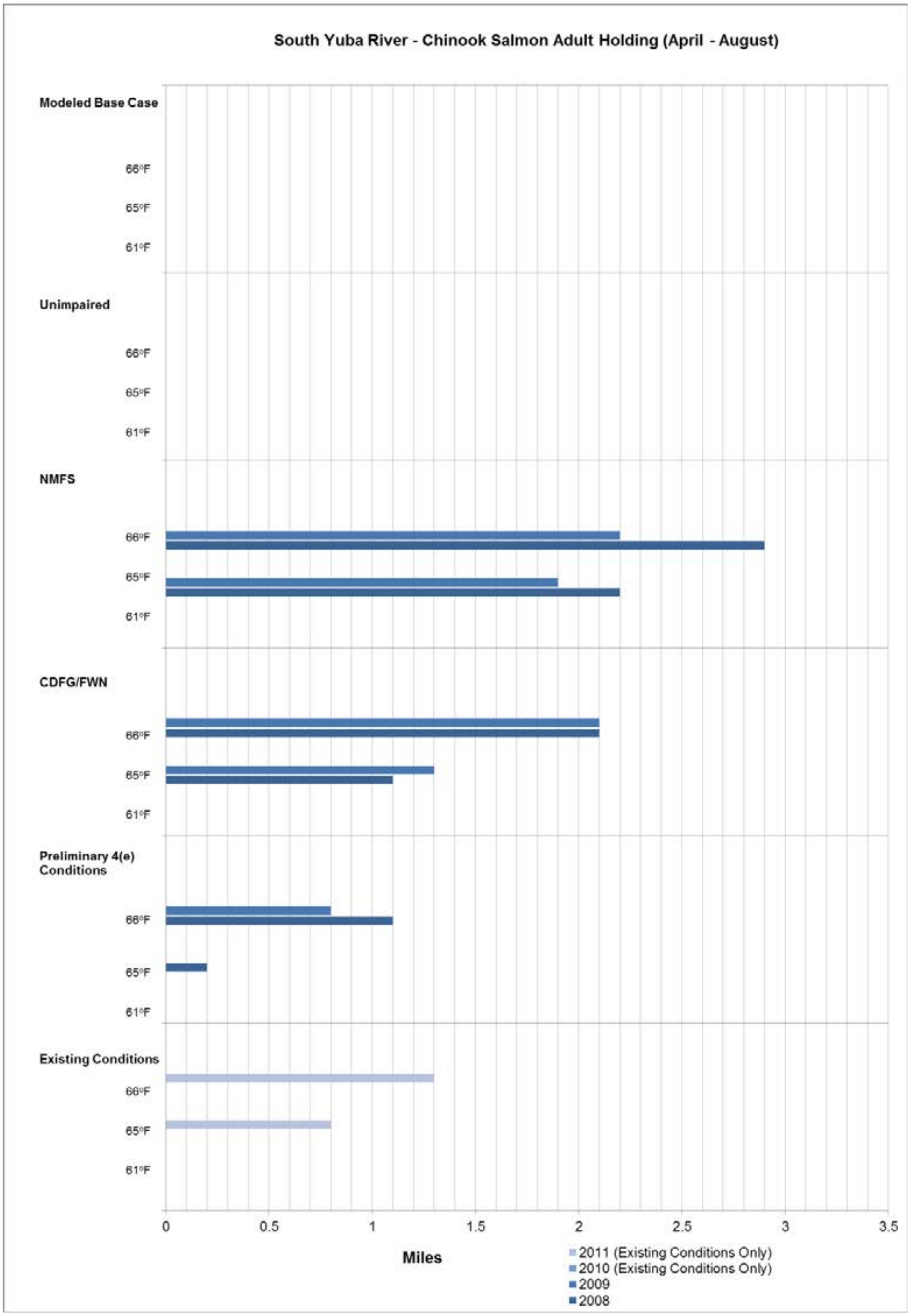


Figure 7. Comparison of the Miles of Spawning Habitat (2008-2011) for Each Spawning Temperature Criterion on the North, Middle, and South Yuba Rivers and the Yuba River under Existing Conditions (a) and on the Middle Yuba River (b) and South Yuba River (c) under the Different Flow Scenarios.

(a) Existing Conditions

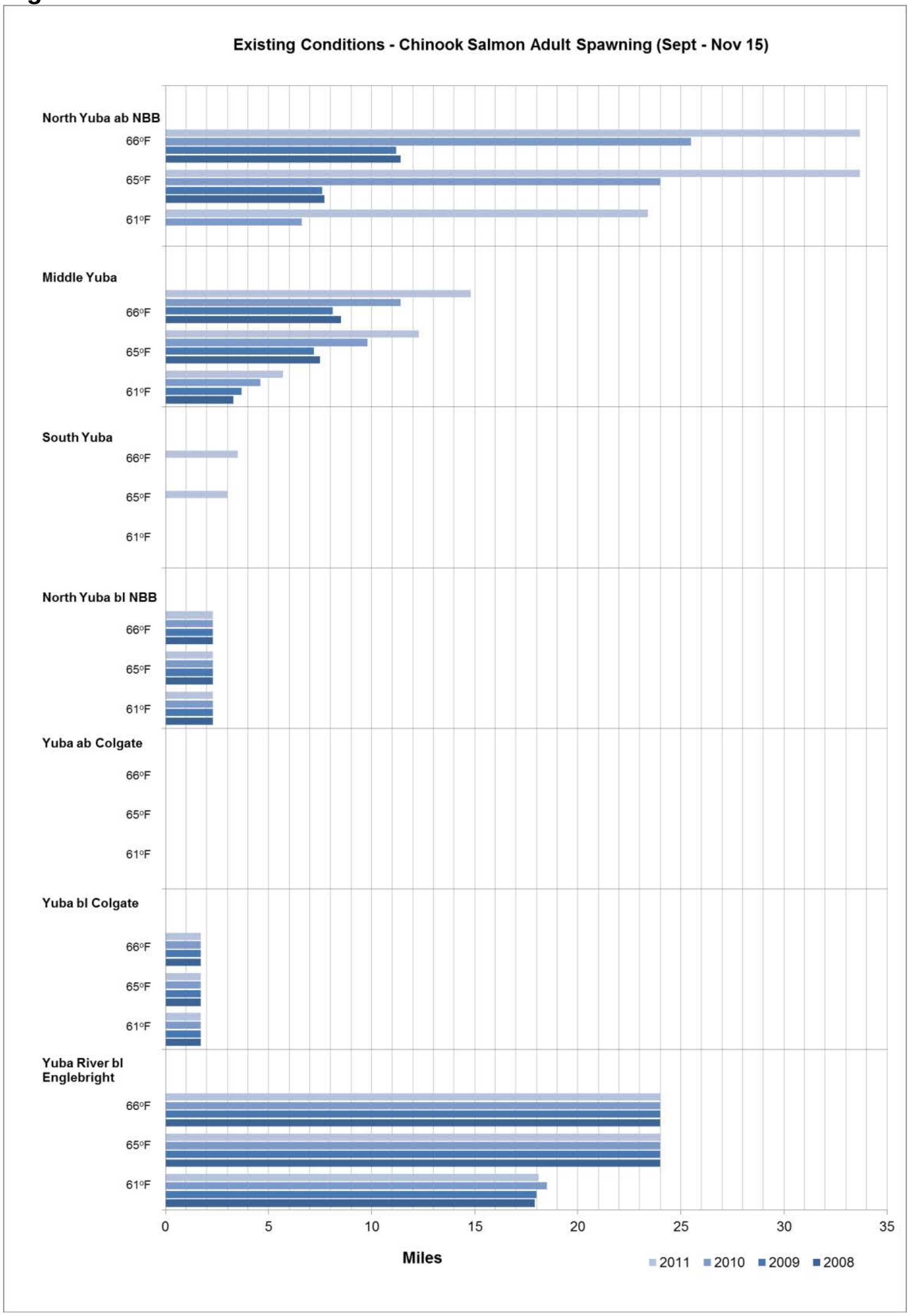


Figure 7. Comparison of the Miles of Spawning Habitat (2008-2011) for Each Spawning Temperature Criterion on the North, Middle, and South Yuba Rivers and the Yuba River under Existing Conditions (a) and on the Middle Yuba River (b) and South Yuba River (c) under the Different Flow Scenarios (continued).

(b) Middle Yuba River

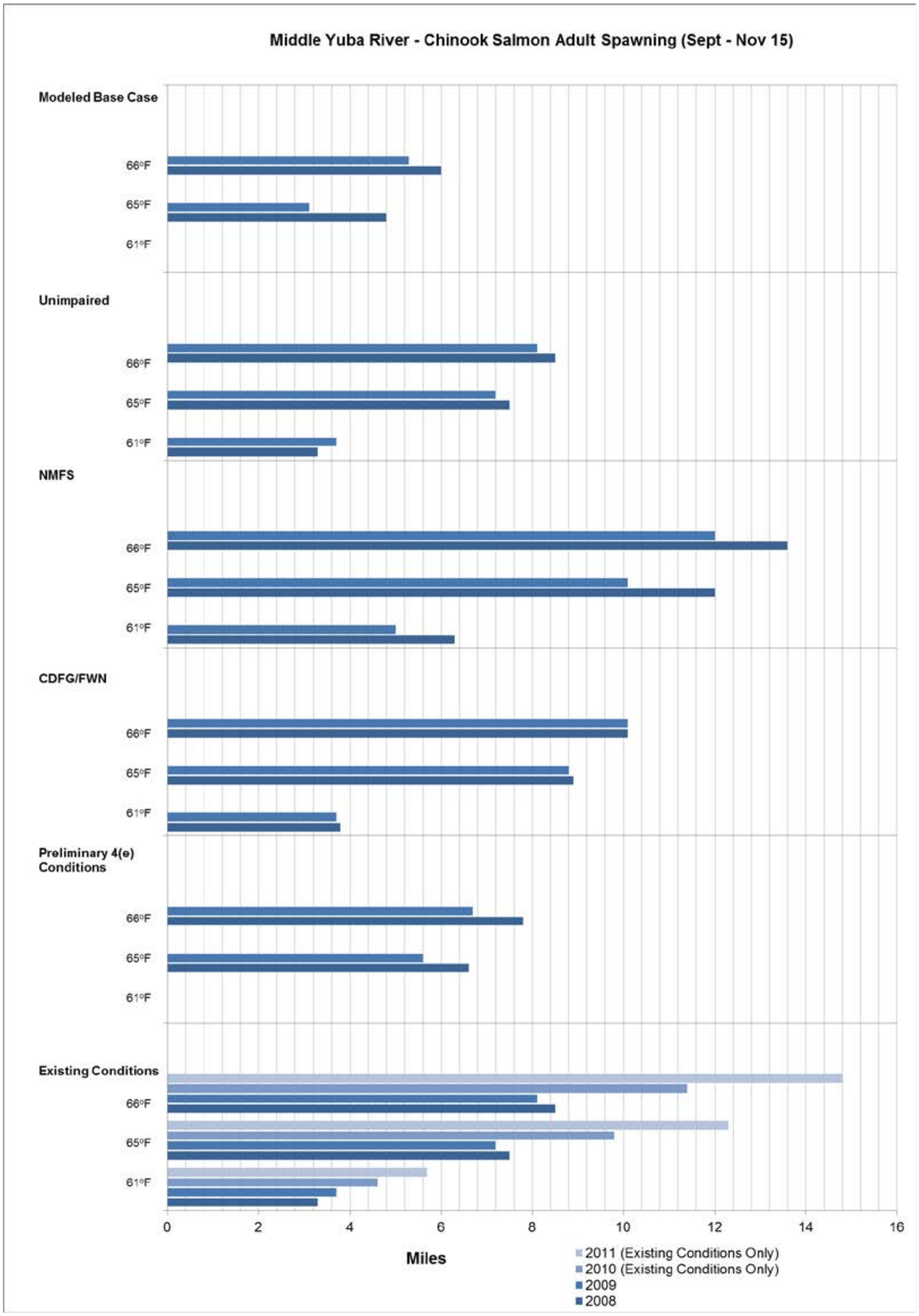


Figure 7. Comparison of the Miles of Spawning Habitat (2008-2011) for Each Spawning Temperature Criterion on the North, Middle, and South Yuba Rivers and the Yuba River under Existing Conditions (a) and on the Middle Yuba River (b) and South Yuba River (c) under the Different Flow Scenarios (continued).

(c) South Yuba River

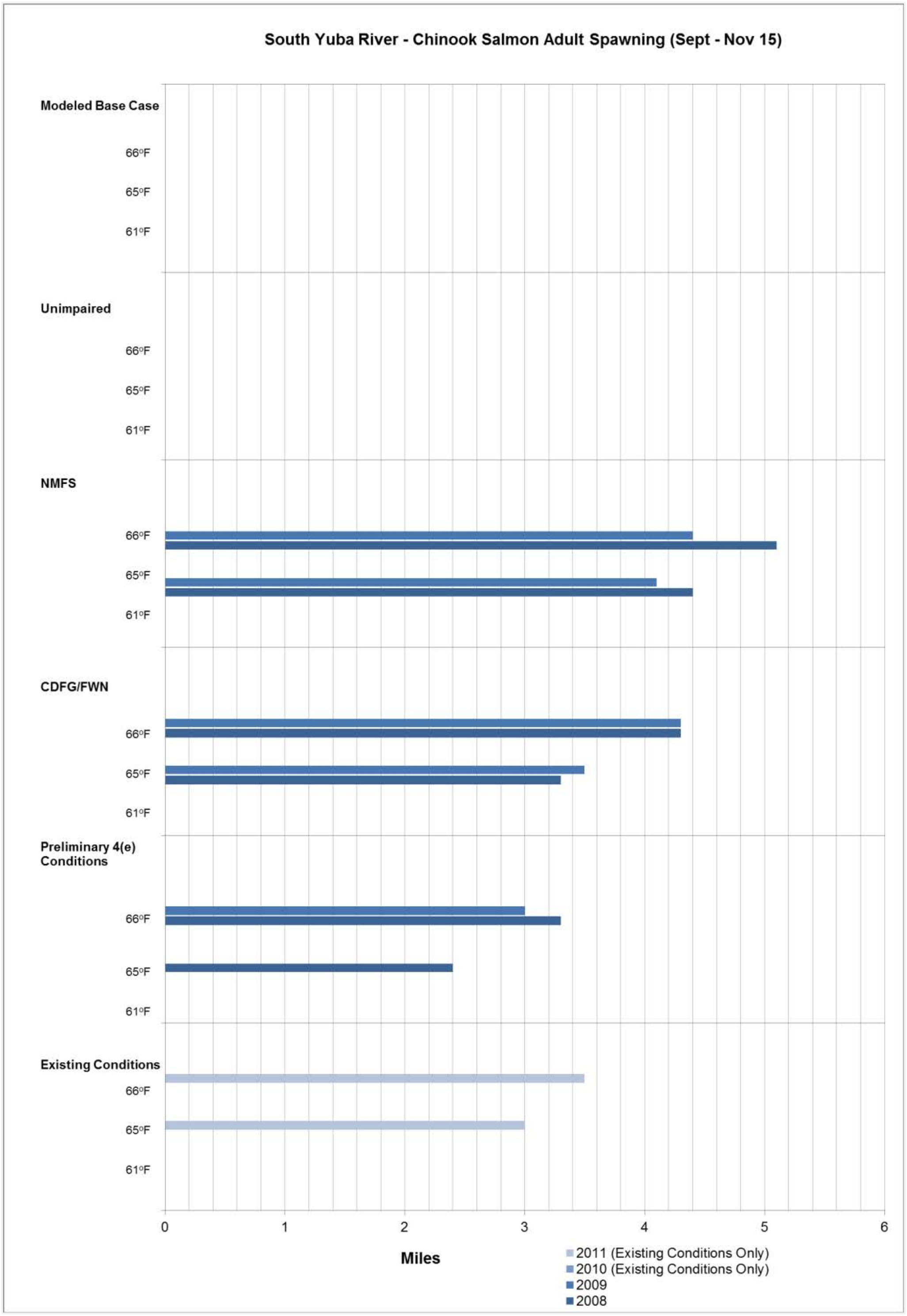
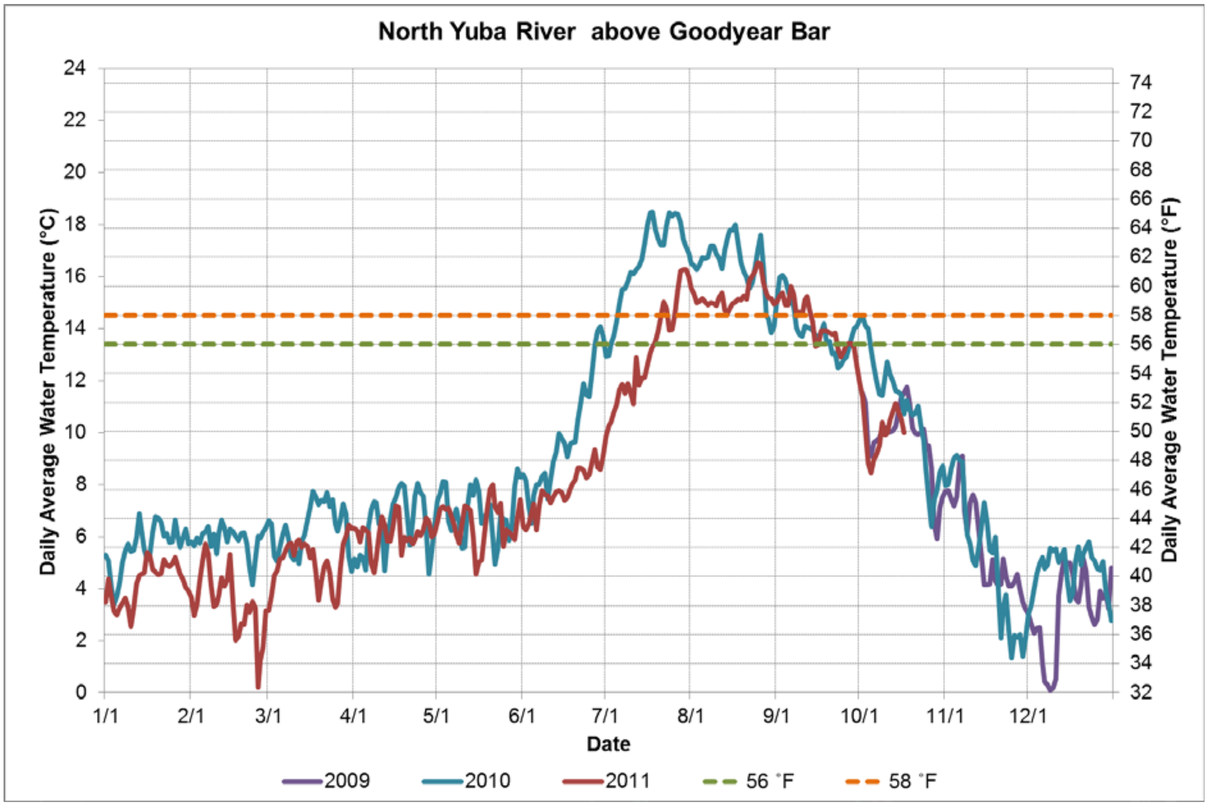


Figure 8. Empirical Temperature Relationships and Spawning Temperature Criteria in the North, Middle and South Yuba Rivers.



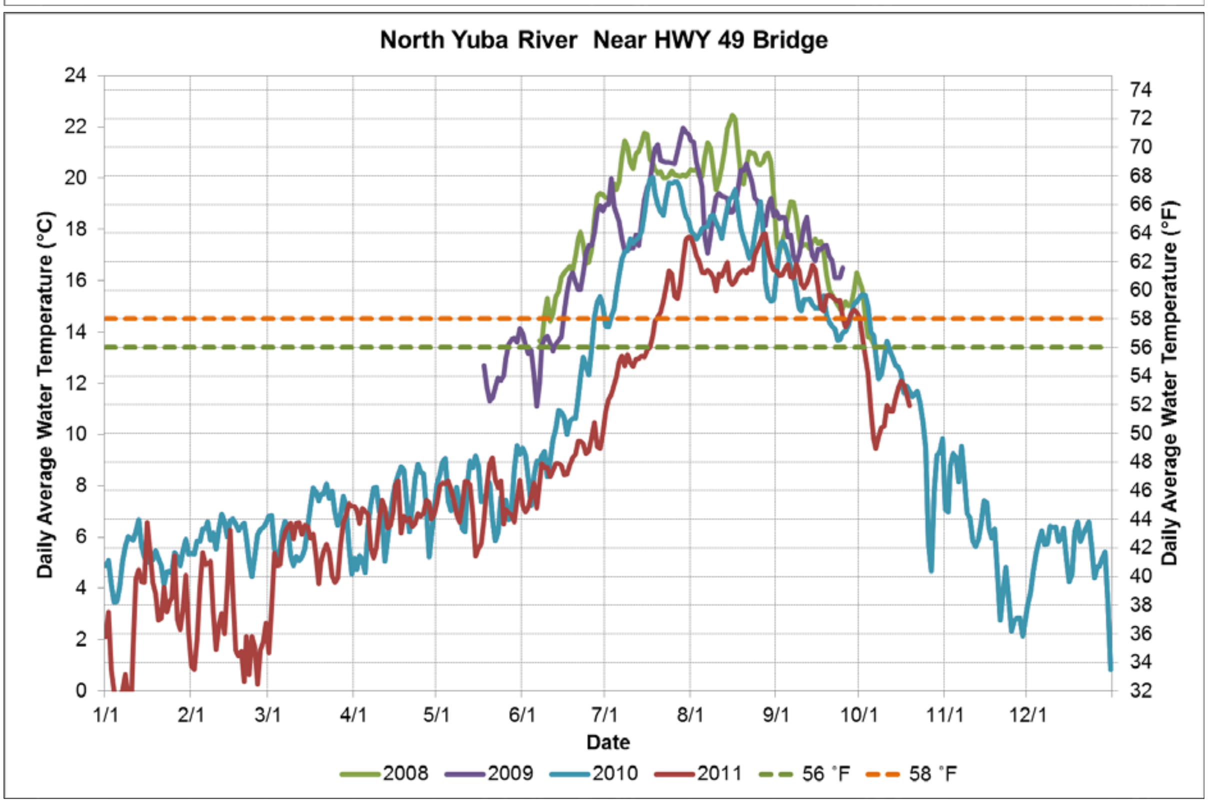
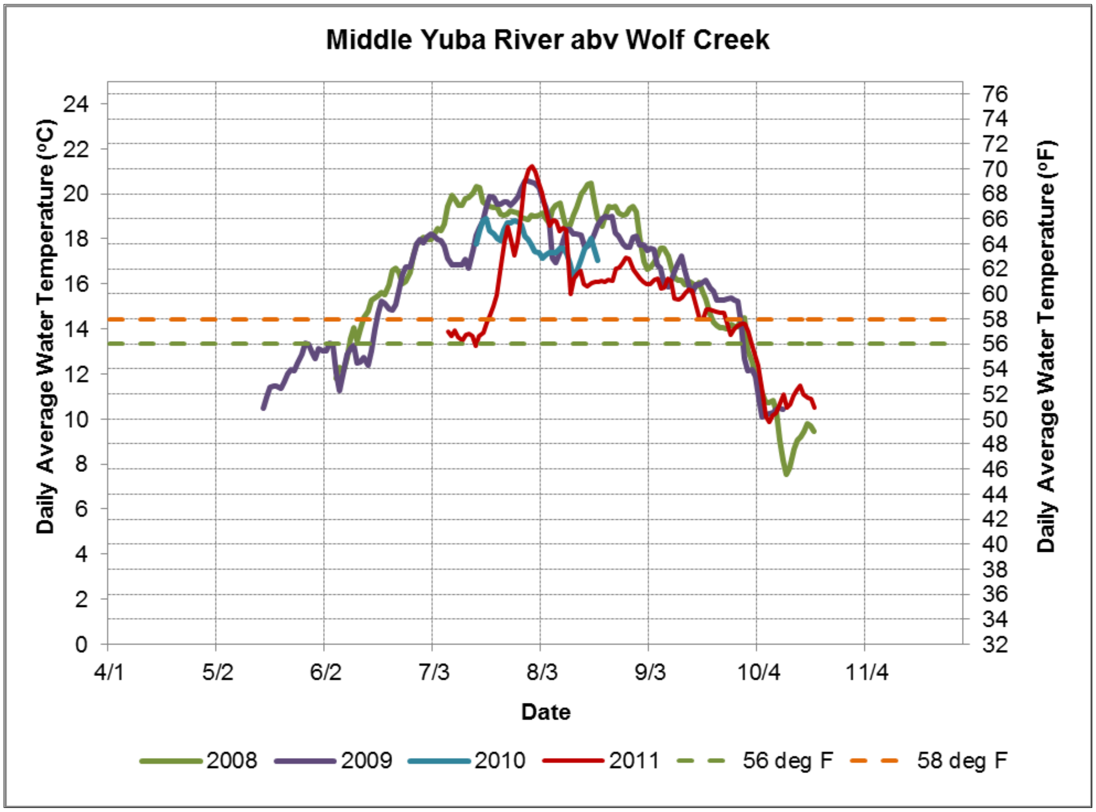


Figure 8. Empirical Temperature Relationships and Spawning Temperature Criteria in the North, Middle and South Yuba Rivers (continued).



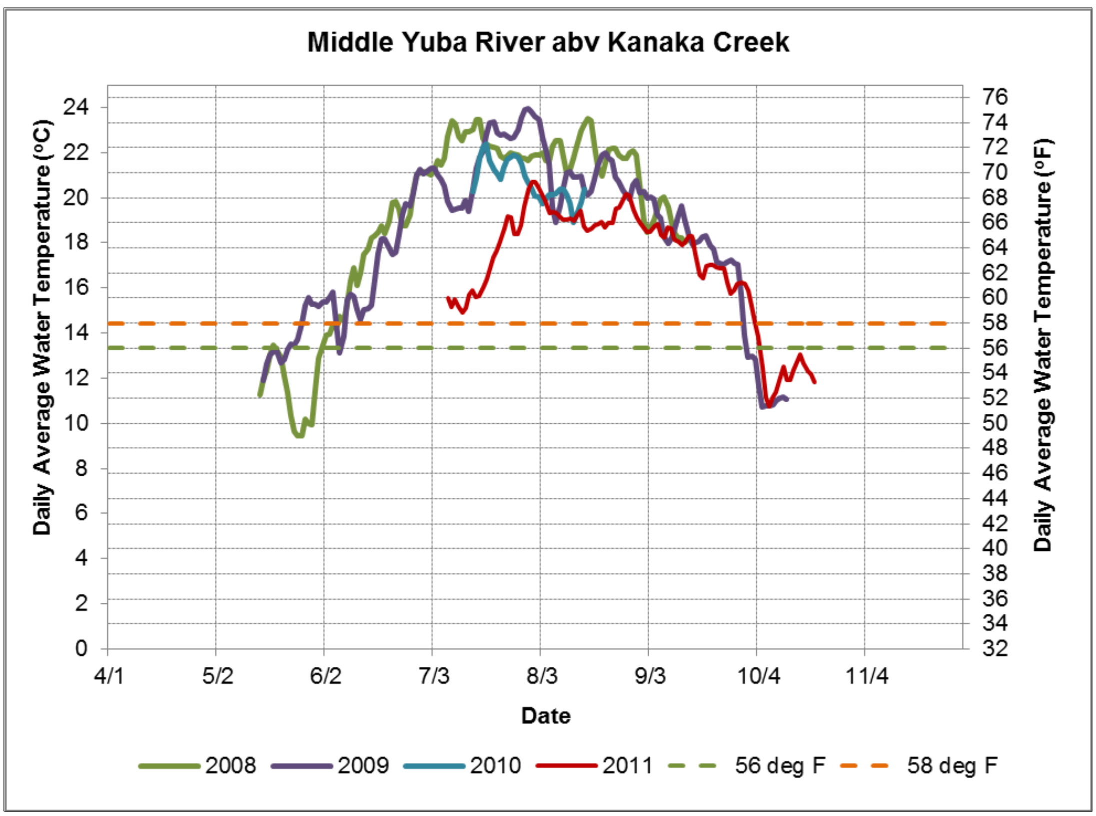
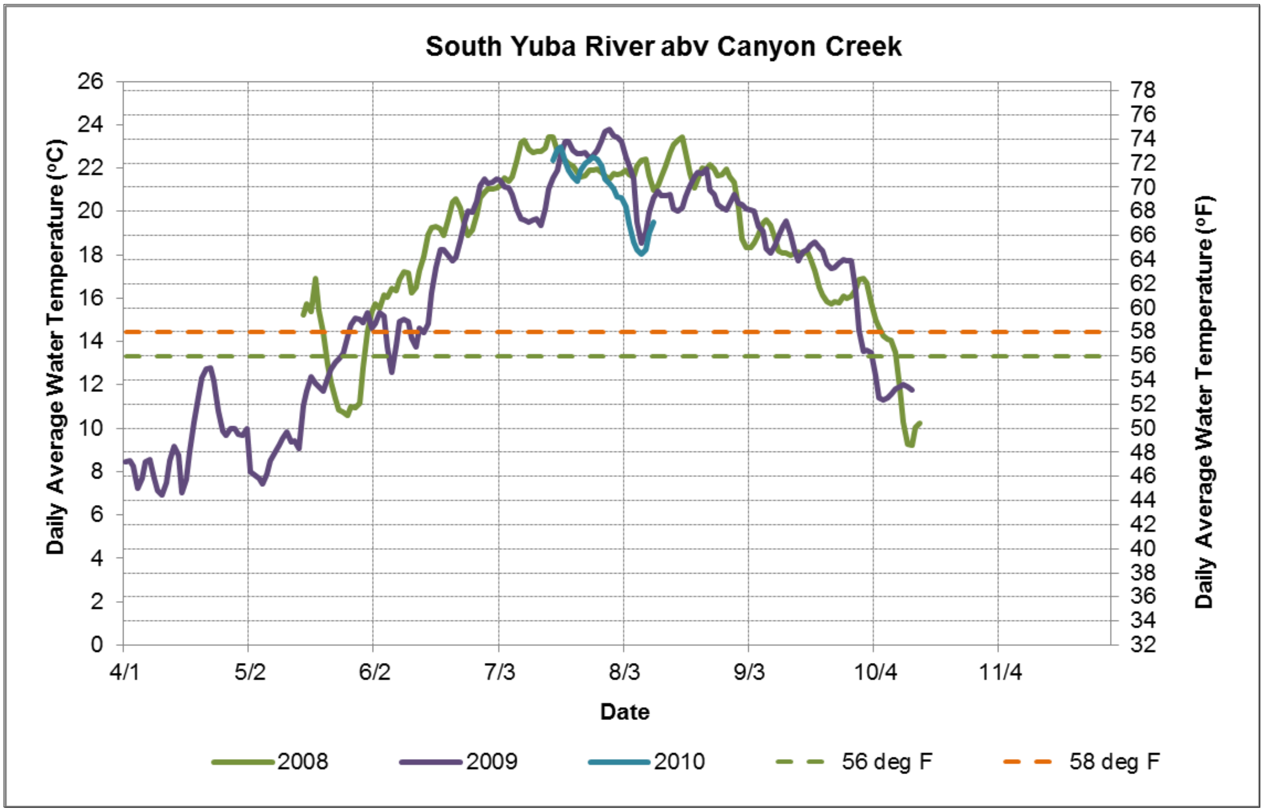


Figure 8. Empirical Temperature Relationships and Spawning Temperature Criteria in the North, Middle and South Yuba Rivers (continued).



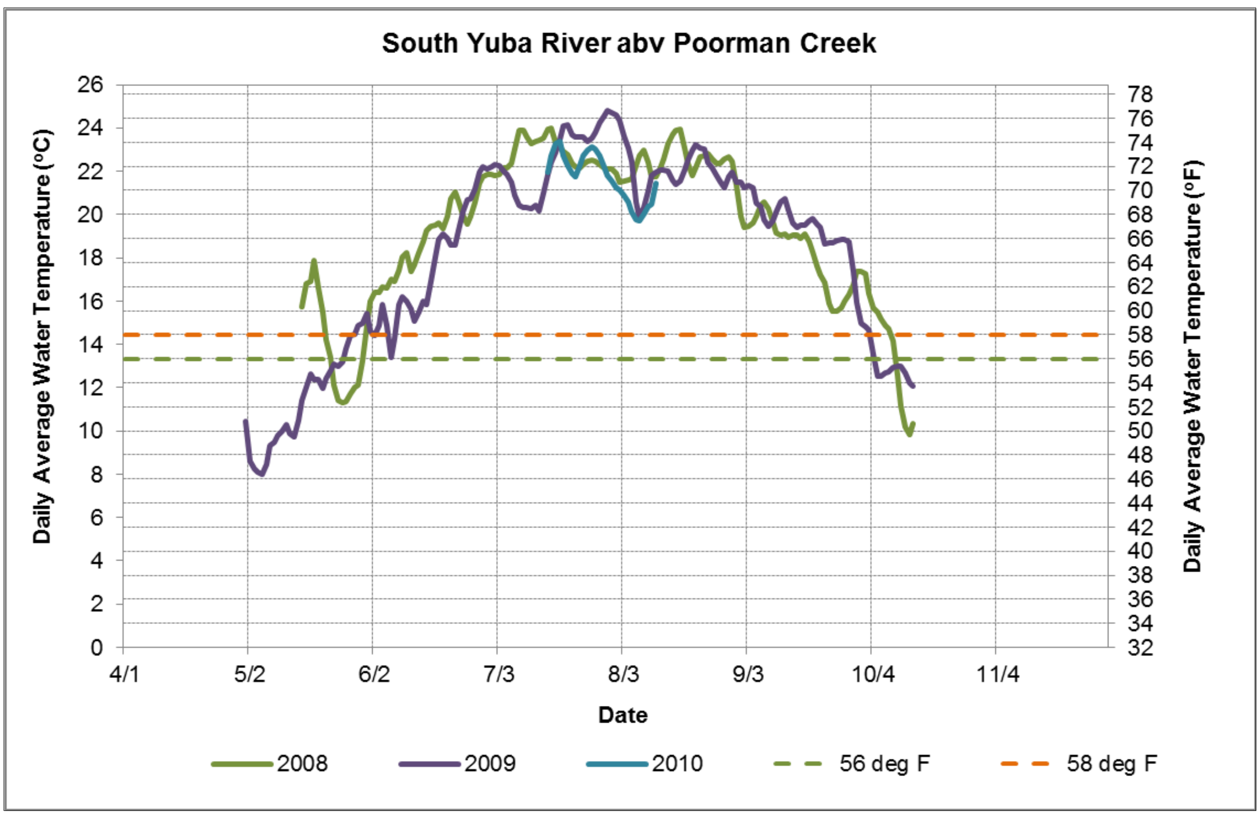


Figure 9. Comparison of the Miles of Rearing Habitat (2008-2011) for Each Rearing Temperature Criterion on the North, Middle, and South Yuba Rivers and the Yuba River under Existing Conditions (a) and on the Middle Yuba River (b) and South Yuba River (c) under the Different Flow Scenarios.

(a) Existing Conditions

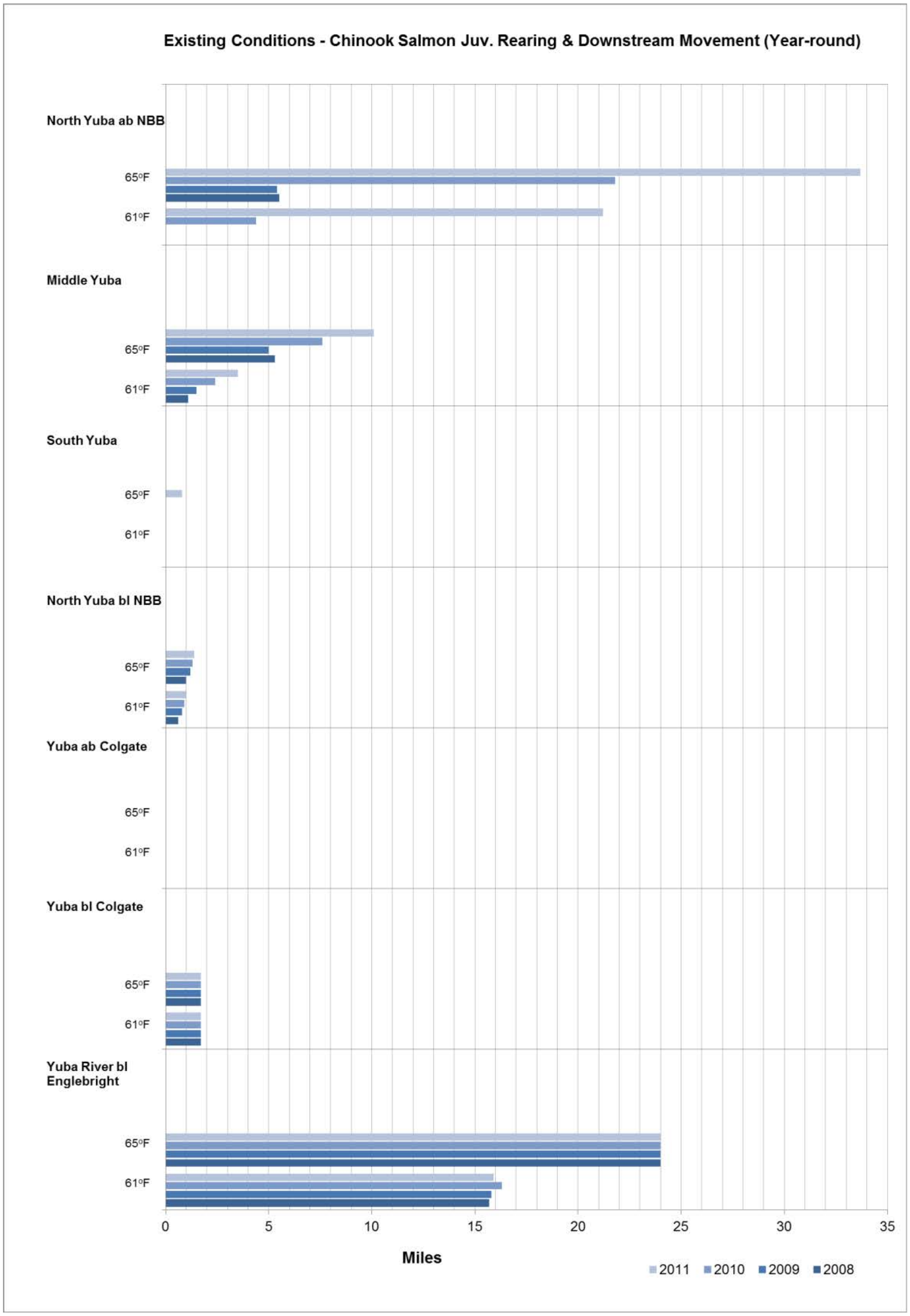


Figure 9. Comparison of the Miles of Rearing Habitat (2008-2011) for Each Rearing Temperature Criterion on the North, Middle, and South Yuba Rivers and the Yuba River under Existing Conditions (a) and on the Middle Yuba River (b) and South Yuba River (c) under the Different Flow Scenarios (continued).

(b) Middle Yuba River

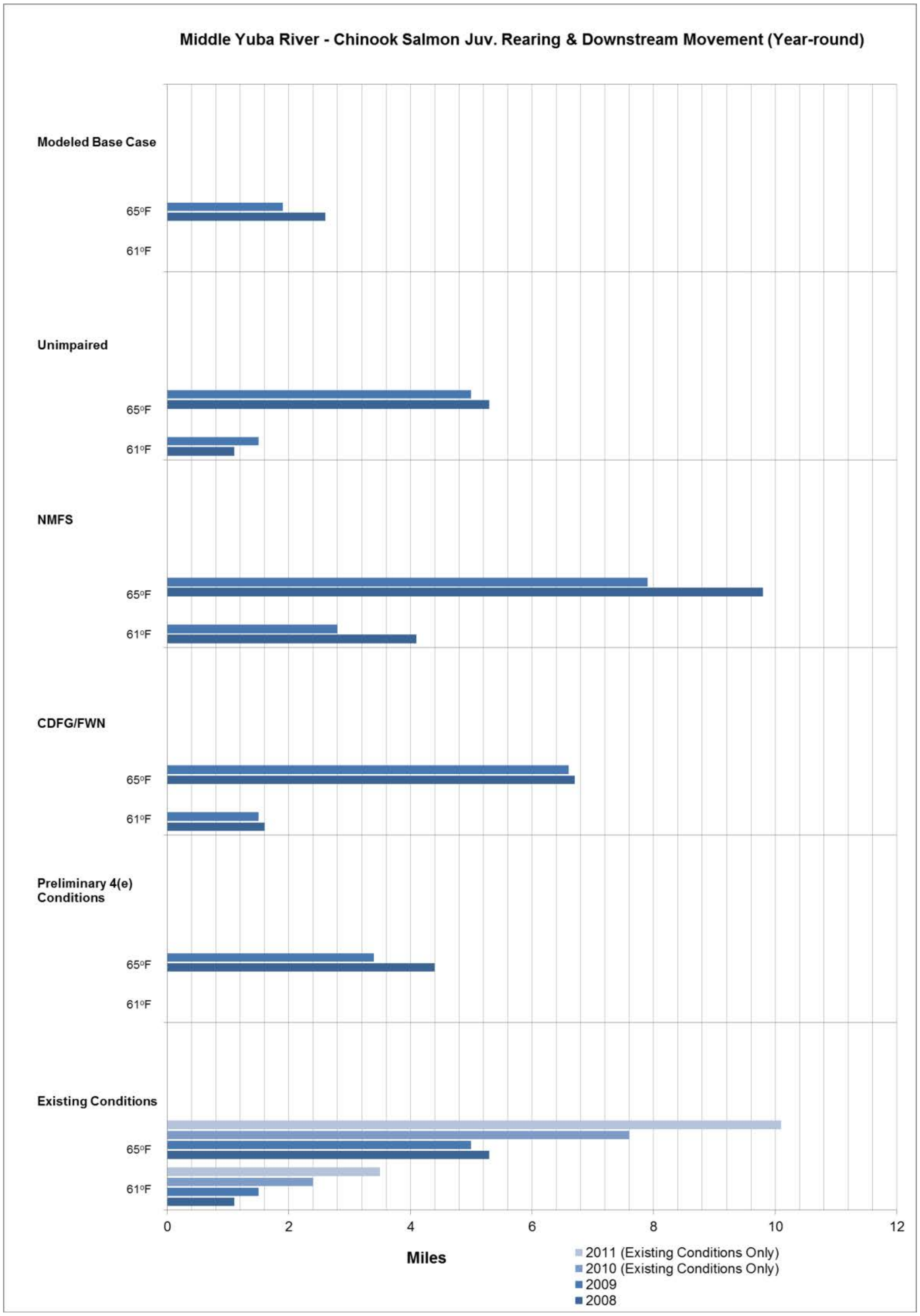


Figure 9. Comparison of the Miles of Rearing Habitat (2008-2011) for Each Rearing Temperature Criterion on the North, Middle, and South Yuba Rivers and the Yuba River under Existing Conditions (a) and on the Middle Yuba River (b) and South Yuba River (c) under the Different Flow Scenarios (continued).

(c) South Yuba River

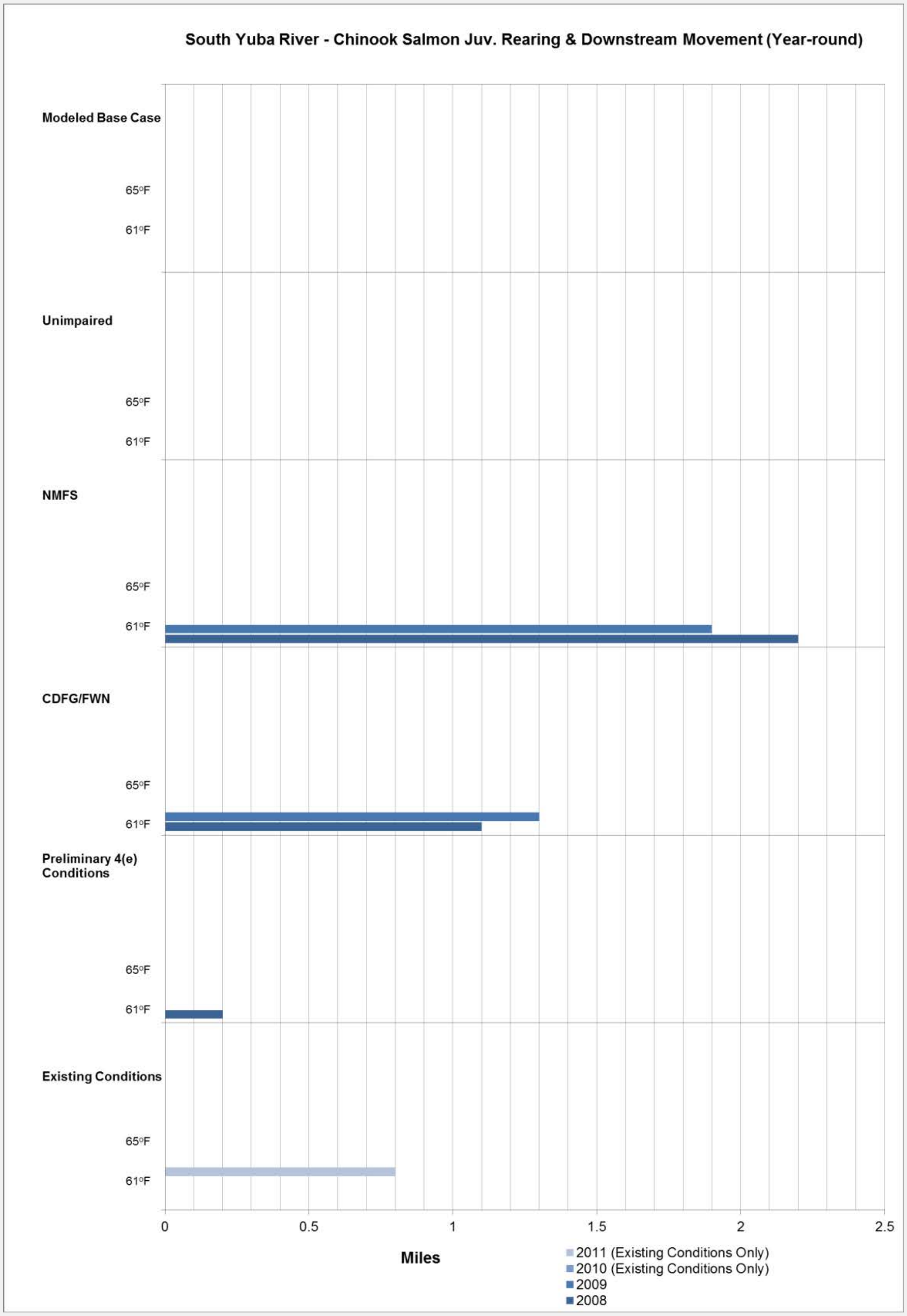


Figure 10. Comparison of the Miles of Steelhead Rearing Habitat (2008-2011) for Each Rearing Temperature Criterion on the North, Middle, and South Yuba Rivers and the Yuba River under Existing Conditions (a) and on the Middle Yuba River (b) and South Yuba River (c) under the Different Flow Scenarios.

(a) Existing Conditions

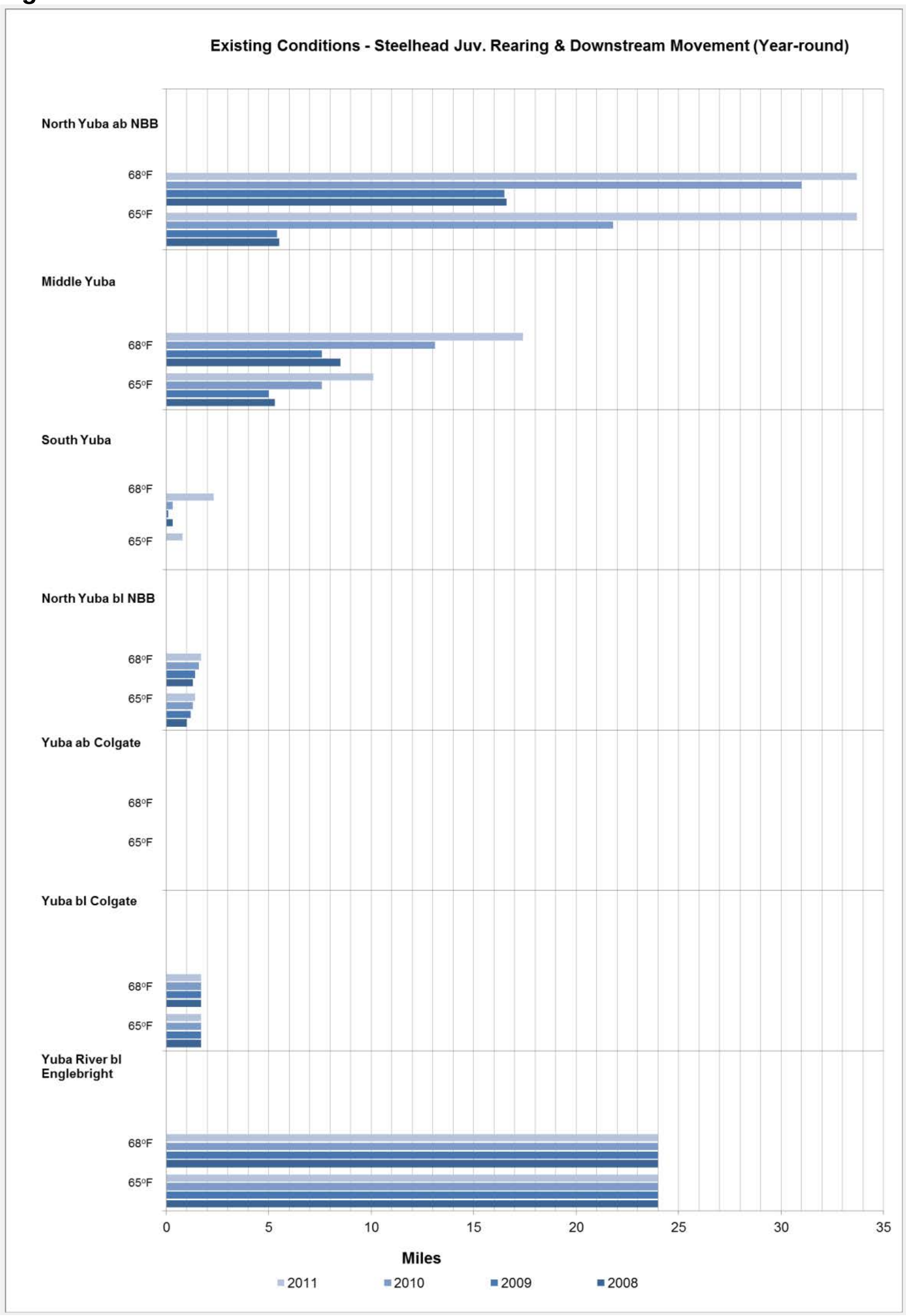


Figure 10. Comparison of the Miles of Steelhead Rearing Habitat (2008-2011) for Each Rearing Temperature Criterion on the North, Middle, and South Yuba Rivers and the Yuba River under Existing Conditions (a) and on the Middle Yuba River (b) and South Yuba River (c) under the Different Flow Scenarios (continued).

(b) Middle Yuba River

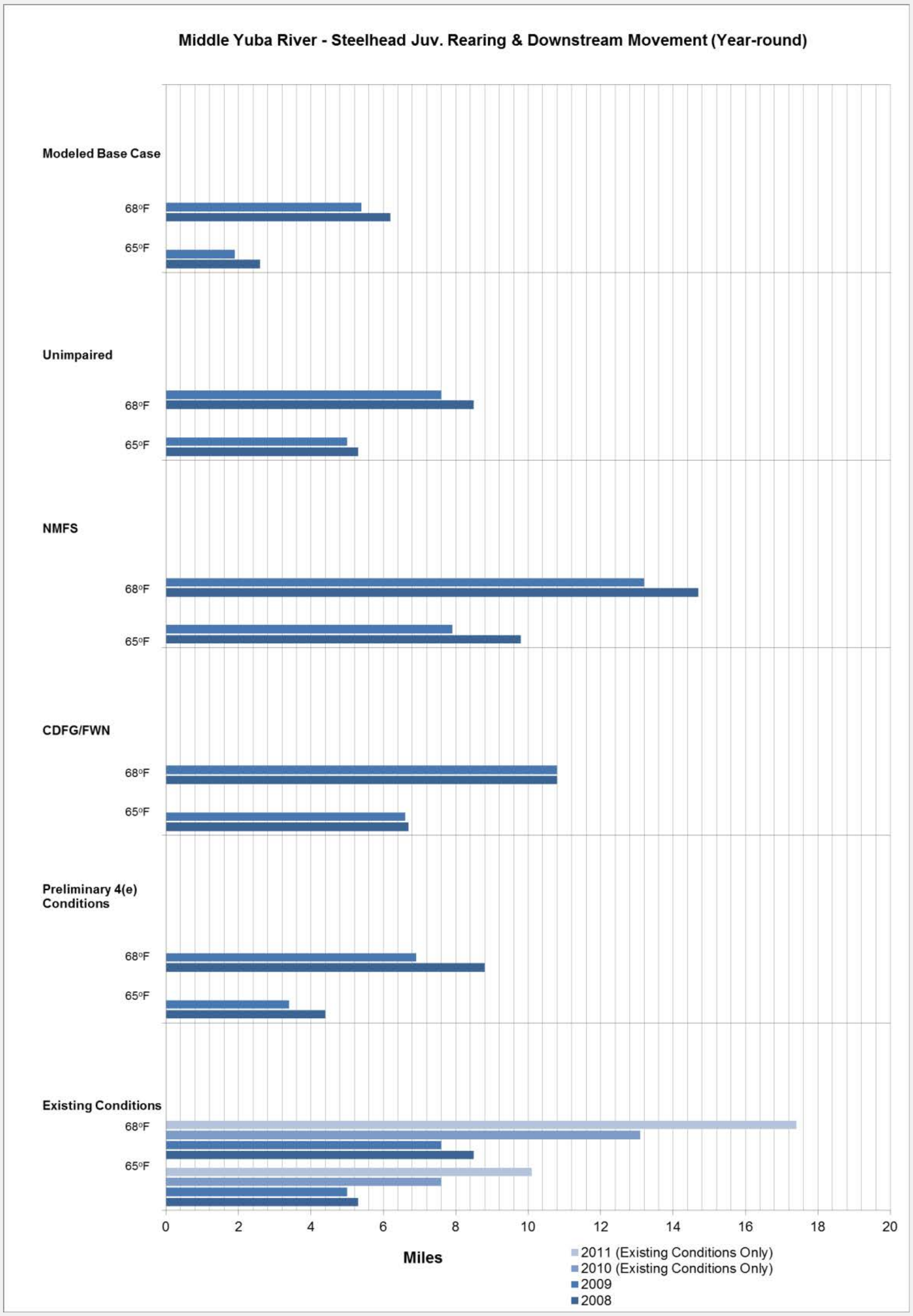
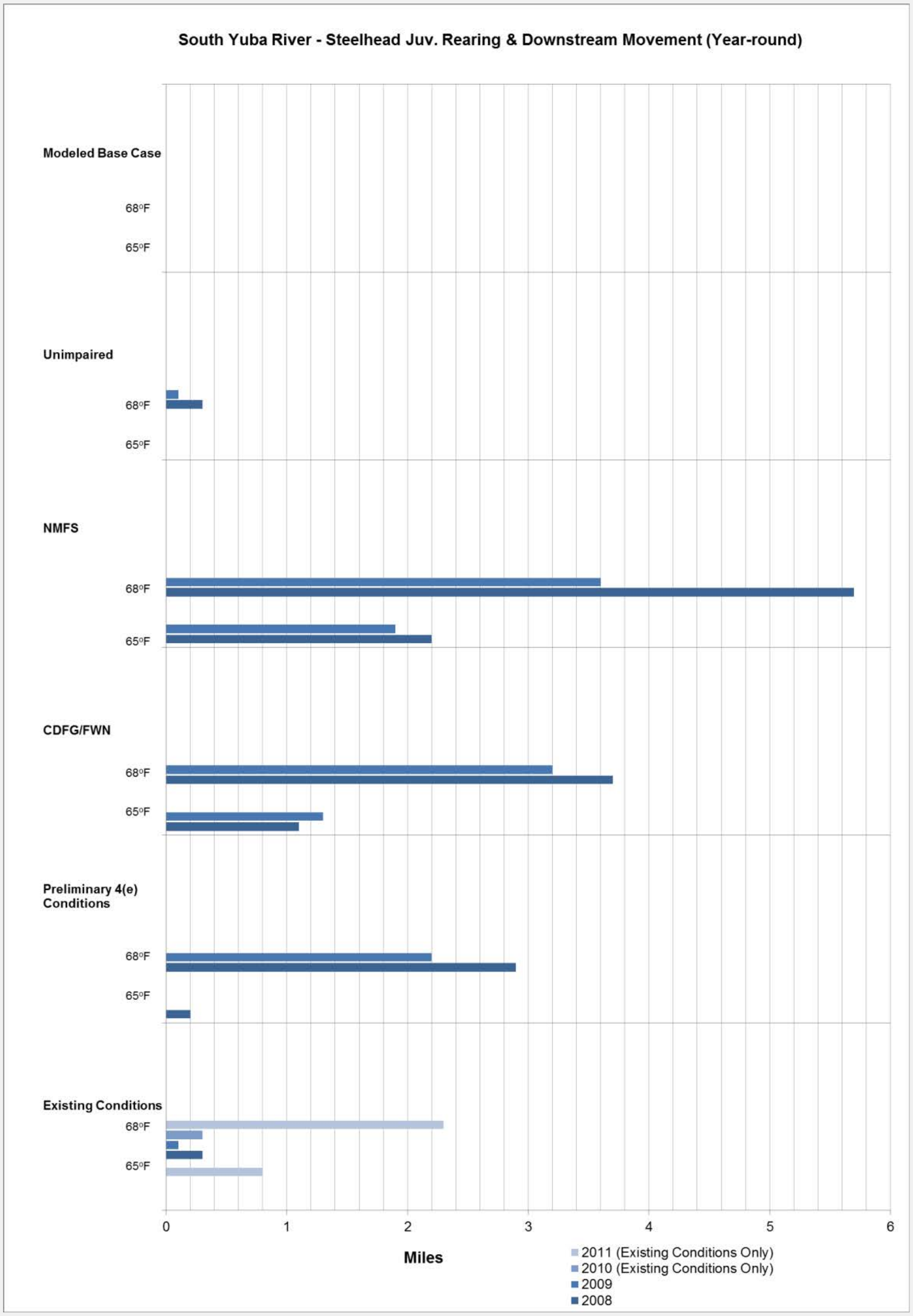
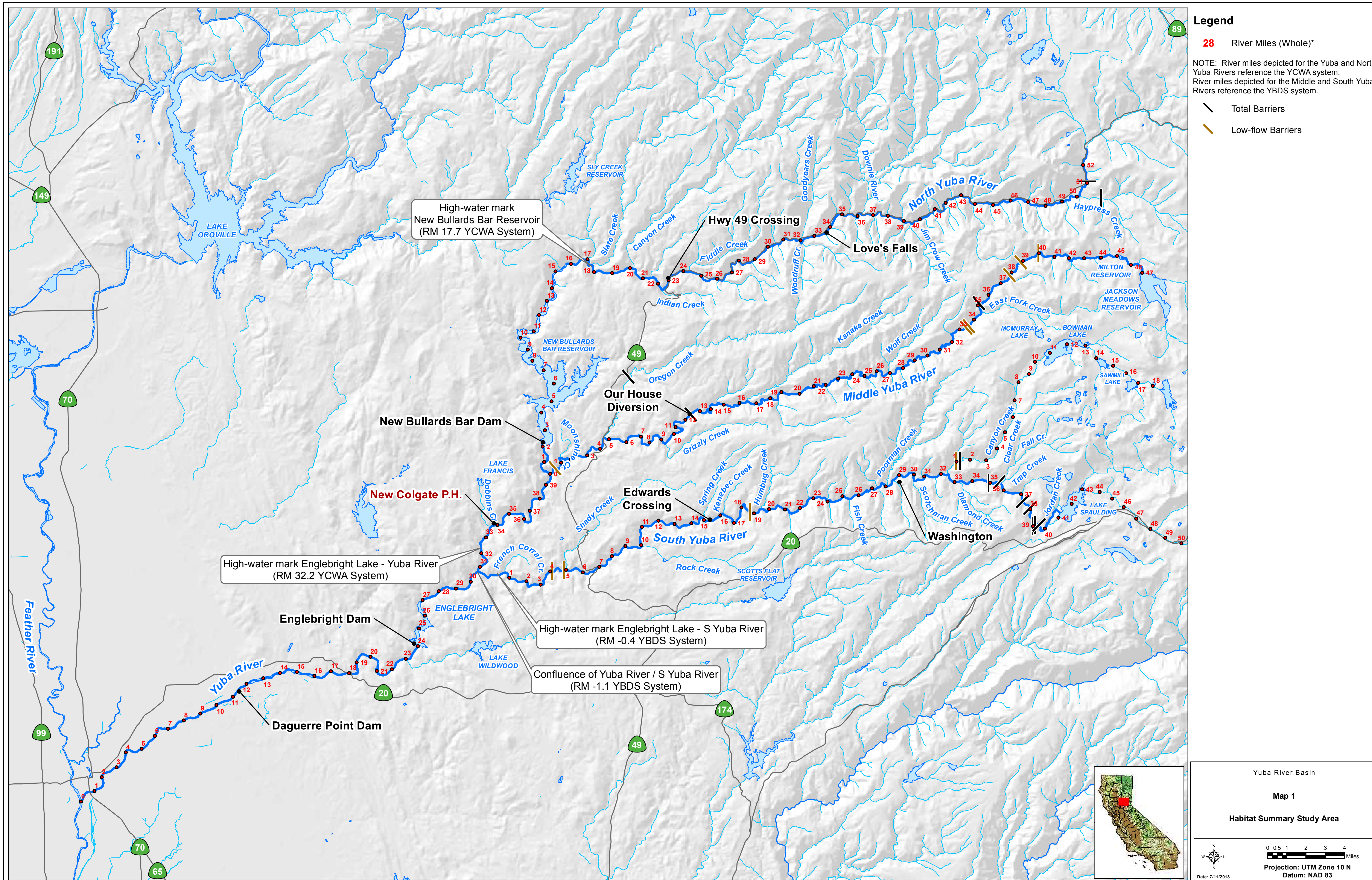


Figure 10. Comparison of the Miles of Steelhead Rearing Habitat (2008-2011) for Each Rearing Temperature Criterion on the North, Middle, and South Yuba Rivers and the Yuba River under Existing Conditions (a) and on the Middle Yuba River (b) and South Yuba River (c) under the Different Flow Scenarios (continued).

(c) South Yuba River



MAPS



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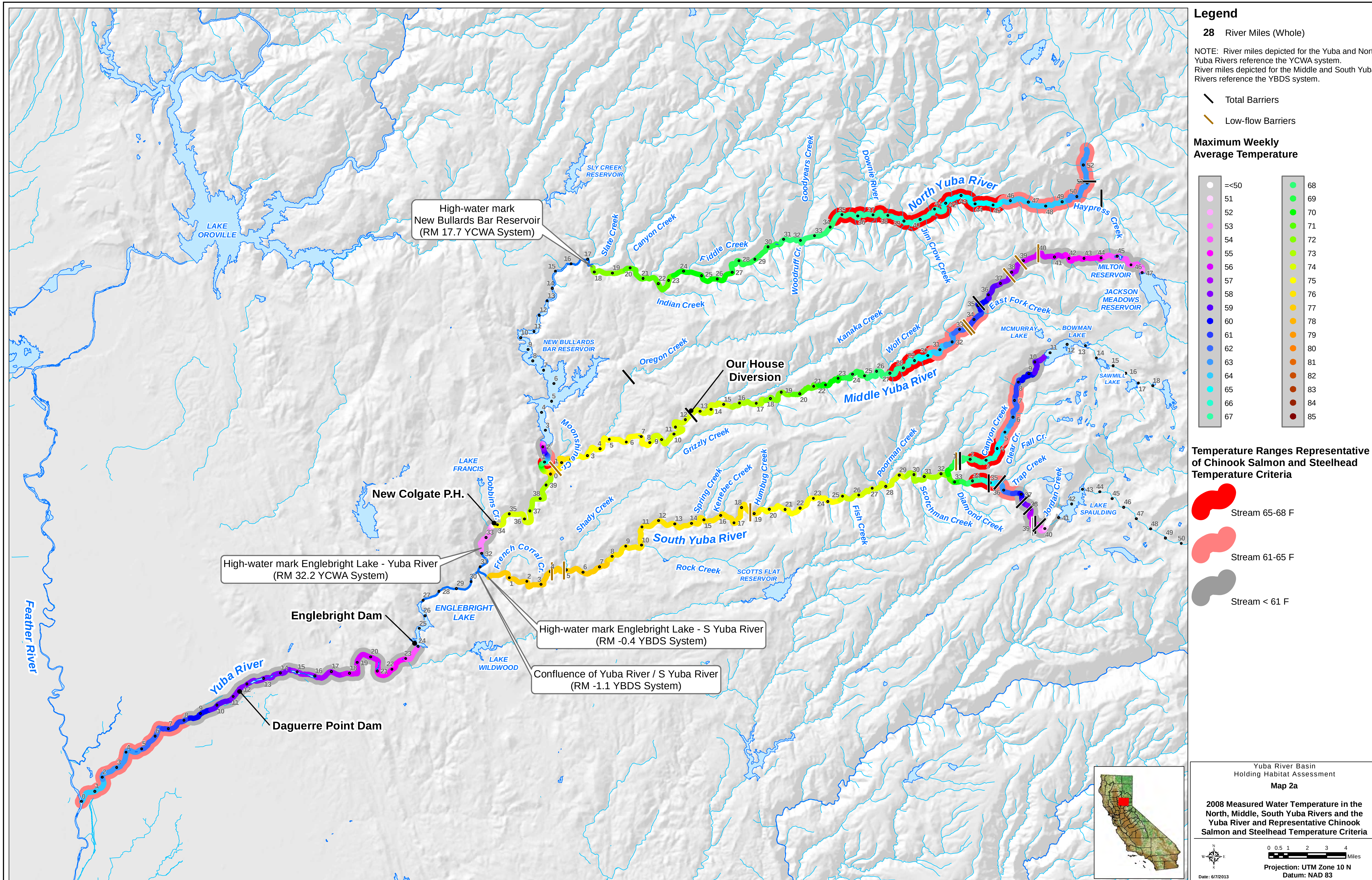

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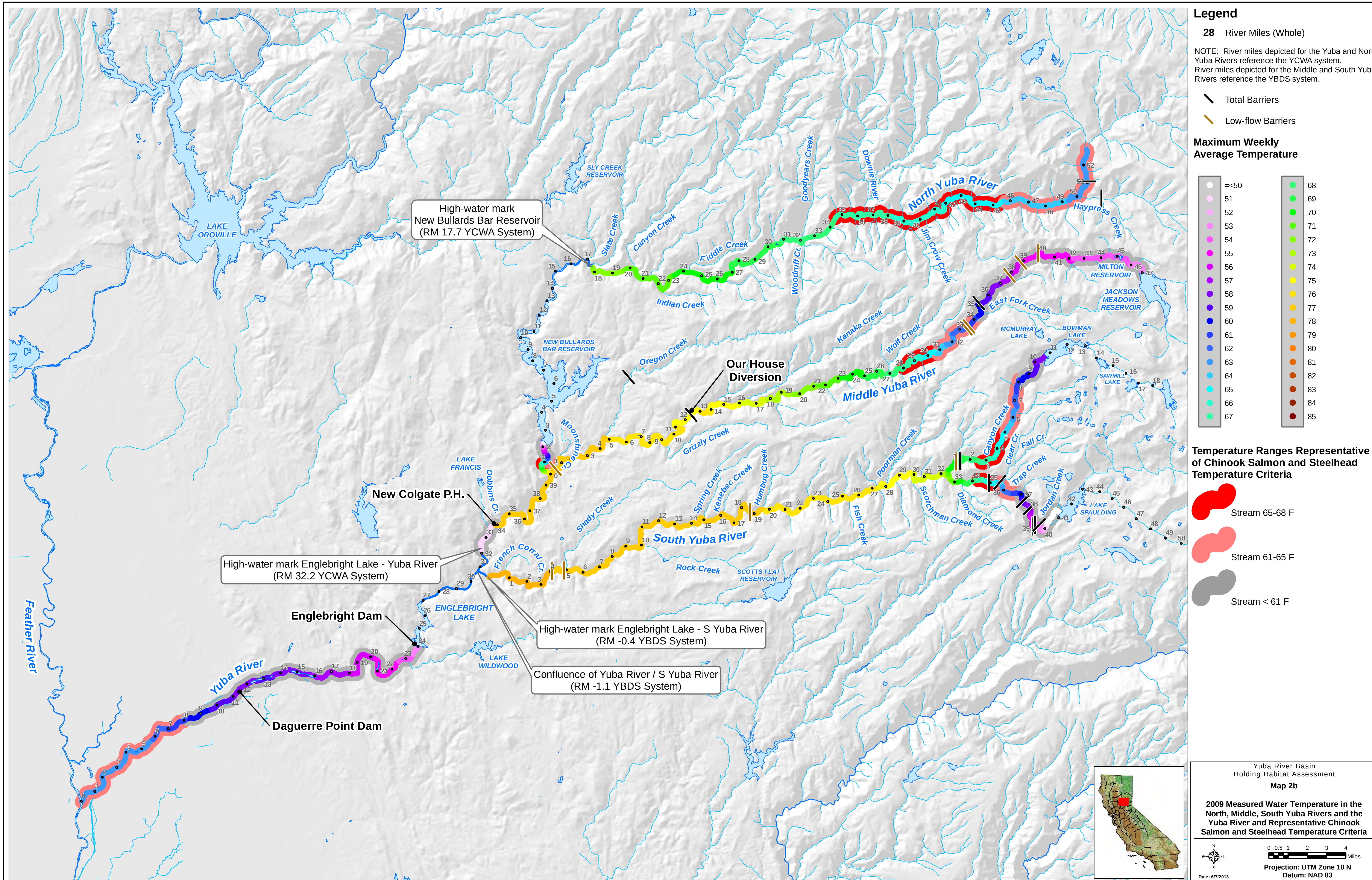

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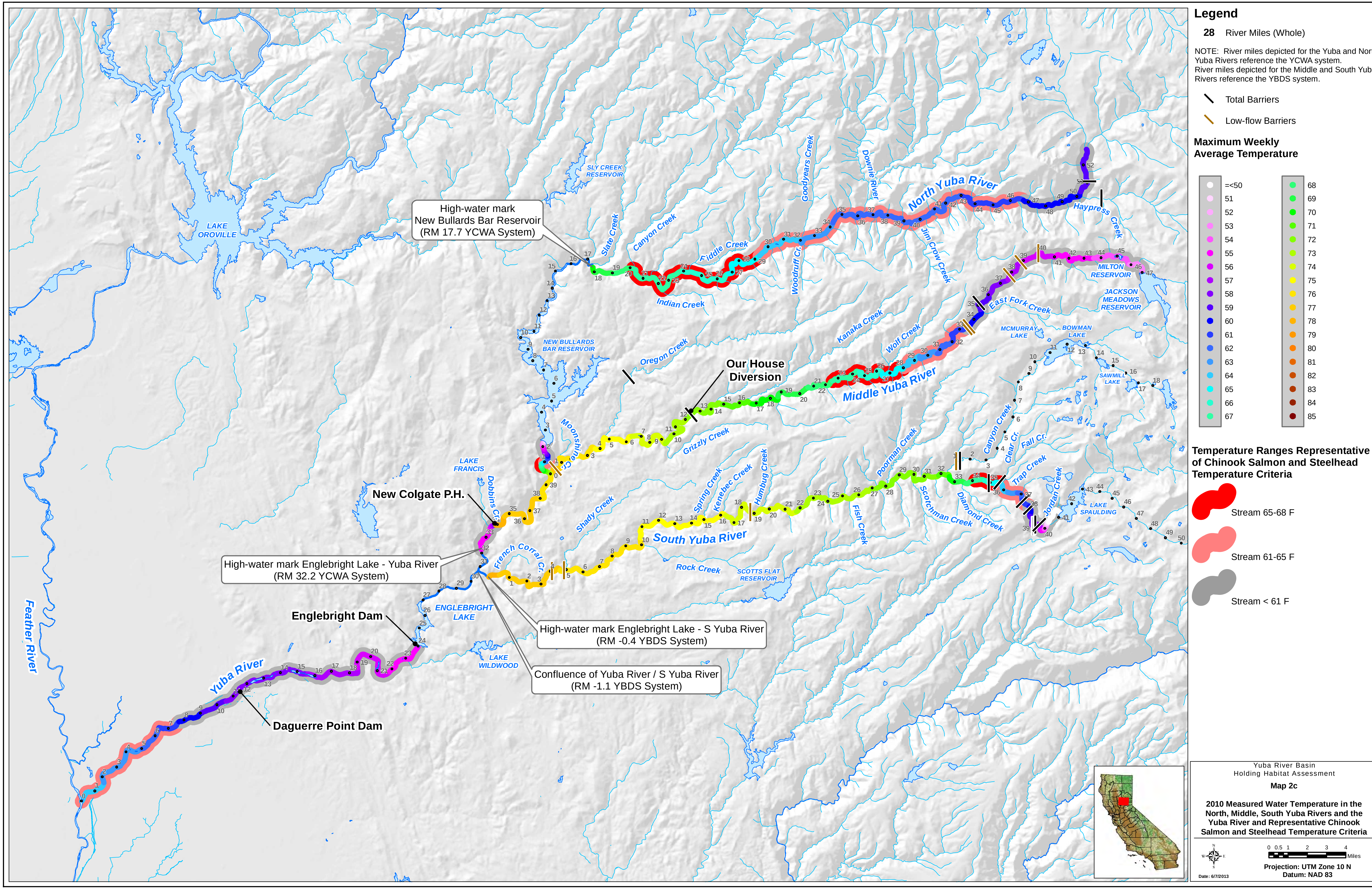

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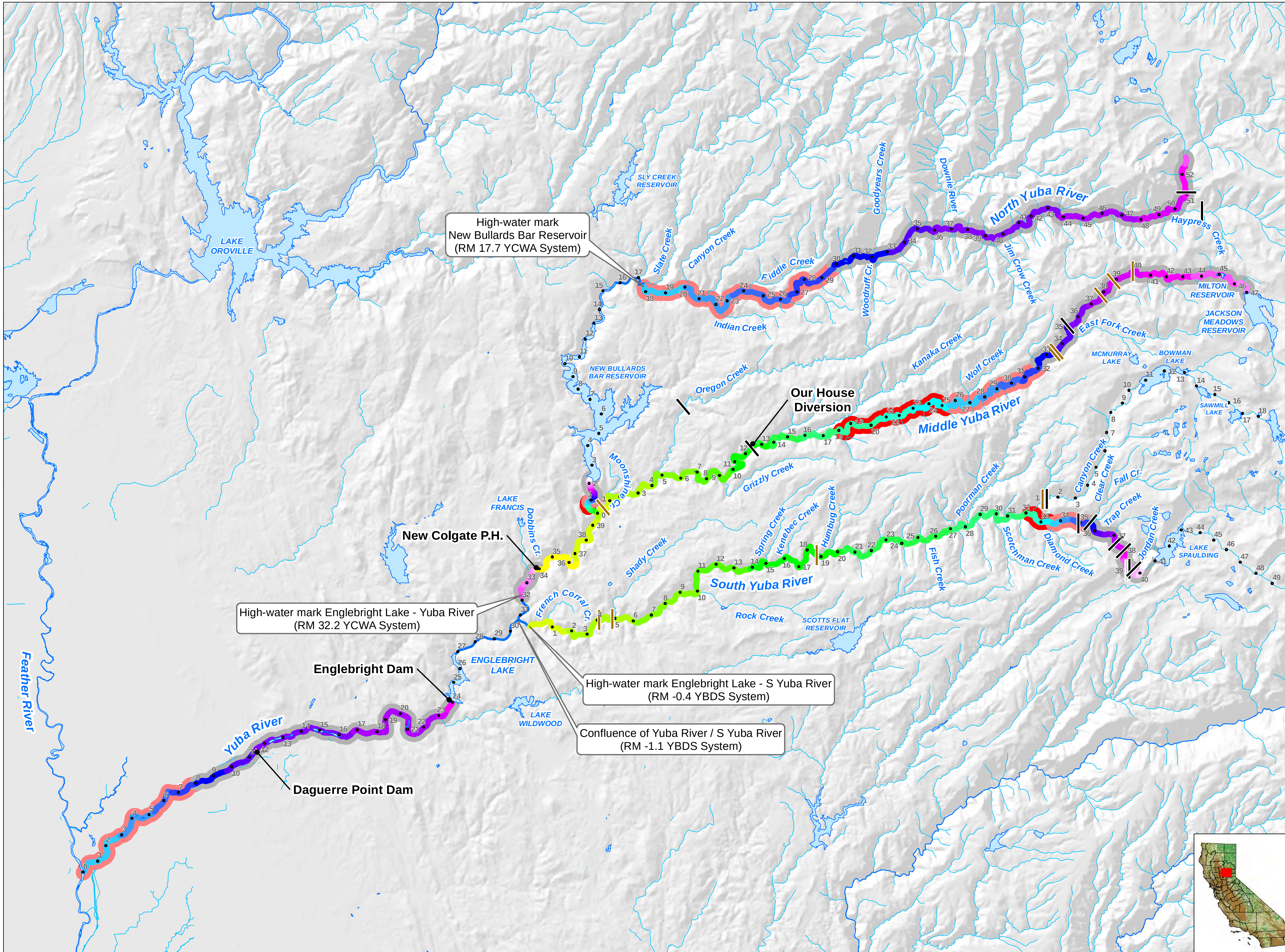

Legend

28 River Miles (Whole)

NOTE: River miles depicted for the Yuba and North Yuba Rivers reference the YCWA system.
River miles depicted for the Middle and South Yuba Rivers reference the YBDS system.

Total Barriers

Low-flow Barriers

Maximum Weekly Average Temperature

=<50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85

Temperature Ranges Representative of Chinook Salmon and Steelhead Temperature Criteria

Stream 65-68 F

Stream 61-65 F

Stream < 61 F

Yuba River Basin
Holding Habitat Assessment

Map 2d

2011 Measured Water Temperature in the North, Middle, South Yuba Rivers and the Yuba River and Representative Chinook Salmon and Steelhead Temperature Criteria

0 0.5 1 2 3 4 Miles

Date: 6/7/2013

Projection: UTM Zone 10 N
Datum: NAD 83

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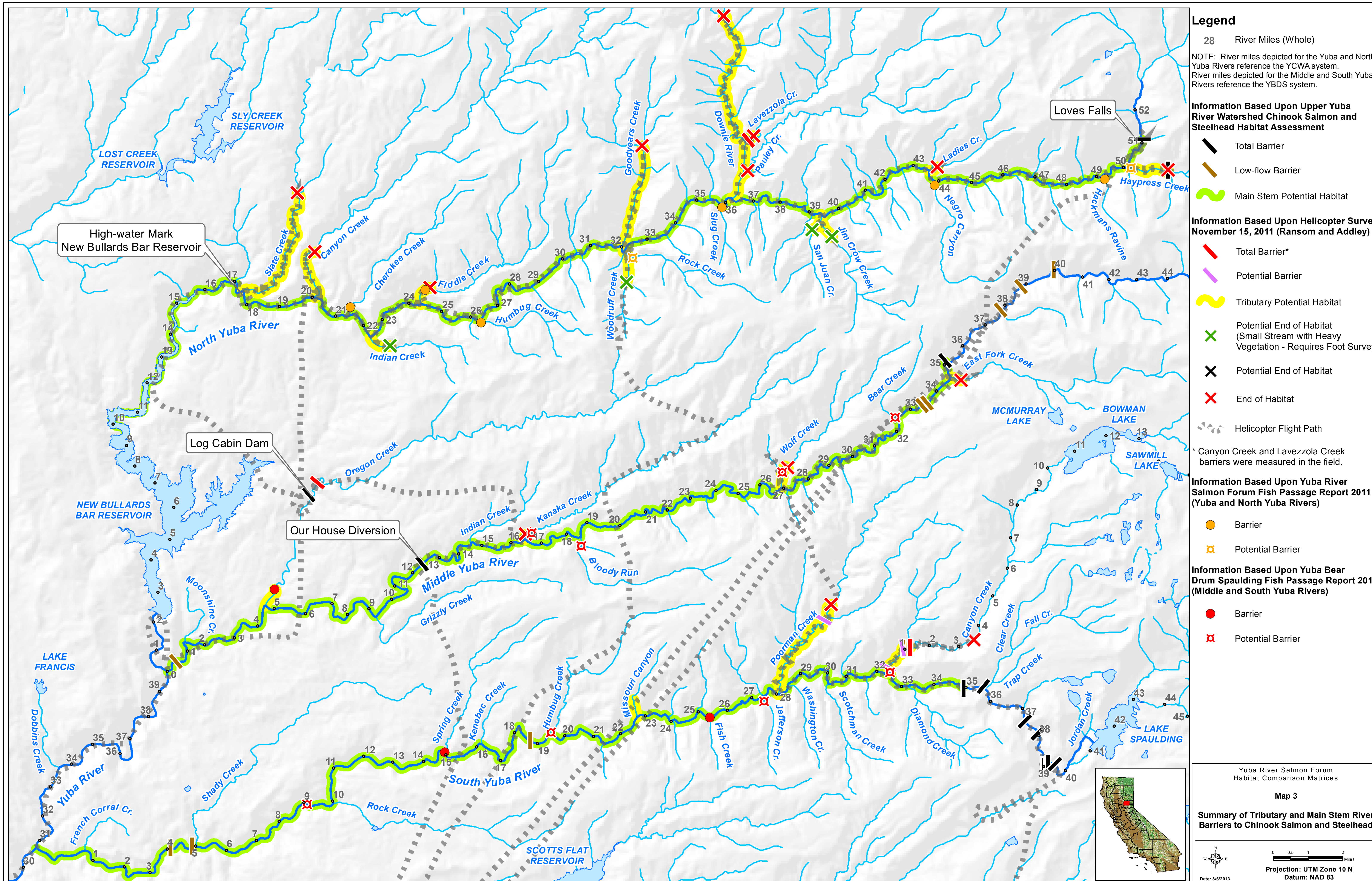
Legend
28 River Miles (Whole)
NOTE: River miles depicted for the Yuba and North Yuba Rivers reference the YCWA system. River miles depicted for the Middle and South Yuba Rivers reference the YBDS system.
Information Based Upon Upper Yuba River Watershed Chinook Salmon and Steelhead Habitat Assessment
Total Barrier
Low-flow Barrier
Main Stem Potential Habitat
Information Based Upon Helicopter Survey November 15, 2011 (Ransom and Addley)
Total Barrier*
Potential Barrier
Tributary Potential Habitat
Potential End of Habitat (Small Stream with Heavy Vegetation - Requires Foot Survey)
Potential End of Habitat
End of Habitat
Helicopter Flight Path
* Canyon Creek and Lavezzola Creek barriers were measured in the field.
Information Based Upon Yuba River Salmon Forum Fish Passage Report 2011 (Yuba and North Yuba Rivers)
Barrier
Potential Barrier
Information Based Upon Yuba Bear Drum Spaulding Fish Passage Report 2010 (Middle and South Yuba Rivers)
Barrier
Potential Barrier
Yuba River Salmon Forum
Habitat Comparison Matrices
Map 3
Summary of Tributary and Main Stem River Barriers to Chinook Salmon and Steelhead
Date: 8/6/2013
Miles
Projection: UTM Zone 10 N
Datum: NAD 83
Loves Falls
High-water Mark
New Bullards Bar Reservoir
Log Cabin Dam
Our House Diversion
SLY CREEK RESERVOIR
LOST CREEK RESERVOIR
NEW BULLARDS BAR RESERVOIR
LAKE FRANCIS
MCMURRAY LAKE
BOWMAN LAKE
SAWMILL LAKE
LAKE SPAULDING
SCOTTS FLAT RESERVOIR
North Yuba River
Middle Yuba River
South Yuba River
Yuba River
Slate Creek
Canyon Creek
Cherokee Creek
Fiddle Creek
Humbug Creek
Indian Creek
Goodyears Creek
Woodruff Creek
Rock Creek
Downie River
Lavezzola Cr.
Pauley Cr.
Slug Creek
San Juan Cr.
Jim Crow Creek
Ladies Cr.
Negro Canyon
Hackmans Ravine
Haypress Creek
Oregon Creek
Kanaka Creek
Bloody Run
Grizzly Creek
Moonshine Cr.
Wolf Creek
Bear Creek
East Fork Creek
Poorman Creek
Canyon Creek
Clear Creek
Fall Cr.
Trap Creek
Jordan Creek
Spring Creek
Kenebec Creek
Missouri Canyon
Fish Creek
Jefferson Cr.
Washington Cr.
Scotchman Creek
Diamond Creek
Shady Creek
French Corral Cr.
Dobbins Creek

APPENDIX A

Butte Creek Water Temperature Data (2001-2007) Used to Determine Butte Creek Upper Tolerable Temperature Limit for Spring-run Chinook Salmon and Butte Creek Holding and Spawning Data Used to Develop Approach for Determining the Length of Spawning Summer Based on Summer Holding Habitat and Downstream Movement Distances Prior to Spawning

APPENDIX B

Lower Yuba River Measured and Linearly Interpolated Water Temperatures (2008-2011)

APPENDIX C

EPA (2003) Water Temperature Criteria Analysis Versus YSF Water Temperature Criteria for the North Yuba River

APPENDIX D

Annual Empirical Temperature Plots with Chinook Salmon Migration Temperature Criteria (64 and 68^{o}F)

APPENDIX E

2008-2011 Existing and Modeled Water Temperatures in the North, Middle, and South Yuba Rivers and the Yuba River and Pool Holding Habitat Suitability Maps

APPENDIX F

Spring-run Chinook Salmon Habitat Summary Comparison Figures- Number of Spawning Redds and the Amount of Rearing Habitat Area

APPENDIX G

Redd Sensitivity Analysis

APPENDIX H

2008-2011 Existing and Modeled Water Temperatures in the North, Middle, and South Yuba Rivers and the Yuba River and Rearing Habitat for Juvenile Chinook Salmon and Steelhead Maps

APPENDIX I

Longitudinal Water Temperature Plots (2008-2009) and the Length of Chinook Salmon and Steelhead Rearing Habitat under Base Case and the Different Flow Scenarios

APPENDIX J

Average July and August Monthly Flows Used to Calculate Habitat Area in the North, Middle, and South Yuba Rivers (2008-2011) under the Different Flow Scenarios